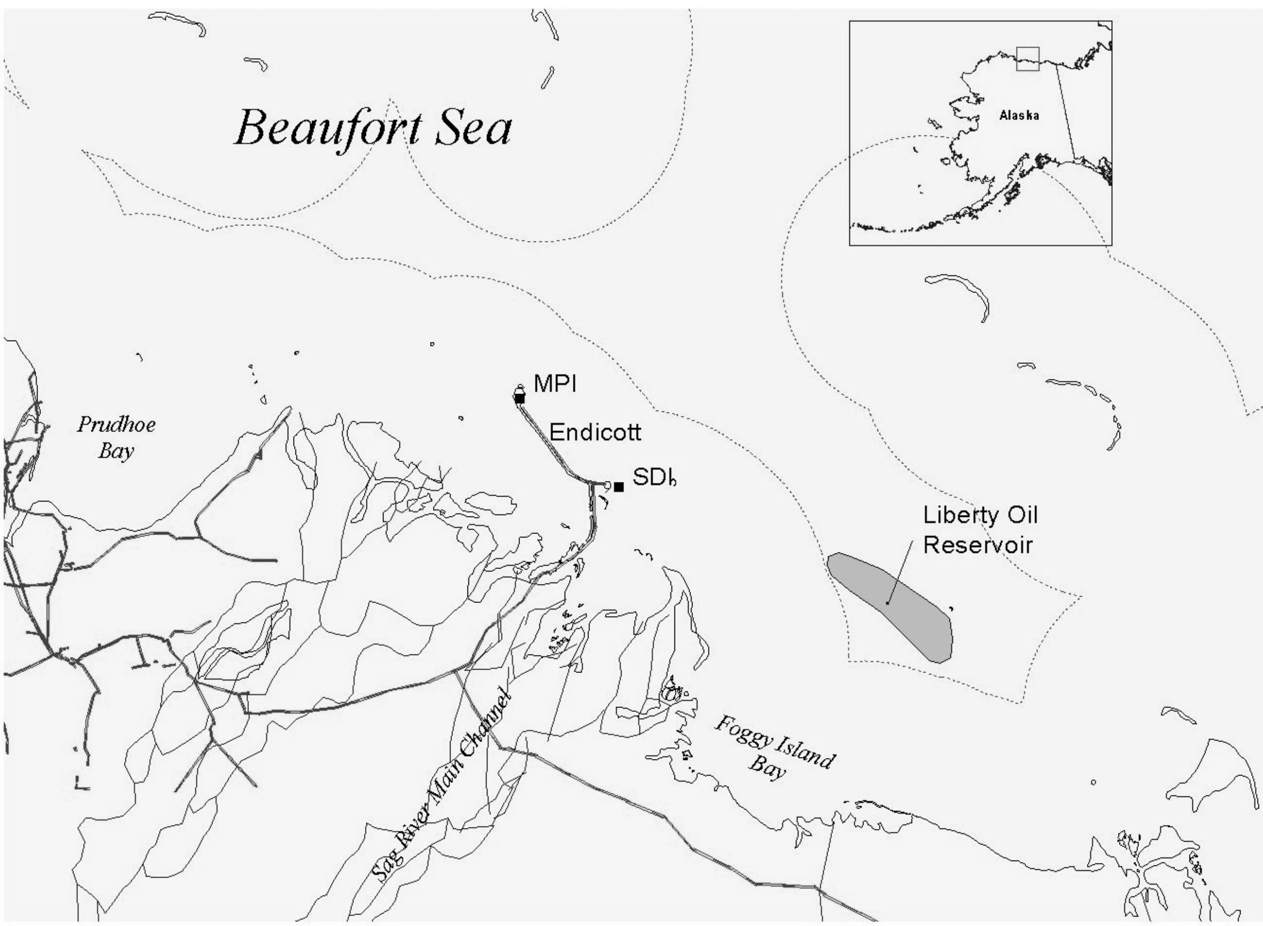
Alaska Outer Continental Shelf

OCS EIS/EA
MMS 2007-054

Liberty Development and Production Plan Ultra Extended Reach Drilling From Endicott - Satellite Drilling Island (SDI)

Environmental Assessment



U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

Alaska Outer Continental Shelf

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Environmental Assessment

Lead Agency:
Minerals Management Service, Department of the Interior

Cooperating Organizations:
US Army Corps of Engineers, Department of Defense
State of Alaska, Department of Natural Resources
British Petroleum Exploration (Alaska), Inc.

U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

October 2007

Finding of No Significant Impact (FONSI)

In accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, the Minerals Management Service (MMS) prepared an Environmental Assessment (EA) on British Petroleum Exploration (Alaska), Inc's (BPXA) proposed Liberty Development and Production Plan (DPP) Ultra Extended Reach Drilling (uERD) Project from Endicott Satellite Drilling Island (SDI). The proposed action consists of drilling six development wells from an expansion of the SDI to produce oil reserves from the Liberty prospect underlying BPXA's outer continental shelf (OCS) leases. The EA is dated October 2007.

The proposed Liberty development wells will be drilled from the existing Endicott industrial complex located in State of Alaska waters. Due to the location, and use of uERD, many potentially adverse impacts to the human environment are mitigated. Compared to the original Liberty project for which an Environmental Impact Statement was prepared in 2002, the current proposed action from Endicott industrial complex, has no subsea sales-oil pipeline; does not require construction of a new "stand-alone" offshore gravel island for drilling/processing; and will require 17 fewer development wells.

Based on the environmental assessment, MMS Alaska Region has determined that the proposal will not have significant effects on the quality of the human environment (40 CFR 1508.27).

Preparation of an environmental impact statement is not required.

Deborah Cranswick (signed) — 11/5/07

Deborah Cranswick
Chief, Environmental Assessment Section
MMS, Alaska OCS Region

Date

Cleveland J. Cowles (signed) — 11/5/07

Cleveland J. Cowles
Regional Supervisor, Leasing & Environment
MMS, Alaska OCS Region

Date

FOREWORD

This Environmental Assessment (EA) is based primarily on information provided to the Minerals Management Service (MMS) by BP Exploration (Alaska) Inc. (BPXA) on their proposed Liberty Development Project.

The Council on Environmental Quality (CEQ) encourages agencies to use environmental information prepared and submitted by the applicant, if appropriate. CEQ's stated intent at 40 CFR 1506.5(a) is "that acceptable work not be redone, but that it be verified by the agency." Per 40 CFR 1506.5(a):

> (a) *Information*. If an agency requires an applicant to submit environmental information for possible use by the agency in preparing an environmental impact statement, then the agency should assist the applicant by outlining the types of information required. The agency shall independently evaluate the information submitted and shall be responsible for its accuracy. If the agency chooses to use the information submitted by the applicant in the environmental impact statement, either directly or by reference, then the names of the persons responsible for the independent evaluation shall be included in the list of preparers (Sec. 1502.17). It is the intent of this paragraph that acceptable work not be redone, but that it be verified by the agency.
>
> (b) *Environmental assessments*. If an agency permits an applicant to prepare an environmental assessment, the agency, besides fulfilling the requirements of paragraph (a) of this section, shall make its own evaluation of the environmental issues and take responsibility for the scope and content of the environmental assessment.

Under a Memorandum of Understanding and consistent with CEQ regulations, the MMS, the U.S. Army Corps of Engineers, and the State of Alaska Department of Natural Resources worked closely with BPXA and its contractors to ensure that the Environmental Impact Analysis (EIA) submitted with the Development and Production Plan (DPP) included as much of the information as possible needed for the National Environmental Policy Act (NEPA) analyses prepared by the Cooperating Agencies. The EIA was designed to provide the necessary environmental information to support agencies' decisionmaking for permits required for the project.

The primary source of the information in this EA is the EIA submitted by BPXA to MMS on April 25, 2007. The information included in the EIA was reviewed and verified by MMS, U.S. Army Corps of Engineers, and State of Alaska Department of Natural Resources. Much of the information in the EIA was taken directly from the 2002 Liberty Final Environmental Impact Statement (EIS). This EA tiers from the 2002 Liberty Final EIS and summarizes and incorporates by reference additional information from the EIS. While this EA adopts major sections of the EIA, MMS also updated and expanded on the information provided in the EIA, as needed. The conclusions in the EA reflect the MMS analysts' conclusions based on MMS's significance thresholds and consideration of additional required mitigation measures developed subsequent to submission of the DPP and EIA.

Alternatives to the proposed action described in Section 1 of the EIA were developed by BPXA and are the alternatives analyzed in this EA as required by the:

- National Environmental Policy Act (NEPA) (40 CFR 1502.14);
- Regulations of the MMS (30 CFR 250.261);
- Regulations of the U.S. Army Corps of Engineers (33 CFR 325 Appendix B), and
- U.S. Environmental Protection Agency 404(b)(1) Guidelines (40 CFR 230).

The EIA contained the following major components:

- Summary of the project as proposed in *Liberty Development Project Development and Production Plan* and alternatives considered;
- Description of the affected environment, including physical, biological, and sociocultural components;
- Assessment of the environmental consequences of the proposed project and alternatives;
- Mitigative measures incorporated into the proposed project, including compliance with lease-sale stipulations; and
- Summary list of consultation and coordination with agencies and the public.

List of Acronyms

LIST OF ACRONYMS

AAC	Alaska Administrative Code
AAQS	Ambient Air Quality Standards
ACS	Alaska Clean Seas
ADCEC	Alaska Department of Community and Economic Development
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOR	Alaska Department of Revenue
AEWC	Alaska Eskimo Whaling Commission
AHRS	Alaska Heritage Resources Survey
Al	Aluminum
ANCSA	Alaska Native Claims Settlement Act
ANIMIDA	Arctic Nearshore Impact Monitoring in the Development Area
ANS	Alaska North Slope
ANWR	Arctic National Wildlife Refuge
AOGCC	Alaska Oil and Gas Conservation Commission
API	American Petroleum Institute
As	Arsenic
ASDP	Alpine Satellite Development Plan
ASOS	Automatic Surface Observing System
ASRC	Arctic Slope Regional Corporation
Ba	Barium
BA	Biological Assessment
BACT	Best available control technology
BAT	Best available technology
bbl	Barrel(s)
Be	Beryllium
BLM	Bureau of Land Management
BMP	Best management practice
BO	Biological Opinion
BOP	Blowout preventer
bpd	Barrels per day
BPXA	BP Exploration (Alaska) Inc.
CAA	Conflict Avoidance Agreement
$CaCO_3$	Calcium carbonate
cANIMIDA	Continuation of Arctic Nearshore Impact Monitoring in the Development Area

CBD	Centers for Biological Diversity
CBS	Chukchi-Beaufort Seas (stock of polar bears)
CCP	Central Compression Plant
Cd	Cadmium
CDOM	Colored dissolved organic matter
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cm	Centimeter(s)
cm/yr	Centimeter(s) per year
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
COY	cubs of the year (polar bears)
Cr	Chromium
CRA	Corrosion Resistant Alloy
Cu	Copper
dB	Decibel
dB Re 1μPa	Decibel re 1 microPascal
DOC	Dissolved organic carbon
DOT	U.S. Department of Transportation
DPP	Development and Production Plan
DS-11	Dive Site 11
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIA	Energy Information Administration and Environmental Impact Assessment
EIS	Environmental Impact Statement
EOR	Enhanced oil recovery
EPA	U.S. Environmental Protection Agency
ERA	Environmental Resource Area
ERD	Extended reach drilling
ERL	Effects Range-Low
ERM	Effects Range-Median
ESA	Endangered Species Act
Fe	Iron
FEIS	Final environmental impact statement
FG	Fracture gradient
FR	*Federal Register*
FSA	Facility Sharing Agreement
ft	foot/feet
FTE	Full-time equivalent
FWS	Fish and Wildlife Service
FY	Fiscal Year
g	Gram
gal	Gallon

g/m^2	Grams per square meter
GNOME	General NOAA Operational Modeling Environment
GPB	Greater Prudhoe Bay
gpd	Gallons per day
GPS	Global Positioning System
H_2S	Hydrogen sulfide
HAZWOPER	Hazardous waste operations
Hg	Mercury
hr	Hour
H_{sat}	Saturating irradiance
HSE	Health, safety, and environmental
Hz	Hertz
ICAS	Inupiat Community of the Arctic Slope
In	inch(es)
IOPs	Inherent optical properties
IRA	Indian Reorganization Act
ISER	Institute of Social and Economic Research
IUCN/SSC	World Conservation Union/Species Survival Commission
kg	Kilogram
KIC	Kaktovik Iñupiat Corporation
km	Kilometer
km^2	Square kilometer
kt	Knot(s)
KSOPI	Kuukpikmiut Subsistence Oversight Panel, Inc.
l	Liter
LCU	Lower Cretaceous Unconformity
LOA	Letter of Authorization
LoSal™	A trademark of BP p.l.c., associated with a BP process to produce low-salinity water for enhanced oil recovery
m	Meter(s)
m/sec	meter(s) per second
m^3	Cubic meter(s)
mb	Millibar(s)
mg	Milligram(s)
mi	mile(s)
MHHW	Mean higher high water
MLLW	Mean lower low water
mm	Millimeter(s)
MMbbl	Million barrels
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
Mn	Manganese
MOU	Memorandum of understanding
mph	mile(s) per hour
MPI	Main Production Island
MPFM	Multi phase flow meter

MSA	Magnuson-Stevens Fishery Conservation and Management Act of 1996
MSDS	Material safety data sheet
MSL	Mean sea level
MWD	Measurement while drilling
NACE	National Association of Corrosion Engineers
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NGLs	Natural gas liquids
NMFS	National Marine Fisheries Service
Ni	Nickel
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
NPR-A	National Petroleum Reserve-Alaska
NRC	National Research Council
NSB	North Slope Borough
NSBSAC	North Slope Borough Science Advisory Committee
NSPS	New Source Performance Standards
NTU	Nephelometric turbidity units
O_3	Ozone
OCS	Outer continental shelf
OCSEAP	Outer Continental Shelf Environmental Assessment Program
OCSLA	OCS Lands Act
ODPCP	Oil Discharge Prevention and Contingency Plan
OHA	Office of History and Archaeology (ADNR)
OHMP	Office of Habitat Management and Permitting (ADNR)
OR&R	Office of Response and Restoration (NOAA)
OSHA	Occupational Safety and Health Administration
OSRP	Oil Spill Response Plan
OSRA	Oil-Spill-Risk Analysis
PAH	Polynuclear aromatic hydrocarbons
PAR	Photosynthetically active radiation
Pb	Lead
PBSG	Polar Bear Specialists Group
PFFR	Photon flux fluence rate
PHC	Petroleum hydrocarbons
$PM_{2.5}$	Very fine particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers
PM_{10}	Particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand

PS-1	Pump Station 1
PSD	Prevention of Significant Deterioration
psi	Pounds per square inch
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
RS/FO	Regional Supervisor, Field Operation
RTE	Radiative transfer equation
SAW	Sensitive Areas Workgroup
Sb	Antimony
SBS	Southern Beaufort Sea (stock of polar bears)
scf/stb	Standard cubic feet per stock tank barrel
scfd	Standard cubic feet per day
SD	Standard deviation
SDI	Satellite Drilling Island
SHPO	State Historic Preservation Officer
SO_2	Sulfur dioxide
S/T	Steranes and triterpanes
STP	Seawater treatment plant
T	Transmissivity
TAPS	Trans-Alaska Pipeline System
TDS	Total dissolved solids
Tl	Thallium
TLUI	Traditional Land Use Inventory
TOC	Total organic carbon
TPHC	Total petroleum hydrocarbons
TSS	Total suspended solids
TVDSS	true vertical depth sub sea
TVP	True vapor pressure
uERD	Ultra extended reach drilling
µg	Microgram
uERD	Ultra Extended Reach Drilling
UIC	Ukpeagvik Iñupiat Corporation
USCG	U.S. Coast Guard
USDOI	U.S Department of Interior
USGS	U.S. Geological Survey
V	Vanadium
yd	Yard(s)
yd^{2}`	Yard(s) square
yr	Year
Zn	Zinc
3D	3-dimensional (seismic surveys)
$<$	Less than
$>$	Greater than
$\leq$	Less than or equal to
$\geq$	Equal to or greater than
$\delta^{13}C$	Stable carbon isotope

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Section 1

Project Summary

1. PROJECT SUMMARY

1.1 PURPOSE OF THE PROPOSED ACTION

In April 2007, BP Exploration (Alaska) Inc. (BPXA) submitted a Development and Production Plan (DPP) to the Minerals Management Service (MMS), for the Liberty Satellite Drilling Island (SDI) Project, as required under 30 CFR 250.204. On October 15, 2007, BPXA submitted a modification to the April 2007 DPP. Specifically, the modification outlined redesign of the gravel mine site, which is adjacent to the existing Duck Island Mine Site; upgrade of the Sagavanirktok River bridge superstructure, versus replacement of the entire bridge; and the bridge design basis/preliminary construction plan.

Previously, in February 1998, BPXA submitted a DPP to MMS for Liberty, as required under 30 CFR 250.204. The 1998 DPP proposed to develop the Liberty oil field from a gravel island constructed on the Outer Continental Shelf (OCS). The proposed project included a manmade offshore gravel island, processing facilities located on the island, an offshore buried pipeline, and an onshore elevated pipeline that would connect the island facilities to the Badami Pipeline, an onshore gravel mine, and onshore and offshore ice roads.

The Liberty (SDI) Project is subject to the Federal, State, and local approvals, as identified in Section 1.3 of the *Liberty Development and Production Plan*, which provides a comprehensive description of the proposed project, including all the information required under 30 CFR 250.241-262. An environmental impact analysis (EIA) document was submitted as an attachment to the DPP as required by 30 CFR 250.227. BPXA met the terms of 30 CFR 250.250 through reference to the existing State- and MMS-approved Endicott Oil Discharge Prevention and Contingency Plan (ODPCP) in accordance with 30 CFR 254.53.

The Liberty Development Project design and scope have evolved from an offshore stand-alone development in the OCS (production/drilling island and subsea pipeline), as described in the 2002 FEIS, to use of existing infrastructure involving an expansion of the Endicott SDI. This project evolution reflects a number of factors including environmental mitigation, advances in ultra-extended-reach drilling (uERD) technology, use of depth-migrated 3-dimensional (3D) seismic data, and advances in reservoir modeling among others.

This EA describes the current Liberty (SDI) Project, discusses the affected environment, and evaluates the potential direct, indirect, and cumulative impacts of the proposed action and alternatives.

1.2 NEED

The Outer Continental Shelf Lands Act (OCSLA) identifies the OCS as a vital natural resource reserve that should be made available for expeditious and orderly development. Consistent with the Act, the purpose of the Liberty (SDI) Project is to recover oil from the Liberty oil field for production and transport of sales-quality oil to the Trans-Alaska Pipeline System (TAPS).

U.S. oil production is expected to decline over the next 2 decades. As a result, the U.S. will increasingly depend on oil imports from foreign producers. To reverse this trend, the U.S. Energy Policy encourages and facilitates domestic oil production. The Liberty field contains large energy reserves with potential recoverable reserves of up to 105 million barrels (MMbbl) of oil and up to 78.5 billion cubic feet of natural gas (including natural gas liquids [NGLs], but excluding carbon dioxide). Production from the Liberty field, therefore, will help achieve U.S. energy goals by satisfying demand for domestic oil and by decreasing U.S. dependence on foreign oil.

The Liberty (SDI) Project also will provide economic benefits to the Federal Government, the State of Alaska, and the North Slope Borough (NSB). Alaska will benefit directly from the infusion of new capital into the economy and the creation of jobs. Over the life of the project, additional benefits will accrue to the State through the State's share of the Federal royalty, the State corporate income tax, and ad valorem tax, some of which also will accrue to the NSB. This benefit will occur at a time when State revenue, heavily dependent on production from the large North Slope oil fields, is declining. The Liberty (SDI) Project will help mitigate the severity of the decline to the State of Alaska and to the U.S.

1.3 SUMMARY PROJECT DESCRIPTION

A detailed description of the proposed Liberty (SDI) Project may be found in the Liberty DPP, and the EIA is an attachment to the DPP. Following is a summary of the project.

The Liberty prospect is located about 5.5 miles (mi) offshore in about 20 feet (ft) of water and approximately 5 to 8 mi east of the existing Endicott SDI (Figure 1-1). To take advantage of the infrastructure at Endicott, BPXA has elected to drill the uERD wells from the SDI by expanding the island by approximately 20 acres to support Liberty drilling. Liberty is one of the largest undeveloped light-oil reservoirs near North Slope infrastructure. BPXA estimates the Liberty (SDI) Project could recover approximately 105 MMbbl of hydrocarbons by waterflooding and using the ***LoSal™*** enhanced oil recovery (EOR) process (***LoSal™*** is a trademark of BP p.l.c.).

The development drilling program will include one to four producing wells and one or two water injection wells. No well test flaring is planned for this drilling program. Production from the Liberty uERD project will be sent by the existing Endicott production flowline system from the SDI to the Endicott Main Production Island (MPI) for processing. The oil would then be transported to the TAPS via the existing Endicott sales-oil pipeline. Produced gas will be used for fuel gas and artificial lift for Liberty, with the balance being reinjected into the Endicott reservoir for enhanced oil recovery. Water for waterflooding will be provided via the existing produced-water injection system available at the SDI. This supply will be augmented by treated seawater if needed from the Endicott Seawater Treatment Plant. The ***LoSal™*** EOR process will be employed during a portion of the flood and will be supplied by a ***LoSal™*** facility constructed on the MPI.

Associated onshore facilities to support this project will include upgrade of the existing West Sagavanirktok River Bridge, ice road construction, and development of a new permitted mine site adjacent to the Endicott Road to provide gravel for expanding the SDI. Existing North Slope infrastructure also will be used to support the project.

All wells for this project will be outside current industry performance for this depth. As a result, the state-of-the-art of uERD must be advanced. BPXA first plans to drill a single well to ensure that such drilling is feasible. If that well is successful and the technology is proven, then BPXA will proceed with drilling additional wells and installing new facilities to complete the project as described in this document

1.4 DEVELOPMENT ALTERNATIVES

For purposes of the EIA submitted with the DPP, BPXA examined the impacts of three development alternatives in addition to the SDI expansion:

- The offshore, stand-alone drilling island evaluated in the 2002 FEIS;
- A drilling pad at Point Brower, with processing at Endicott; and
- A drilling pad near the Kadleroshilik River with processing at Badami.

Figure 1-2 shows these alternatives, which are discussed briefly below. Table 1-1 presents of a comparison of the proposed SDI expansion with these three alternatives in terms of major project components. A brief description of each alternative is provided below.

1.4.1 Offshore Island Project

BPXA's originally proposed Liberty Project involved a self-contained offshore drilling operation with processing facilities on an artificial gravel island with a buried sales oil pipeline to shore to connect with the Badami sales oil pipeline for shipment to the TAPS. The island would have been located in Foggy Island Bay in 22 ft of water about 6 mi offshore and 1.5 mi west of the abandoned Tern Island.

Infrastructure and facilities necessary to drill wells and process and export 65,000 barrels (bbl) of oil per day to shore would be installed on the island. The project involved 14 producing wells, 6 water injection wells, 2 gas injection wells (1 of which would be preproduced), and 1 disposal well (23 total) at a wellhead spacing of 9 ft. Space for up to 40 well slots would be provided. Produced gas would be used for fuel gas and artificial lift, with the balance being either reinjected or exported for use in an EOR program at the nearby Badami Unit. Seawater would be treated and used to waterflood the Liberty reservoir. Produced water would be commingled with treated seawater and injected as waterflood. A 12-inch (in) sales-oil pipeline would be built to transport crude oil to the Badami sales-oil pipeline, and a 6-in products pipeline would import fuel gas for drilling and start-up activities to Liberty from the Badami products pipeline prior to first Liberty production, and would then export product to the Badami pipeline after startup. The offshore portion of the pipelines would be approximately 6.1mi long. The overland portions will be approximately 1.5 mi long to a tie-in point with the Badami pipeline system.

Associated onshore facilities to support this project would include use of existing permitted water sources, ice road and ice pad construction, and development of a gravel mine site in the Kadleroshilik River floodplain. In addition, existing North Slope infrastructure would be used in support of this project.

In accordance with the National Environmental Policy Act (NEPA), MMS prepared the 2002 *Liberty Development and Production Plan Final Environmental Impact Statement* (USDOI, MMS, 2002). The FEIS analyzed the environmental impact as well as the impacts associated with modifying five project components (island location and pipeline route, pipeline design, upper slope protection system, gravel mine site, and pipeline burial depth). The proposed project was compared to three alternatives consisting of combined project components. In addition, the FEIS evaluated the effectiveness of potential mitigating measures and cumulative impacts resulting from the BPXA proposal and the alternatives.

1.4.2 Point Brower Drilling Pad

This alternative would involve building a new gravel pad onshore at Point Brower to access the Liberty reservoir by means of uERD. A 15.2-mi-long pipeline would be built from the pad to the Endicott facilities on the MPI, where the oil would be processed for shipment in the Endicott sales oil line. The project would also involve construction of a 7.3-mi-long gravel road to connect the pad to the existing Endicott Road to provide the necessary logistical support for the uERD wells.

1.4.3 Kadleroshilik Pad

This alternative would involve a new gravel pad onshore near the mouth of the Kadleroshilik River to access the Liberty reservoir by means of uERD. An 11.5-mi-long pipeline would be built from the pad to the existing Badami facilities, where the three-phase fluid would be processed to ship oil through the Badami sales oil pipeline. A gravel road 15.2 mi long would be constructed from the pad to the Endicott Road to provide for necessary logistical support.

Section 2

Affected Environment

2 AFFECTED ENVIRONMENT

This section discusses the affected environment in the vicinity of the proposed Liberty (SDI) Project area and alternatives. The discussion covers the physical, biological, cultural, and socioeconomic environments. The MMS updated the information and expanded on the information provided in the EIA, as needed.

2.1 AIR ENVIRONMENT

2.1.1 Climate and Meteorology

The North Slope of Alaska is bounded to the south by the Brooks Range and by the Arctic Ocean to the north. The mountains provide a natural barrier separating this region climatically from the rest of Alaska (Figure 2.1-1). This region is the coldest and driest of Alaska with a Köppen climatological classification of ET (polar tundra) and frequent high winds. The winters are cold and the summers are cool and short, with only 3 to 4 months with mean temperatures above freezing.

The following sections provide climatological data based on five locations (Barrow, Prudhoe Bay, Deadhorse, Kuparuk, and Barter Island) in Arctic Alaska (National Climatic Data Center [NCDC]). The climate stations are shown in Figure 2.1-1, while the characteristics are given in Table 2.1-1. No climate stations with long-term records are located in the immediate vicinity of the Liberty (SDI) Project area. However, the data at the five stations indicated above provide a reasonable depiction of the conditions anticipated at the Liberty site.

2.1.1.1 Air Temperature

Table 2.1-2 presents the air temperatures for Barrow, the station with the longest record of climatological data on the North Slope. These data are presented graphically in Figure 2.1-2. The data shown are for the period 1975 to 2004, as climatological normals are usually based on a 30-year period. July is on average the warmest month, with a mean temperature of 4.6 °C, while February is the coldest month with a mean of -26.0 °C. For most of Alaska, January is the coldest month, and this delay of 1 month in the Arctic is typical for a maritime climate. Only 3 months (June, July, August) have a mean temperature above the freezing point, and the average daily maxima are below 10 °C for all months. The record high, 26 °C, was measured on 13 July 1993. The lowest temperature recorded in Barrow during the last 30 years was -47 °C, and this occurred on 3 January 1975. This is a relatively benign value compared to the Statewide absolute minimum of -62 °C, measured at Prospect Creek south of the Brooks Range in northern Interior Alaska. The relatively strong winds experienced year-round in Arctic Alaska are a primary reason why temperatures do not go as low as in the Interior.

Table 2.1-3 presents climatological data for other stations on the North Slope. It should be noted, however, that the observational period is not identical for the different stations and slight differences in the climatological statistics might occur due to this fact.

In general, the two stations located directly at the Beaufort Sea coastline (Barrow and Barter Island) are somewhat cooler in the summer than the three other stations, which are located a distance inland. The period with mean temperatures above freezing also is extended at the inland stations. Alternatively, the winter temperatures at the coastal stations were somewhat warmer, a sign of the maritime influence of the Beaufort Sea.

2.1.1.1 Precipitation

Precipitation is light on the North Slope. The annual precipitation (water equivalent) for four of the stations is summarized in Table 2.1-4. Because the precipitation record for Deadhorse is incomplete, these data were not included. The mean annual precipitation ranges from 10.1 centimeters (cm) at Kuparuk to 15.7 cm at Barter Island. The precipitation maximum occurs in August for all stations while during the winter months (November through April), the precipitation is very light.

The annual snowfall for the four stations is presented in Table 2.1-5. The mean annual snowfall ranges from 78.2 cm at Kuparuk to 106.2 cm at Barter Island. The maximum snowfall, 211.7 cm, was recorded at Barter Island. A permanent snow cover normally is established in September. The increase in snow depth (Figure 2.1-3) is fairly rapid from the middle of September through the end of October, when about half of the seasonal maximum snow cover is reached. The snow depth increases slowly from November through March, with the maximum snow cover of about 30 to 40 cm reached in April. Thereafter, melting commences, and the snow depth declines quickly. By mid- to late June the seasonal snowpack has disappeared.

The depth of snow on the ground is influenced primarily by snowfall during the winter. However, due to blowing and drifting, the snow cover can be redistributed. Furthermore, densification of freshly fallen snow occurs. Both processes can result in a decrease in snow depth at a time when the temperature is far below the freezing point and no melt is possible. Figure 2.1-3 does not show such processes, as it is the average of many years of observations.

2.1.1.2 Wind

The winds are fairly strong on the North Slope, with monthly mean values around 10 knots (kt) (1 kt = 0.51 meter per second [m/sec]). There is no strong annual course in wind speed, but there is a slight indication of a maximum in the fall when the adjoining Beaufort Sea is still ice free and the land has already substantially cooled. This strong thermal contrast in the surface temperature of the ocean and land might at times enhance the wind speed. The mean monthly and annual wind-speeds for Barrow, Deadhorse, and Barter Island are presented in Table 2.1-6.

Winds are normally from an easterly direction, with westerly winds occurring more infrequently. The mean annual wind rose for Barrow (Figure 2.1-4) clearly shows the bi-modal wind direction distribution. Calms are very seldom, with annual values of less than (<) 2%.

Five years of wind speed and direction measurements at Endicott are available as part of the MMS Beaufort Sea Meteorological Monitoring and Data Synthesis Project (USDOI, MMS, 2007a). The average hourly mean wind speed measured between January 2001 and September 2006 was 5.3 m/sec, while the maximum hourly mean wind speed was 23.7 m/sec. The maximum instantaneous wind speed at the Endicott site during this period was 30.6 m/sec. Wind directions were bimodal, typically prevailing from an east northeasterly direction (approximately 45% of the time) or from a west northwesterly direction (approximately 25% of the time (USDOI, MMS, 2006c). It should be noted that the wind measurements at Endicott are known to be biased low during winter months due to icing problems (USDOI, MMS, 2006c)

2.1.1.3 Storminess

Storms are of special interest for many reasons, such as coastal erosion, visibility restrictions due to blowing snow, operational restrictions, and possible extremely low wind chill factors. Figure 2.1-5 presents the number of days during which the wind speed at Barrow exceeded 30 kt (15.4 m/sec) for at least 1 hour. On average, there are about 10 cases of such high wind events each year, with dramatic annual variability. There is an indication that the frequency has increased, but the change is not statistically critical. Further, such strong storms are least likely to occur in summer, but most likely to occur in the fall (Table 2.1-7).

2.1.1.4 Cloudiness

The mean cloudiness on the North Slope is high, especially in late summer/early fall, when Arctic stratus clouds are observed for most of the days. At Barrow, the long-term mean cloudiness value for September is 93%. The minimum in cloudiness is observed in winter with values around 50%.

2.1.1.5 Atmospheric Pressure

The atmospheric pressure reduced to sea level is nearly identical for both Barrow and Barter Island. The station pressure approximates the sea level pressure for these stations, as they are both less than 12 m above sea level. The lowest mean pressure (1012.2 millibars [mb]) is observed in late summer, which also is the time with the highest amount of cloud cover and the greatest amount of precipitation. The highest mean atmospheric pressure (1020.7 mb) is observed in March and is accompanied by a low amount of cloudiness and little precipitation.

2.1.1.6 Visibility

Visibility is measured continuously at the Deadhorse airport as part of the Automatic Surface Observing System (ASOS). The most restrictive category (visibility <1 mi) occurs on average about 10% over the year, with a minimum in summer and a maximum in winter. This distribution is likely caused by blowing snow, which can strongly impair visibility when severe. In the absence of snow cover (summer), such events cannot occur. In contrast, conditions of blowing or drifting snow take place nearly 25% of the time during the winter. Further, fog is more likely to occur in the summer, when it is formed over the cold ocean and drifts into the coastal area. In the winter, freezing fog may occur, especially in the presence of a temperature inversion.

2.1.1.7 Climate Change

Temperature Trends

Temperature trends from 1948 to 2004 are plotted in Figure 2.1-6 for the five climatological stations on the North Slope. The record extends to 1948 for only two stations (Barrow and Barter Island). In general, the time series of mean annual temperatures for the different stations are very similar. This finding is expected due to the fairly uniform surface conditions (tundra) found at each station.

While large variations in the annual temperatures occur from year to year, a general warming trend is apparent. The best-fit linear trend for the Barrow data indicates a temperature increase from -13 °C to -11 °C over the 56-year period. This increase of 2 °C over 56 years is substantial when compared to the global average of about 0.6 °C per century (IPCC, 2001), and is an often-observed enhancement of warming in polar regions. Furthermore, the warming trend is in general agreement with Stafford, Wendler, and Curtis (2000) and Shulski, Hartmann, and Wendler (2003), who analyzed the temperature trends of Alaska for slightly earlier time periods. It also is noteworthy that the temperature in Arctic Alaska has continued to rise in the last 25 years, a time during which the mean annual temperature of the rest of Alaska has remained constant or decreased somewhat (Hartmann and Wendler, 2005).

When seasonal temperature trends are considered, substantial warming is evident during winter, while the warming trend is less pronounced in spring and summer. The temperature trend for fall is quite flat, but recent years display above-normal temperatures. This finding is consistent with the observed decrease in sea ice concentrations in coastal regions during this time period (Wendler et al., 2003). Figure 2.1-7 illustrates the decrease in Beaufort Sea ice concentrations between 1970 and 2000.

In Figures 2.1-8 and 2.1-9 the number of days with temperatures below (-18 °C and 34 °C) and above (0 °C and 10 °C) certain thresholds are presented as a time series plot for Barrow from 1949 to 2004. The number of days with a minimum temperature below -18 °C decreased from 170 to 160 days during the 55-year period. More pronounced is the decrease of days with extreme low temperatures (below -34 °C). At the beginning of the time period, there were on average 40 days annually with the minimum temperature below -34 °C. Currently, there are only 22 such days, a reduction close to 50%. This finding is in agreement with the general warming trend that has occurred during the last half century in northern Alaska.

As indicated in Figure 2.1-9, days with a high temperature above 0 °C and 10 °C have increased in frequency of occurrence between 1949 and 2004. Days when the maximum temperature was above freezing (0 °C) increased from 102 to 121 during the 55-year period, while the increase for days with maxima above 10°C increased from 15 to 24 (an increase of about 50%). If this trend continues, vegetation changes may be expected for the North Slope, depending also on the precipitation regime.

Precipitation Trends

A decrease in precipitation of about one-third has been observed in the Arctic for the last half century (Stafford, Wendler, and Curtis, 2000). This decrease was not limited to Alaska, but also was found in most of the Western Arctic (Curtis, Hartmann, and Wendler, 1998). The change is especially pronounced in winter and spring, when the highest temperature increase has been observed. This finding is somewhat surprising, as normally an increase in temperature is associated with an increase in precipitation.

Snowmelt Trends

There has been a trend for earlier snowmelt in the Arctic, as first pointed out by Foster (1989), who analyzed the Barrow data going back to 1940. Dutton and Endres (1991) suggested that the trend was in part due to the rapid development in the village of Barrow, and that the effect was overestimated by Foster. Stone et al. (2002) confirmed Foster's finding when they showed that from 1940 to present the snowmelt occurs some 8 days earlier on average. This result is not unexpected given the climatological observations, which show a decreasing trend in winter snowfall and higher spring temperatures.

2.1.2 Air Quality

Good air quality exists in the Liberty (SDI) Project area, which is located in the Northern Alaska Intrastate Air Quality Region. The Alaska Department of Environmental Conservation (ADEC) has designated the area as in attainment or unclassifiable for all criteria pollutants, including nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}), ozone (O_3), sulfur dioxide (SO_2), and lead. The closest existing nonattainment area to the Liberty (SDI) Project area is the Eagle River area of Anchorage, designated nonattainment for PM_{10} and located approximately 1,000 kilometers (km) south of the project area. A portion of the Fairbanks North Star Borough may be designated as nonattainment for very fine particulate matter ($PM_{2.5}$) sometime in 2007 or 2008. Fairbanks is located approximately 625 km south of the project area.

Measurement of ambient concentrations of NO_2, CO, and SO_2 was begun on the SDI on February 1, 2007. Recent ambient pollutant data are available from monitoring stations located on A Pad and the Central Compression Plant (CCP) pad at the nearby Greater Prudhoe Bay (GPB) facility. The data collected in 2005, which are summarized in Table 2.1-8, confirm that the air quality in the area is good and that measured pollutant concentrations are well below any applicable air quality standard.

ADEC has classified the Liberty (SDI) Project area as a Prevention of Significant Deterioration (PSD) Class II area. The nearest PSD Class I area is Denali National Park including the Denali Wilderness but excluding the Denali National Preserve. Denali National Park is located approximately 725 km south of the project area.

2.2 RESERVOIR GEOLOGY

The Liberty Field is located about 5 mi offshore, southeast of Endicott (Figure 3-1). The Tern #3 and Liberty #1 wells establish the presence of producible hydrocarbons within the Kekiktuk Zone 2 reservoir. Two additional wells exist in the Liberty (SDI) Project area (Tern Island #1A and #2A) and provide additional data on the field. A depth-migrated 3-dimensional (3D) seismic survey covers the accumulation and is used to map the reservoir and define the field limits. The well and seismic data support an estimate of 105 MMbbl of recoverable oil.

2.3 GEOMORPHOLOGY

2.3.1 Marine Geology

The Liberty prospect is located at the northern extremity of the Arctic Coastal Plain province. Part of the North Slope physiographic unit, the Arctic Coastal Plain is characterized by a gently sloping tundra-covered plain extending from the foothills of the Brooks Range to the Beaufort Sea. The area is underlain by continuous permafrost, and consists of alluvial and glacial sediments overlying sedimentary bedrock (TAPS Owners, 2001).

Foggy Island Bay is situated between the Sagavanirktok and Shaviovik rivers, and is sheltered by the McClure Islands. The coast can be defined as a tectonically stable trailing-edge type (Inman, 2003). The shoreline is actively retreating, through both wave-induced and thermal erosion processes.

Surficial seafloor sediments found in Foggy Island Bay typically consist of a 2- to 3-m layer of Holocene deposits composed primarily of fine sands and silts (BPXA, 1998). Borings drilled in support of the Liberty (SDI) Project during 1998 indicate that the Holocene sediments are generally lagoonal and deltaic deposits (Duane Miller and Associates, 1998). Coarser sand and gravel are found at higher-wave-energy environments near the shoreline and the barrier islands. Pleistocene deposits comprised of stiff plastic silt and clay are present under the Holocene layer, but also outcrop on the seafloor in some areas (Duane Miller and Associates, 1998). Permafrost was not encountered in the offshore areas during the 1998 soil-boring program. Frozen soils were prevalent, however, near the shoreline and onshore (Duane Miller and Associates, 1998).

A lag deposit of cobbles and boulders known as the "Boulder Patch" is found in Foggy Island Bay. The course material is derived from the Flaxman formation, and is widely believed to have originated from the bedrock of the Canadian Shield (Duane Miller and Associates, 1998). The Boulder Patch is a unique biological community.

2.3.2 Bathymetry

Water depths inside the barrier island chain typically are <30 ft. In general, the sea bottom is characterized by mild slopes and only minor local relief. Widely scattered strudel scours and ice gouges comprise the primary local relief.

Water depths on the east side of the SDI typically range from 2 to 3 m (Bell and Associates, 2007). Shallower water prevails to the south and west.

2.3.3 Coastal Sediment Processes

The nearshore waters of the Alaskan Beaufort Sea typically remain ice-covered for about 9 months of the year. As a result, the total wave energy impacting the coastline tends to be small compared to that which might occur in a more temperate climate. However, waves generated by northeast and northwest storms can produce erosion of the mainland coast, barrier islands, and coastal facilities.

2.3.3.1 Coastal Sedimentation and Erosion

Sedimentation rates in the Liberty (SDI) Project area range from nondetectable (i.e., no recent sediment in the past 50 years) to 0.05 to 0.1 cm/yr (Trefry et al., 2003), and partially support the work by Reimnitz, Graves, and Barnes (1988) that describes the area as net erosional at present. Deposition of fine-grained sediments closer to the mouth of the Sagavanirktok River is expected, but no direct determinations of sedimentation rates have been made nearshore.

Sediment sources to the region include coastal erosion and fluvial material derived from the Sagavanirktok, Kadleroshilik, and Shaviovik rivers. Arcuate-shaped deltas are present at the ocean outlet of each of these rivers. Waves and currents transport the deltaic sediments along the coast and offshore.

Coastal retreat tends to occur at two different rates (Walker, 1983). Storm-induced erosion typically is rapid, and is most pronounced during westerly storms due to the rise in sea level that accompanies such events. More gradual retreat results from the seasonal cycle of thawing and periods of sustained high air temperatures, which induce thermal erosion of ice-rich sediments. These sediments are then removed by normal summer wave conditions.

At many arctic coastal locations, the coastal bluffs thaw during the summer months, creating mud flows which drain onto the beach below. If the thawing is extensive, as might occur during periods of abnormally high temperatures, large-scale slumping or "thermal erosion" can become the dominant cause of bluff recession (Leidersdorf, Gadd, and Vaudrey, 1996). Thermal erosion is most rapid along bluffs that contain monolithic ice lenses ("massive ice") or a high percentage of ice and fine-grained sediments. Such slumping of the thawed bluff material, particularly when gravel and sand are present, may deliver substantial volumes of beach sediment that temporarily protect the bluff face from wave-induced undercutting.

Prior investigators have reported a wide range of bluff retreat rates along the Alaskan Beaufort Sea coast. These findings indicate that erosion rates can vary substantially from location to location, and from year to year at a given location. Bluff retreat estimates along the Alaskan Beaufort Sea coast are summarized in Table 2.3-1, while bluff retreat rates specific to Foggy Island Bay are presented in Table 2.3-2.

Estimated long-term bluff retreat rates along the Alaskan Beaufort Sea coast (Table 2.3-1) range from a modest 0.3 m/yr to over 9 m/yr. Short-term erosion rates can exceed the long-term rates, particularly during periods of frequent coastal storms or sustained high air temperatures. At the Heald Point location, for example, the short-term bluff retreat rate during the 1980s (2.4 to 3.1 m/yr) was found to be twice that of the long-term rate (Leidersdorf, Gadd, and Vaudrey, 1996). The Heald Point site included a section of bluff that contained a 2-m-thick lens of massive ice, further underscoring the importance of thermal erosion in ice-rich bluffs (Leidersdorf, Gadd, and Vaudrey, 1996). Despite witnessing large-scale bluff erosion at many arctic coastal locations, Leffingwell (1919) also emphasized that certain shore areas have remained stable for centuries.

Estimates of bluff erosion rates were developed for four locations in Foggy Island Bay in support of previously considered development strategies for Liberty (Coastal Frontiers, 1997a, 2006). Three of these sites were located on the mainland shoreline, while one was located at Point Brower in the Sagavanirktok River delta (Figure 2.3-1). Bluff recession rates at the three mainland sites were found to be moderate by arctic standards. The maximum short-term rates ranged from 1.6 to 2.7 m/yr, while the long-term recession rates ranged from 0.6 to 1.1 m/yr. The east side of the Pt. Brower site exhibited considerably higher erosion rates than those observed at the mainland sites. The average long-term erosion rate along the east side of the Pt. Brower Site was 2.0 m/yr, while the maximum short-term bluff recession rate was 9.6 m/yr. In contrast, the west side of the Pt. Brower site was relatively stable with an average long-term bluff recession rate of 0.2 m/yr, and a maximum short-term rate of 2.0 m/yr.

2.3.3.2 Barrier Island Processes

The barrier islands that shelter Foggy Island Bay are highly dynamic sedimentary structures that fluctuate in location and shape in response to the environmental forces of waves, wind, currents, and ice. These islands are bounded by dynamic inlets and are subject to sporadic, rapid, and generally westward sediment transport driven by the persistent easterly winds of the region.

Barrier islands in the Beaufort Sea typically are oriented parallel to the mainland coast and are separated from the mainland by lagoons and bays. By virtue of their location, they receive the full impact of coastal storms while providing partial protection for the mainland coast. Arctic barrier islands typically experience dramatic changes in plan form due to phenomena that include elongation, truncation, coalescence, inlet formation, and inlet closure. Wiseman et al. (1973) hypothesized that thermal erosion may play a particularly important role in the formation of some arctic barrier islands. They theorized that the lagoons backing barrier island chains originated through the erosion and coalescing of thaw lakes. This implies that the islands are actually residuals of the original shoreline. The fact that several offshore islands (such as Tigvariak Island, located immediately east of the Liberty site, and Flaxman Island, located farther to the east) have a tundra veneer lends some credence to this hypothesis.

Arctic barrier islands are commonly low in profile, slender in width and arcuate in shape. These characteristics, coupled with the storm surge induced by westerly winds, make them susceptible to wave overwash as well as high alongshore sediment transport rates. Their migratory nature has been well-documented in the past (Wiseman et al., 1973; Cannon and Rawlinson, 1978; Gadd et al., 1982; Miller and Gadd, 1983). Migration rates on the order of several meters per year are common, with the movement typically directed to the west in response to the prevailing easterly storms of the open-water season. However, island movement to the east also has been observed.

2.4 OCEANOGRAPHY

The Liberty prospect is located in Foggy Island Bay, which is part of Stefansson Sound. The Liberty facilities are located on the SDI along the Endicott Causeway (Figure 1-1). Foggy Island Bay is situated between the Sagavanirktok and Shaviovik rivers, and is sheltered by the McClure Islands. Three rivers discharge into Foggy Island Bay: the East Channel of the Sagavanirktok River, the Kadleroshilik River, and the Shaviovik River. The main channel of the Sagavanirktok River discharges directly east of the Endicott Causeway, and the western channel discharges directly west of the causeway into Stefansson Sound.

2.4.1 Seasonal Generalities

The Alaskan Beaufort Sea typically is ice-covered for about 9 months of the year. Breakup in Stefansson Sound and Foggy Island Bay occurs from mid-May to mid-June and is initiated by river breakup and the overflow of freshwater onto the landfast ice. Open-water typically occurs by mid- to late July. The initiation of freezeup in the Liberty (SDI) Project area ranges from late September to late October. All of Foggy Island Bay and most of Stefansson Sound become entirely ice-covered within 1 week after freezeup begins. The transition from freezeup to winter ice conditions in Foggy Island Bay and nearshore Stefansson Sound usually occurs in early to mid-November when the ice thickness is at least 30.5 cm.

2.4.2 Circulation

Circulation in Foggy Island Bay and Stefansson Sound is influenced by atmospheric pressure systems, tidal motion, river discharge, sea ice characteristics, and bathymetry. Wind-driven circulation predominates during the open-water season. Major contributors to under-ice circulation during winter months include wind-induced coastal setup, tides, and sea-ice brine rejection.

Winds are predominately from a northeasterly direction, southwesterly winds occurring more infrequently (Moorhead et al., 1992a; Hoefler Consulting Group, 2005). During the open-water season, easterly winds generate currents to the west, while westerly winds move water to the east. Surface currents are greater than bottom currents (Aagaard, 1984). The mean current direction is to the west, owing to the prevalence of easterly winds.

Cross-shore circulation also occurs during both easterly and westerly wind events. This phenomenon is known as Ekman transport. Coriolis forces deflect surface waters offshore during easterly wind events. Modest upwelling occurs as bottom water moves onshore in response to offshore movement of surface water. Conversely, westerly winds promote onshore movement of surface waters accompanied by a modest offshore movement of bottom water known as downwelling. In both cases, the transport of bottom water (upwelling or downwelling) only partially compensates for the surface water transport. The net result is decreased water levels during easterly wind events and increased water levels during westerly wind events.

Circulation under ice is generally westerly in direction, but is muted compared to open-water conditions (BPXA, 1998). Despite ice cover during the winter, meteorological-driven circulation can occur through wind-stress and coastal setup and setdown (EBASCO, 1990). Weingartner and Okkonen (2001) speculate that wind-forced currents dominate during the winter. Tidal motions also contribute to under-ice circulation (BPXA, 1998). In addition, density-driven currents resulting from brine rejection in sea ice occur during the winter (EBASCO, 1990).

During the spring freshet, the large and sudden discharge of fresh water from rivers can induce under-ice circulation. Weingartner, Okkonen, and Danielson (2005) estimates that the freshwater plume associated with spring river discharge can extend up to 20 km offshore. During May and June 2004, Alkire and Trefry (2006) measured an under-ice plume from the Sagavanirktok River that extended approximately 17 km to the north and 15 km to the west. Following river breakup, North Slope river flow rates are typically low and exert less influence on nearshore circulation during the open-water season.

2.4.3 Currents

As indicated above, wind-driven circulation predominates during the open-water season, with easterly winds generating currents to the west and westerly winds moving water to the east. Winds are predominately from an easterly direction; hence the mean current direction is to the west.

Weingartner, Okkonen, and Danielson (2005) obtained year-round current measurements at four locations in the nearshore Alaskan Beaufort Sea for a period of 3 years between 1999 and 2002. Two stations (McClure and Dinkum) were located near Liberty. The maximum current velocity measured at the McClure and Dinkum stations during the open-water season was 68 and 110 cm/sec, respectively, and more than 50% of the current measurements exceeded 15 cm/sec. Current directions were found to be appreciably correlated with winds. Current velocities for the open-water season presented in the Liberty DPP FEIS (USDOI, MMS, 2002) are in general agreement with the findings of Weingartner, Okkonen, and Danielson (2005).

Open-water current measurements were obtained as part of the Endicott Environmental Monitoring Program on several occasions during the 1980s (LGL Ecological Research Associates Inc. and Northern Technical Services, 1983; Hachmeister et al., 1987; Short et al., 1990; Short et al., 1991; Morehead et al., 1992a; Morehead et al., 1992b; Morehead, Dewey, and Horgan, 1993). During the summer of 1982 (prior to construction of the Endicott facilities), the mean current speeds at four sites in the Sagavanirktok River delta ranged from 12 to 15 cm/sec, with a maximum recorded current speed of 51 cm/sec. Following construction of the causeway, current speeds at sites near the SDI typically ranged from 5 to 15 cm/sec. The maximum recorded current velocities ranged from approximately 25 to 60 cm/sec. These findings are in general agreement with the more recent observations of Weingartner, Okkonen, and Danielson (2005).

Increased current velocities have been documented in the vicinity of the Endicott Causeway breaches (Rummel, Schrader, and Winnick, 1987; Johannessen and Hachmeister, 1987 and 1988; Morehead et al., 1992b; Morehead, Dewey, and Horgan, 1993). Current directions were found to be bi-modal, responding to changes in wind direction and largely perpendicular to the breach orientation. Mean daily current velocities were highly variable. During the summer of 1987, for example, mean daily current speeds for the near-surface waters at the breaches were found to range between 7 and 108 cm/sec. The maximum current speeds at the outer breach ranged from approximately 110 to 250 cm/sec. At the inner breach, the maximum current speeds were found to be slightly lower, ranging from approximately 90 to 150 cm/sec.

Current velocities during the winter are more muted when compared to those observed during the open-water season. Under-ice currents are affected by tides and atmospheric pressure variation rather than by meteorological process (BPXA, 1998). The current direction is westerly/northwesterly 60 to 70% of the time on average (Ban et al., 1999). Under-ice current velocities were collected by Aagaard (1984) at two nearshore Beaufort Sea sites in March and April, 1976. Currents generally were found to be <5 cm/sec. More recently, Weingartner, Okkonen, and Danielson (2005) documented a maximum under-ice current velocity in Foggy Island Bay and Stefansson Sound (McClure and Dinkum stations) of 14 and 20 cm/sec, respectively. Approximately 90% of the current measurements were <10 cm/sec. In contrast to the open-water season, under-ice currents were not well correlated with winds. These findings are in general agreement with the current velocities presented for winter conditions in Liberty DPP FEIS (USDOI, MMS, 2002).

Under-ice currents were measured in Foggy Island Bay and Stefansson Sound by Weingartner, Okkonen, and Danielson (2005) at the time of the spring freshet. Cross-shore current velocities of approximately 10 cm/sec were observed with strong correlation to discharge rates and the associated under-ice plume of the Sagavanirktok River eastern channel. These velocities were much greater than cross-shore directed flow rates observed under the ice during the winter months. During the 2004 spring freshet, Alkire and Trefry (2006) documented an average under-ice current of 7.2 cm/sec, with a mean northwesterly direction. Currents in excess of 10 cm/sec were typically found at plume fronts.

2.4.4 Water Levels

Tides in the Beaufort Sea are semidiurnal in nature, meaning that two high tides and two low tides occur each day. The National Ocean Service (NOS) reports a mean tide range of 16 cm and a diurnal range of 21 cm for the tide station located in Prudhoe Bay (NOS, 2006). The tidal characteristics for this station, which are directly applicable to the conditions at Foggy Island Bay and Stefansson Sound, are shown in Table 2.4-1. Mean lower low water (MLLW) lies 10.3 cm below mean sea level (MSL), while mean higher high water (MHHW) lies 10.6 cm above MSL.

Given the relatively small tide range, water-level fluctuations in the vicinity of the Liberty (SDI) Project area are governed more by meteorological effects than by astronomical tides. As discussed in Section 2.4.2, Coriolis forces deflect surface waters offshore during easterly wind events and onshore during westerly wind events. As a result, westerly wind events produce positive storm surges, while easterly wind events produce negative surges. Since the Prudhoe Bay tide station was established in 1990, the lowest observed water level was 102 cm below MSL on October 9, 2006 (NOS, 2006). The greatest water level measured during the 16-year period of record was 116 cm above MSL on August 11, 2000 (NOS, 2006).

A site-specific hindcast of oceanographic conditions was conducted for the Liberty (SDI) Project in 1997 (OCTI, 1997) using input data from a more generalized deep-water hindcast study of conditions in the Beaufort Sea performed in 1982 (Oceanweather, Inc., 1982). Extreme water levels for westerly storms were predicted for three locations: the original Liberty Island site and two candidate pipeline shore crossings ("East" and "West"). The predicted water levels included three components: storm surge, astronomical tides, and inverted barometer effect. The resulting predictions for each site are given in Table 2.4-2. The 100-year-return-period water level at the original island site is predicted to be 1.89 m above MSL, while for the two shore crossing sites, it is predicted to range between 1.89 and 2.04 m.

More recently, a joint industry project was begun to update the original deepwater hindcast study (Oceanweather, Inc., 1982) referenced above. The updated hindcast, known as "Beaufort Sea Ocean Response Extremes," or "BORE," incorporates more than two decades of additional storm events and the possible effects of climate change (Oceanweather, Inc., 2005). A site-specific hindcast of oceanographic conditions in the vicinity of Endicott was conducted using the BORE results (Resio and Coastal Frontiers, 2007). The resulting predictions are given in Table 2.4-2. The 100-year-return-period water level in the vicinity of the SDI is predicted to be 1.66 m above MSL.

2.4.5 Waves

The open-water season in Foggy Island Bay and Stefansson Sound is brief, with sea ice covering the region for about 9 months of the year. During the open-water season, wave heights are limited by the shallow waters adjacent to the coast and the shelter provided by barrier islands. Moreover, the proximity of the arctic pack ice limits the fetch available for wave generation.

Beaufort Sea storms, and hence wave directions, can be classified as either easterly or westerly. Easterly storms typically are of longer duration than westerly storms (Oceanweather, Inc., 1982). As indicated in Section 2.4.4, westerly storms often are accompanied by elevated water levels, while easterly storm may produce lower than normal water levels. Westerly storms tend to be more severe, in part due to the associated storm surge.

Wave measurements were obtained in Stefansson Sound during the summers of 1980, 1981, 1982, and 1983 in support of the Endicott Development (LGL Ecological Research Associates Inc. and Northern Technical Services, 1983; OSI, 1984). In 1980 and 1981, wave heights were less than 0.6 m approximately 90% of the time, with an average wave period <4 sec. The maximum wave height measured was 1.7 m. Small, short-period waves also persisted through most of the summer of 1982, with an average wave height of <0.2 m and an average wave period of <4 sec. Wave heights exceeded 1.0 m on only three occasions, with each event associated with an easterly storm. The largest wave height measured was 1.3 m with an associated period of 3.5 sec. During the summer of 1983, the sea surface was calm (wave heights were <0.1 m) approximately 50% of the time. The greatest wave height measured was 0.6 m on October 6.

Given the scarcity of wave measurements in the Beaufort Sea, extreme wave information must be generated using oceanographic hindcast models. A site-specific hindcast of oceanographic conditions was conducted for the Liberty (SDI) Project in 1997 (OCTI, 1997) using input data from a more generalized deepwater hindcast study of conditions in the Beaufort Sea performed in 1982 (Oceanweather, Inc., 1982). Extreme wave conditions for easterly and westerly storms were predicted for three locations: the original Liberty Island site and two candidate pipeline shore crossings ("East" and "West"). The resulting predictions for westerly and easterly storms are given in Tables 2.4-3 and 2.4-4.

In all cases, the wave heights associated with westerly storms were found to be larger than those with easterly storms. The 100-year westerly wave height at the original island site (located in a water depth of 6.4 m, MSL) was predicted to be 3.7 m with a period of 11.4 sec. At the East Shore Crossing site in a water depth of 0.6 m, the 100-year westerly wave height was predicted to be 1.0 m with a period of 11.4 sec. Slightly smaller wave heights were predicted for the West Shore Crossing site in a water depth of 0.6 m, with a 100-year westerly wave height of 0.9 m and associated period of 11.4 sec.

As indicated in Section 2.4.4, the BORE project was initiated in 2004 as an update to the original deep-water hindcast study (Oceanweather, Inc., 2005). A site-specific hindcast of oceanographic conditions in the vicinity of the SDI was conducted using the BORE results (Resio and Coastal Frontiers, 2007). Predictions of extreme wave conditions for easterly and westerly storms were derived for nine locations around the perimeter of the proposed SDI pad expansion (Figure 2.4-1). The predictions for easterly and westerly storms are given in Tables 2.4-5 and 2.4-6.

The predicted wave heights along the perimeter of the proposed pad expansion vary considerably due to sheltering from the Endicott Causeway and SDI, and the variation in water depths. On the northern side of the pad (Sites 7, 8, and 9), wave heights associated with westerly storms were found to be larger than those with easterly storms. The predicted 100-year westerly wave heights at this location ranged from 2.2 to 2.3 m, with wave periods of 11.8 to 11.9 sec. The east and south sides of the pad expansion (Sites 1 through 6) are sheltered from westerly waves. The predicted 100-year easterly wave heights at these sites ranged from 0.4 to 1.6 m, with wave periods of 11.5 to 11.9 sec.

2.4.6 River Discharge

The Sagavanirktok River, the Kadleroshilik River, and the Shaviovik River discharge into Stefansson Sound. The Sagavanirktok and Shaviovik rivers drain from the foothills of the Brooks Range, with drainage areas of approximately 11,000 and 4,400 km^2, respectively (USDOI, MMS, 2002). The Kadleroshilik River is confined to the coastal plain, draining an area of approximately 1,700 km^2 (USDOI, MMS, 2002).

The average annual flow rate is approximately 78 m^3/sec in the Sagavanirktok River, 23 m^3/sec in the Shaviovik River, and 9 m^3/sec in the Shaviovik River (BPXA, 1998). River flow during the winter months is minimal to nil (TAPS, 2001). The peak flow rates typically occur at the time of spring breakup or during the summer months in response to thunderstorms in the Brooks Range. The maximum mean monthly discharge for the Sagavanirktok River (164 m^3/sec) occurs in June (Figure 2.4-2). The average daily discharge measured in the Sagavanirktok River from 1983 to 2006 is shown in Figure 2.4-3. The maximum flow rate during the period of record, 935 m^3/sec, occurred in August 2002.

Rivers are the primary source of fresh water entering nearshore Stefansson Sound. River water temperatures in the summer (10 to 17 °C) are higher than the nearshore water temperature, and typically remain warmer until September (USDOI, MMS, 2002). At certain times of the year, river discharge can affect nearshore circulation.

In the spring, before the sea ice starts to deteriorate, melting snow swells the upland river channels. The bottomfast ice offshore of the river deltas forms a dam, which causes the flood waters to pour out over the top of the sea ice during late May or early June. As breakup progresses, river water also flows below the sea ice. The average date that the Sagavanirktok River begins to overflood the sea ice in Stefansson Sound and western Foggy Island Bay is May 20, with a standard deviation of 9.6 days, based on a 26-year period from 1973 through 1999, excluding 1991 (Coastal Frontiers, 1999b). During this period the Kadleroshilik and Shaviovik also flood the sea ice along the southern and southeastern shoreline of Foggy Island Bay. As breakup progresses, river water also flows below the sea ice.

The overflood water, which can exceed a depth of 1 m, can spread as far as 6 km offshore into Foggy Island Bay. Historical river overflood limits in Foggy Island Bay and nearshore Stefansson Sound, shown in Figure 2.4-4, display inter-annual variability (D.F. Dickins and Associates, 1999; Coastal Frontiers, 2000, 2003a). In the floating landfast ice zone (typically in water depths greater than 2 m), the overflood waters drain through holes and discontinuities in the ice sheet caused by tidal cracks, thermal cracks, stress cracks, and seal breathing holes. Drainage in the bottomfast ice zone (typically in water depths <2 m) is limited until the ice sheet loosens and rises to the surface.

If the overflow rate is high, powerful strudel jets can develop at the drain sites and create large scour depressions in the seafloor. Drainage, and hence seafloor scouring, tends to be more severe in the floating landfast ice zone and less pronounced in the bottomfast ice zone. In both cases, however, strudel drainage can provide a pathway to transport an oil spill below the ice sheet.

The locations of individual drainage features in Foggy Island Bay were mapped on five occasions between 1997 and 2003 (Coastal Frontiers, 1998, 1999a, 2000, and 2003a). An attempt was made to record all drainage features off the East Channel of the Sagavanirktok River during each of the 5 years. The average number of drains found off the Sagavanirktok River was 51. The greatest number of drains observed was 141 (mapped in 1997), while the fewest number was 10 (mapped in 1998). Comprehensive mapping of drainage features attributable to the Kadleroshilik River overflood was performed only in 1997 and 1998. Nine features were found in 1997, while 64 drains were mapped in 1998. In 1997, 30 drains were mapped off the western portion of the Shaviovik River overflood.

River water also flows under the sea ice. Sea Ice is discussed above in Section 2.4.3.

2.4.6.1 Ice Seasons

Sea ice covers the Foggy Island Bay and nearshore Stefansson Sound for a little more than 9 months of each year. The average length of the ice season is 288 ± 10 days, with a median freeze-up date of October 4 and a median breakup date of July 4. First open-water usually occurs in the 6-m water depth range by July 19. The average length of the gross open-water season is 77 days. The dates are based on a combination of on-site observations from 1980 through 1996 (Vaudrey, 1981a-1986a; Vaudrey, 1988a-1992; Coastal Frontiers, 1997b; satellite imagery from 1972 through 1996 (National Ice Center, 1997); and ice charts acquired from 1953 through 1975 (Cox, 1976).

Freezeup

Freezeup is defined as the first time in the fall when nilas or young ice (10 to 15 cm thick) covers 100% of the sea surface at a specific site or over a particular region. The initiation of freeze-up ranges from the third week in September to the last week in October with a median date of October 4. An undisturbed ice sheet can typically grow to 30 cm thick within the first 3 to 4 weeks after freezeup occurs.

All of Foggy Island Bay and most of Stefansson Sound become entirely ice-covered within 1 week after freezeup begins. However, the young first-year ice (10 to 30 cm thick) remains susceptible to movement and deformation by storm winds in October. These events are not unusual in the middle of Foggy Island Bay. A total of five ice pileup events created by freezeup ice movements affected Tern Island during the month of October from 1982 through 1984.

First-year ridging (60 to 90 cm high) and rafting may occur during these early freezeup ice movement events. However, 80% of the time (i.e., 8 out of 10 years) the first-year sheet ice in Foggy Island Bay remains relatively flat (surface ice features <60 cm high) throughout the year. Flat ice is not always an indicator that no ice movement has occurred. For example, young ice can be completely removed from an area during a storm. When new ice is formed, it may remain intact and quite smooth, giving no indication that appreciable ice movement had occurred earlier.

Once the sheet ice thickness reaches 30 cm, the ice cover becomes relatively stable, confined by the shoreline of Foggy Island Bay to the south, the McClure Island chain to the north, Tigvariak Island to the east, and the Endicott Development to the west. During seven freezeup studies conducted from 1979 through 1985 (OSI, 1979; Vaudrey, 1981a-1986a), no freezeup ice movement in Foggy Island Bay was observed or measured after November 1. The sheet ice can be considered part of the landfast ice zone after mid-November.

Winter

The sea ice regime of the Alaskan Beaufort Sea is usually depicted by a schematic cross-section, which divides the ice into three distinct zones (fast ice, shear or stamukhi zone, and pack ice). While simplistic, this schematic may have some validity in describing the ice that lies to the north of the barrier islands, but it is totally irrelevant to Stefansson Sound and Foggy Island Bay, which are located south of the barrier islands.

The first-year sheet ice constitutes the only appreciable ice feature in Stefansson Sound during the winter. It attains an average maximum ice thickness of 1.8 to 2.1 m by the end of May, growing roughly 30 cm per month from October through March. As the landfast ice sheet continues to grow throughout the winter, the ice becomes bottomfast when it contacts the seafloor in areas where the water depth is less than about 2 m. The sediments beneath the bottomfast ice become ice-bonded as the freezing front penetrates the seafloor.

During the winter, rapid changes in temperature may produce thermally-induced shrinkage cracks in the floating landfast ice, usually propagating from sources of stress concentration, such as manmade gravel islands (including the SDI), or promontories along the coast (e.g., Point Brower). In addition, a working tidal crack can be expected at the perimeter of the floating fast ice along the shoreline and around any grounded ice feature. Other than these minor cracking events, the first-year sheet ice in Stefansson Sound and Foggy Island Bay remains virtually motionless throughout the winter — with measured monthly ice movement rates ranging from 0 and 200 cm/month based on data compiled by OSI (1976; 1978a,b; 1980) and Vaudrey (1996).

Breakup

The transition from winter to breakup season begins in late April or early May, when the daylight hours are lengthening and air temperatures are on the increase. By early to mid-May, the ice sheet has lost sufficient bearing capacity that ice roads can no longer support over-ice operations.

Before the sea ice starts to show apparent signs of deterioration, melting snow in early May helps swell the upland river channels. The bottomfast ice in the shallow water offshore of the river deltas forms a dam, which causes the flood waters of the Sagavanirktok, Kadleroshilik, and Shaviovik rivers to pour out over the top of the sea ice during late May or early June. Typically by mid- to late June, about 2 to 3 weeks after the flooding has ceased, most of the landfast ice within the overflood zone will have melted in place from a combination of the fresh, relatively warm, water and the increased heat absorption by the dirty ice.

Warm air temperatures initiate meltpool formation on the top of the landfast ice sheet, especially where the surface is contaminated with dirt. In late May or early June, meltpools usually cover less than 10% of the landfast ice area beyond the overflood limits. Just before breakup in late June, the number of meltpools increases dramatically, covering approximately 40 to 50% of the sheet-ice surface.

Breakup is defined as the time when the ice concentration goes from 10 tenths to 9 tenths or less. The breakup mechanism for sheet ice is related to lines of weakness that develop along a series of meltpools or old thermal or stress cracks in concert with in-situ sheet-ice deterioration. Melting of the landfast ice reduces confinement, and wind stress may cause breakup along a line of meltpools or along existing cracks. During late June or early July, any 20-kt wind that begins to blow probably will initiate breakup of the floating landfast ice in Foggy Island Bay. The median breakup date is July 4.

Summer

The area in and around Stefansson Sound usually becomes open water by the third week in July, about 2 to 3 weeks after the initial breakup. Open water is defined as 1 tenth or less ice concentration. There is almost a 50% chance of an ice invasion which is greater than 1 tenth ice concentration, shortly after the appearance of the first open-water. Each invasion usually has a duration of about 1 week. Fewer than 10% of these invasions will contain small multiyear ice fragments.

Vaudrey (1997) computed summer season ice statistics for three ice concentration levels from a 44-year data base (1953-96). In severe summers, there is an 18% chance of having 2 to 3 ice invasions of greater than 1 tenth ice concentration. Higher ice concentrations of 3 tenths and 5 tenths are possible, but not likely. There is a 23% chance of having one invasion of 3 tenths ice concentration and a 9% chance of having one invasion of 5 tenths ice concentration. However, the chances of having more than one invasion of 3 tenths or 5 tenths ice concentration is virtually zero in Foggy Island Bay. There are typically 77 days between first open-water and freezeup, but the total number of days of open water is dependent on the number and duration of summer ice invasions.

2.4.6.2 Ice Features

First-Year Ice Sheet

The predominant ice feature in Stefansson Sound and Foggy Island Bay is first-year sheet ice that remains landfast throughout the winter, typically from early November through June. During the winter, the landfast sheet ice grows relatively undisturbed. Sheet-ice thickness is predicted empirically as a function of air temperature using the method of Bilello (1960). Table 2.4-7 presents the average predicted monthly landfast ice-sheet thickness, along with the 10-year minimum and 100-year maximum ice thickness (Vaudrey, 1997).

The sheet-ice growth rate is generally about 30 cm per month between November and April, and the landfast sheet ice attains an average thickness of 1.8 m by April 1. Growth after April 1 slows due to warming air temperatures, but the landfast ice may add another 15 cm of thickness by the end of May. The 100-year maximum undeformed first-year ice thickness is 2.29 m. Auger-hole ice-thickness measurements made in Stefansson Sound during freezeup in 1980 through 1982, midwinter in 1978 and 1984, and early June in 1984 through 1986 differed from the predicted ice thicknesses by only 3 to 5 cm (Vaudrey, 1988a).

Ice Rideup and Pileup

Ice rideup occurs when the ice sheet is driven by a storm wind relatively intact up a beach, coastal pad or manmade island. If the advance of the ice is halted by the slope or by a vertical obstruction, such as a sheet pile wall or tundra bluff, the sheet ice breaks up into individual blocks which form an ice pileup at or near the waterline. Several factors influence the susceptibility of a given location to ice rideup, pileup, and possible encroachment or override. Motion of the sheet ice is initiated by wind stress acting on the ice surface, but the single most important factor in initiating a ride-up or pile-up event is the loss of confinement of the sheet ice. Reversal of the wind direction is the usual cause of confinement loss, due to the presence of cracks or small leads in the nearshore ice.

The most common event is a combination of ice rideup and ice pileup, which occurs when the ice sheet rides up the slope some distance until increasing frictional resistance causes the ice to rubble and form a pileup. If the ice pileup grows to a sufficient height that its peak is above the work surface elevation of a coastal pad or manmade island, ice blocks at the top of the pile can tumble down onto the work surface. Such an event occurred at BPXA's Endeavor Island (3.5-m water depth), which is located adjacent to the Endicott MPI, in October 1982 (Vaudrey, 1983b) when a 30- to 40-kt southwesterly storm (with an estimated return period of 20 years) created an ice pile-up high enough (7.5 m) to permit 20-cm-thick ice blocks to encroach 3 to 5 m onto the work surface of the island.

The coastline, barrier islands, and manmade islands in the Alaskan Beaufort Sea are subject to ice movement against them during both freezeup (early October through late November) and breakup (late June through early July). However, the risk of ice rideup and encroachment at the proposed SDI pad expansion during breakup is considered to be inconsequential due to: (1) rotting ice from the river overflood and (2) higher frictional resistance of the slope protection at the shoreline of the SDI (which cause the sheet ice floes to break up into small blocks and start to form a rubble pile).

The data base for determining the susceptibility of the proposed Liberty pad expansion at the SDI to ice rideup and pileup consists of a combination of 8 years (1978 through 1985) of personal observations by Kovacs (1983 and 1984) and Vaudrey (1981; 1982a,b; 1983a,b; 1984a,b; 1985a,b; and 1986a,b); 4 years (1949, 1955, 1976, and 1977) of aerial photography analysis by Harper and Owens (1981); and a literature review of historical accounts by Kovacs and Sodhi (1980 and 1988).

Frequent ice ride-up and ice pile-up events have occurred at manmade gravel islands located near the SDI. Tern Island, which is located 15 km east of the SDI, experienced ice ride-up or ice pile-up events during each of four successive freezeup seasons (1982 through 1985) and during three of four breakup seasons (1982 through 1984) after construction. One such event is shown in Figure 2.4-5. A similar experience of frequency and intensity of ice rideup and pileup was observed at the Duck III manmade gravel island (located about 3 km east of the SDI) during the freeze-up and breakup seasons of 1982 through 1985. As an example, on October 15-17, 1984, a 15- to 20-kt westerly storm drove 15-cm-thick ice past Duck, creating a 5- to 6-m-high pileup on the western side of the island (Figure 2.4-6).

A recently completed study for the proposed Liberty pad expansion at the SDI estimated a 100-year ice-pile-up height of approximately 13 m (Vaudrey, 2007). For the six slope protection alternatives considered, the predicted ice encroachment distances ranged from 4.3 to 13.7 m.

Rafted Ice, Ridges and Rubble Piles

Because the sheet ice becomes relatively stable within 4 weeks after freezeup in early October, deformed first-year ice features, such as rafted ice, ridges, and rubble piles, are present in limited extent in Stefansson Sound and Foggy Island Bay.

Rafted ice is an ice sheet consisting of two or more sheet thicknesses caused by overriding. Very thin ice may grow, under light pressure, in a pattern of finger rafting to produce ice floes composed of as many as 10 layers, each 5 to 10 cm thick. Rafted ice rarely occurs in Foggy Island Bay and nearshore Stefansson Sound after the ice thickness reaches 30 cm.

Small (60- to 90-cm-high) first-year ridges may develop infrequently across Foggy Island Bay during early freezeup ice movement. A ridge, which is a linear ice feature, forms as a result of buckling when two ice floes collide. Very little, if any, ridge building occurs after the ice becomes landfast sometime in November.

Rubble piles, which are grounded ice features of areal, rather than linear, extent, are composed of ice broken into blocks of different shapes. Rubble piles rarely occur in the protected bays and lagoons inside the barrier island chain, unless they form as part of an ice pileup event against the shoreline, a barrier island, or a manmade gravel island. As with rafting and ridging, rubble piles typically occur only during a 4-week period after freezeup, when the ice sheet is thin and susceptible to movement, and during breakup in late June or early July. Three rubble piles were observed inside the barrier island chain between 1978 and 1985. The features had similar dimensions: 300 to 450 m long, 50 to 100 m wide, with an above-water height of 7 to 10 m (Vaudrey, 1980; Vaudrey, 1983a; Vaudrey, 1984a).

Multiyear Ice

Multiyear ice is sea ice that has survived at least one melt season. Multiyear ice invasions of the nearshore Beaufort Sea occurred on several occasions in the early 1980s prior to and during freeze-up, but no multiyear ice has ever been observed floating around in Foggy Island Bay. A handful of multiyear ice fragments 15 to 30 m in diameter have been observed in the lagoons during 2 of the 7 years (1979-1985) in which freeze-up studies were conducted. These fragments were grounded on shoals at entrances between barrier islands, such as the Newport Entrance north of Tigvariak Island. In consequence, multiyear ice fragments do not represent a hazard to the proposed Liberty pad expansion at the SDI.

2.4.6.3 Ice Movement

All ice motion is dominated by winds. During breakup and early freezeup, when the ice is more confined, the ice movement rate is about 2 to 3% of the wind speed. When ice floes move in relatively open water, the ice movement rates are roughly 4 to 5% of the sustained wind speed. Ice movement in Stefansson Sound is generally in a west-northwest or east-southeast direction, following the “bow-tie” pattern of prevailing easterly or westerly storm winds (Climatic Atlas, 1988).

Movement rates of freeze-up, breakup, and summer ice have been computed from ARGOS satellite-positioning buoys (Colony, 1979; Cornett and Kowalchuk, 1985; St. Martin, 1987; Thorndike and Cheung, 1977a and 1977b; Vaudrey, 1987; Vaudrey, 1989a) and from ice floe monitoring (Tekmarine, Polar Alpine Inc., and OCTI, 1985). Table 2.4-8 presents cumulative frequency distributions of ice drift speed during freeze-up and breakup based on daily ice-movement rates computed from ARGOS-buoy records collected in the eastern Beaufort Sea between 1979 and 1987 and from three site-specific ARGOS GPS stations deployed between Northstar and West Dock during the 1996 breakup season (Vaudrey and Dickins, 1996). The speeds depicted in Table 2.4-8 are daily averages for long-term ice movements, but short-term ice drift speeds, averaged over a period of 2 to 6 hours, can be dramatically higher. Extreme values for ice movement rates are in the range of 2.5 to 3.0 kt.

Movement of the landfast ice sheet occurs during the winter. Oceanographic Services, Inc. (OSI, 1976; 1978a,b; 1980) performed 4 consecutive years (1975-76 through 1978-79) of ice movement measurements using wireline stations. Four of these stations were located in Stefansson Sound. The ice-movement rates for the 20-year and 100-year return periods are 3.5 m/hr and 5.8 m/hr, respectively, based on a statistical analysis (Miller, 1996; Vaudrey, 1997) of the maximum hourly ice-movement rates recorded during each measurement year. The net ice movement by month for January through April for 3 years of ice measurements by Oceanographic Services, Inc. is summarized in Table 2.4-9. Although the 100-year ice movement rate is predicted to be 5.8 m/hr, more than 99% of the time the ice movement rate was less than 30 cm/hr.

Vaudrey (1996) reported similar ice movements measured in the winter of 1995-96 at a single wireline station located in 6.4 m of water in Stefansson Sound, 6 km south of Reindeer Island and 24 km west-northwest of the SDI. The maximum ice movement rate was 95 cm/hr based on 10-minute data and 21 cm/hr based on hourly data. The net movement was 134 cm for January, 73 cm for February, and 9 cm for March and April, resulting in an average ice movement rate of 56 cm/month over the 4-month period.

2.4.6.4 Sea Ice Changes

Satellite imagery obtained between 1979 and 2006 suggests that the areal extent of sea ice during summer and winter months has declined throughout most of the Arctic Ocean. The analysis of long-term data sets indicates substantial reductions in both the extent (area of ocean covered by ice) and thickness of the arctic sea-ice cover during the past 20 to 40 years, with record minimum summer extent in 2002 and again in 2005, and extreme minima in summer 2003, 2004 and 2006 (Stroeve et al., 2005; NASA, 2005; Comiso, 2006a, Stroeve, 2007).

In September 2002, summer sea ice in the Arctic reached a record minimum during summer, 4% lower than any previous September since 1978 and 14% lower than the 1978-2000 mean (Serreze et al., 2003). Three years of low ice extent followed 2002 Taking these 3 years into account, the September ice-extent trend for 1979 to 2004 declined by -7.7% per decade (Stroeve et al., 2005); from 1979 to 2005 declined by -9.8% per decade (Comiso, 2006a); and from 1979 to 2006 delined by -9.81% per decade (Stroeve et al., 2007).

The analysis of 2005 and 2006 arctic winter sea ice shows record low ice extent and area (Comiso, 2006b). The reported values are approximately 6% lower than average for each year (Comiso, 2006b). Stroeve et al. (2007) report a -1.8 and a -2.9% per decade trend for the periods 1953-2006 and 1979-2006, respectively. In contrast, evidence for reduced sea ice thickness during this period developed from upward-looking sonar is inconclusive (Serreze, Holland, and Stroeve, 2007).

Wendler et al. (2003) observed a decrease in sea ice concentrations in coastal regions of the North Slope between 1972 and 1994 (Figure 2.1-7). This finding correlates with an air temperature increase of approximately 1.1 °C during the same period. Sea ice concentrations were found to decline in all months except January. The decline was most pronounced in July and August, with changes on the order of 20% over the 23-year period. Declines during winter months were more modest, at about 3% over the period of record.

Using satellite imagery, Mahoney et al. (2006) identified the possibility of a reduced duration of landfast ice presence along the Arctic Coast of Alaska during the last three decades. Earlier onsets of thawing temperatures in the spring and later incursions of pack ice in the fall are contributors to this trend. Breakup along the Beaufort Sea coast in recent years (1996-2004) was estimated to begin 21 days earlier than in the 1970s, while the formation date of landfast ice during the same period was found to have changed little since the 1970's (Mahoney, Eicken, and Shapiro, 2007). Ice-free conditions were found to occur approximately one month earlier along the Beaufort Sea coast (Eicken et al., 2006). Similarly, Dickins and Oasis (2006) identified a trend of longer open-water seasons during the past decade when compared to the duration of ice-free conditions documented between 1950 and 1984.

The implications of the reduced extent of sea ice for regional oceanography include a longer open-water season and greater areas of open-water available for wave generation. Extended open-water seasons will result in more total wave energy reaching the coast, which in turn could increase shoreline erosion rates. Notwithstanding the trend towards diminished ice cover in the Beaufort Sea, there is no clear evidence that the severity of the wave climate has increased. Oceanweather, Inc. (2005) speculates that the wave-generating potential of the predominantly easterly and westerly storms is not critically affected by the northerly migration of the ice edge.

2.5 MARINE WATER QUALITY

Marine water quality is measured by the physical and chemical characteristics of the water. Seawater contains naturally occurring constituents derived from atmospheric, terrestrial, and freshwater environments, as well as those derived from human activities (pollution). Due to limited industrial activity, most contaminants in the Beaufort Sea and on the North Slope occur in low levels.

Industrial activities are the primary source of pollutants entering the marine environment. These contaminants may be classified as either physical, chemical, or biological. Suspended solids are the principal physical pollutant. Chemical pollutants include both organic (e.g., crude and refined oil) and inorganic substances (e.g., trace metals). Waterborne viruses, protozoa, or bacteria, and excessive biological growth can be characterized as biological pollution.

2.5.1 Salinity and Temperature

Temperature and salinity in the Beaufort Sea are summarized in the Liberty DPP FEIS (USDOI, MMS, 2002). Freshwater discharge from the Sagavanirktok River influences the temperature and salinity of Foggy Island Bay. The impact is greatest near the time of the spring freshet, when river flow rates typically are highest. The freshwater initially creates a brackish nearshore zone with salinities of 10 to 15 parts per thousand (ppt). As mixing commences, salinities increase to 15 to 25 ppt with water temperatures ranging from 0 to 9 °C. The nearshore waters become relatively well-mixed as the open-water season progresses, with salinities greater than 25 ppt and temperatures decreasing to 0 to 2 °C. During the winter, under-ice water temperatures ranging from -2 to 0 °C have been recorded in Foggy Island Bay, while measured salinities have ranged from 21 to 30 ppt during the winter.

Numerous measurements of water temperature and salinity in Foggy Island Bay and the Sagavanirktok River delta were obtained on several occasions during the 1980s as part of the

Endicott Environmental Monitoring Program (LGL Ecological Research Associates Inc. and Northern Technical Services, 1983; Hachmeister et al., 1987; Short et al., 1990; Short et al., 1991; Morehead et al., 1992a; Morehead et al., 1992b; Morehead, Dewey, and Horgan, 1993). Water temperature and salinity near the SDI are highly variable during the open-water season due to the proximity of the Sagavanirktok River and circulation of nearshore water masses. Water temperatures in the Sagavanirktok River tend to fluctuate with air temperatures. During the 1982 monitoring program, for example, the river water temperatures varied from 17 °C in July to 2 °C in September. It is not uncommon for water temperatures near the SDI to vary from 10 °C to 0 °C during the summer. Similarly, salinities in the region may vary from 0 ppt (fresh river water) to 26 ppt (consistent with shelf bottom water).

2.5.2 Dissolved Oxygen

Dissolved-oxygen levels in the Beaufort Sea are summarized in the Liberty DPP FEIS (USDOI, MMS, 2002). Like many cold climate waters, dissolved-oxygen levels in the Beaufort Sea typically are near saturation. Dissolved-oxygen levels during the open-water period are reported to range between 8 and 12 milligrams per liter (mg/l), while under-ice dissolved-oxygen concentrations during the winter are reported to range between 7.6 and 13.2 mg/l. However, areas with limited circulation can turn anoxic before spring breakup. Biological oxygen demand in Foggy Island Bay is reported to be <1 mg/l.

2.5.3 Turbidity

Satellite imagery and data for total suspended solids (TSS) show that turbid waters are generally confined to water depths <5 to 8 m inside the barrier islands (USDOI, MMS, 2002). Turbidity is caused by the presence of fine-grained particles in the water column. These particles are derived from river runoff, coastal erosion and resuspension of seafloor sediments by waves and currents.

During the open-water period of July to September, concentrations of TSS vary in response to water depth, wind conditions and the presence of sea ice. In Foggy Island Bay, concentrations of TSS are typically in the range of 5 to 15 mg/l during July and August, with occasional values greater than 30 mg/l as shown in Tables 2.5-1 and 2.5-2 (Rummel, Schrader, and Winnick, 1987; Dunton et al. 2005). During the 1982 open-water season, a TSS concentration of 400 mg/l was recorded in the nearshore waters of the Sagavanirktok River delta (LGL Ecological Research Associates Inc. and Northern Technical Services, 1983).

Dunton et al. (2005) made extensive measurements of TSS in Foggy Island Bay during 2001 and 2002. Maximum values for TSS (20 to 25 mg/l during summer 2001) were found in shallow water along the Endicott Causeway (Figure 2.5-1). Concentrations of TSS were generally less than 10 mg/l near the originally proposed Liberty Island location (Figure 2.5-1 and Trefry et al., 2004a). Dunton et al. (2005) showed that light attenuation increased directly with increasing concentrations of TSS and that new growth of kelp in the Boulder Patch was indirectly related to levels of TSS during the summer.

As summarized in Table 2.5-3, concentrations of TSS during the open-water period are well correlated to winds and storm events. For example, the maximum values for TSS observed during summer 1999 (Table 2.5-3) were found immediately following a 5-day storm with greater than (>) 25-kt winds. However, during summer 1999, Foggy Island Bay was not sampled until well after the storm subsided, and thus the 1999 data show a smaller maximum value than reported for the overall coastal Beaufort Sea (Table 2.5-1).

During the ice-covered period, concentrations of TSS are believed to be very low. Trefry et al. (2004a) reported background levels of TSS in Foggy Island Bay of 0.1 to 0.6 mg/l under ice during April 2000 with a similar range of TSS under ice across the study area for the Arctic Nearshore Impact Monitoring in the Development Area (ANIMIDA) study area during 2001 and 2002 prior to the onset of spring runoff. Weingartner and Okkonen (2001) and Weingartner, Okkonen, and Danielson (2005) deployed year-round moorings inside the barrier islands, including one in Foggy Island Bay from 1999 to 2002. Transmissivity (T) at the moorings was greater than 80% and relatively uniform under ice from February to May. Lower values for transmissivity (i.e., higher TSS) were observed under ice from November to February, indicating that there may be late fall or early winter events that promote some sediment resuspension under ice. This finding is consistent with a previous study which reported TSS levels of 2.5 to 76.5 mg/l under ice along the pipeline route for the then-proposed Liberty Project (Montgomery Watson, 1997 and 1998).

During spring runoff in late-May to mid-June, a large pulse of suspended sediment is discharged into Foggy Island Bay from the Sagavanirktok River. Rember and Trefry (2004) found maximum levels of TSS of 400 to 600 mg/l in the Sagavanirktok River for several days during the spring event in 2001 (Figure 2.5-2). Maximum values for TSS in the Sagavanirktok River during the spring floods of 2002 and 2004 were 300 to 350 mg/l due to lower river flow and, in 2002, a period of cooling and refreezing during the spring meltwater event. Concentrations of TSS from 63 to 314 mg/l were reported during breakup for the Sagavanirktok River from 1971 to 1976 by the U.S. Army Corps of Engineers (Envirosphere Company, 1993). During July through September, concentrations of TSS in the Sagavanirktok River range from 0.2 to 30 mg/l (Rummel, Schrader, and Winnick, 1987; Trefry et al., 2004a). Values for TSS at the higher end of this summer range are directly linked to rain storms.

Spring runoff from the Sagavanirktok River enters Foggy Island Bay as a 0.5- to 2-m-thick layer under the ice with concentrations of TSS that range from 5 to 50 mg/l (Trefry et al., 2006). Alkire and Trefry (2006) traced the flow of river water under ice to the barrier islands during the spring floods of 2004, and Trefry et al. (2006) showed the distribution of TSS in the Sagavanirktok River plume under the ice.

2.5.4 Hydrogen Ion Concentration (pH)/Acidity/Alkalinity

A description of the acidity/alkalinity of Beaufort Sea waters is provided in the Liberty DPP FEIS (USDOI, MMS, 2002). Typical pH values for seawater range from 7.8 to 8.2, while freshwater pH values generally range from 6.0 to 7.0. During the open-water season, pH values in the central part of the Beaufort Sea are reported to range from 7.8 to 8.2. Under-ice pH values during the winter are reported to range between 6.8 and 8.1.

2.5.5 Trace Metals

Trace metals can be useful indicators of industrial impacts because metals are sometimes enriched in the raw and finished materials used in modern industry. Bottom sediments are the ultimate sink, or depository, for trace metals released into the marine environment, and thus many environmental assessments of metals in the environment begin with sediment studies.

Previous studies of trace metals in sediments from the coastal Beaufort Sea have generally shown that metal concentrations are highly variable, but at natural levels with minimal localized inputs from development (Sweeney and Naidu 1989; Snyder-Conn et al., 1990; Crecelius et al., 1991; Naidu et al., 1997, 2001; Valette-Silver et al., 1999). Snyder-Conn et al. (1990) identified elevated levels of Ba, Cr, Pb and Zn in areas adjacent to one or more disposal sites for drilling effluent. Crecelius et al. (1991) found elevated levels of Ba at a few sites in western Harrison Bay and Cr near the mouth of the Canning River, with no other indications of metal contamination.

The MMS ANIMIDA (1999-2003) and Continuation of ANIMIDA Programs (2004-2007) were specifically designed to investigate the distribution of 16 trace metals (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Tl, V and Zn) near the Liberty Prospect, the Northstar area and in the coastal Beaufort Sea from Harrison Bay to Camden Bay. Considerable variability was found in the concentrations of all metals as well as total organic carbon (TOC) in surface and subsurface sediments from the study area, including Foggy Island Bay (Table 2.5-4).

Concentrations of selected trace metals in sediments from a given depositional environment commonly follow a strong linear trend versus Al. As a result, the observed variability of trace metal concentrations often can be resolved by normalizing metal values with Al. A range of natural metal/Al ratios has been developed for all 16 metals listed above. Natural levels are defined as concentrations within the prediction interval or at <10% above the upper prediction interval (e.g., Cu, Pb, Hg and Ba in Figure 2.5-3). Trefry et al. (2003) reported that only 8 of 1,222 metal concentrations from the broad study area were elevated above natural levels. One of the eight anomalies was for Ba in sediment from Foggy Island Bay near the Liberty Prospect, and five anomalies were found in sediment in the Northstar area.

The historical record of metals in sediments from the coastal Beaufort Sea also was determined during the ANIMIDA Program. Concentrations of trace metals were determined for 104 samples from six cores, including one in Foggy Island Bay (Trefry et al., 2003). Some variability in concentrations of metals was observed in each core, mainly due to variations in the amounts of fine-grained sediment. Overall, concentrations of Ag, Ba, Be, Co, Cr, Cu, Hg, Ni, Pb, Sb, Tl, V and Zn in these cores were not impacted by anthropogenic inputs or diagenesis and show long-term (many decades) deposition of uncontaminated sediments.

More than 50 samples of suspended sediment from the Sagavanirktok River have been collected and analyzed for trace metals since 2000 (Rember and Trefry, 2004; Trefry et al., 2004b). All data for metals in suspended sediment from the river plot within the prediction intervals for natural sediment (e.g., Figure 2.5-3). In general, concentrations of trace metals in suspended sediment from the Sagavanirktok River are higher than in coastal sediments because the suspended particles are clay-rich and do not contain the metal-poor quartz sand and carbonate shell material found in bottom sediments from the Foggy Island Bay.

Sediment quality criteria have been established for several trace metals to help assess possible adverse effects to biota from elevated levels of metals in sediments. Long et al. (1995) introduced an effects range-low (ERL) that is defined as the concentration of a substance that affects 10% of the test organisms and an effects range-median (ERM) that is defined as the concentration of a substance in the sediment that results in an adverse biological effect in about 50% of the test organisms.

Six (Ag, As, Cd, Hg, Pb and Zn) of the 17 metals investigated during this study have been assigned reasonable ERL and ERM concentrations by Long et al. (1995), and these values are listed in Table 2.5-4. None of the concentrations of the these metals in the coastal Beaufort Sea sediments, including Foggy Island Bay, exceeded their respective values for the ERM (Table 2.5-4). Therefore, adverse biological effects as the result of trace metals are not expected to be a frequent occurrence at any site in the study area. Furthermore, no concentrations of Ag, Cd or Pb from this study exceeded the respective values for the ERL (Table 2.5-4), indicating that adverse biological effects from these four metals would be rare. One sediment sample (of 192 total) collected near West Dock contained Hg and Zn at levels that were slightly greater than the ERL (Table 2.5-4). Overall, sediments sampled in Foggy Island Bay and the coastal Beaufort Sea were not contaminated with metals and would rarely cause adverse effects to benthic organisms.

Concentrations of dissolved metals in Foggy Island Bay and throughout the coastal Beaufort Sea are similar to or less than the world average values in coastal and marine areas (Table 2.5-5). With respect to dissolved trace metals, the area seems pristine. Concentrations of dissolved metals in the incoming water of the Sagavanirktok River also are low relative to typical river water (Table 2.5-5), most notably for As, Cr and Hg. These data provide no indication of contamination from dissolved metals in Foggy Island Bay.

Trace metals in marine systems may be assimilated into the food chain and lead to adverse effects to the marine biota and ultimately to humans. In the ANIMIDA/cANIMIDA programs, concentrations of trace metals were determined for clams, amphipods and some fish collected in 1999, 2000 and 2002 (Brown et al., 2004, 2006). For Ba, Cd, Cu, Pb, V and Zn, samples had been previously collected and analyzed in 1986 and 1989 (Boehm et al., 1990).

Mean concentrations of Ba, Cu, Pb, V and Zn in clams (*Astarte* sp.) sampled during 1986, 1989, 1999 and 2000 were relatively uniform (see Figure 2.5-4 for Cu, Pb and Zn). Such uniformity is encouraging because body burdens for metals can be used as a long-term indicator of metal availability. This uniformity also suggests that no detectable shifts in metal levels in *Astarte* have occurred between 1986 and 2000. Some variability in concentrations among years was observed (e.g., Hg in Figure 2.5-4). However, these shifts are sometimes related to the amount of sediment, albeit small, in some samples. In addition, the small number of pools of samples limits the statistical power of the data. No evidence for metal contamination has been found for clams, amphipods or fish (Brown et al., 2004, 2006).

2.5.6 Hydrocarbons

As previously described in the Liberty DPP FEIS (USDOI, MMS, 2002), concentrations of aliphatic and aromatic hydrocarbons in sediments from the coastal Beaufort Sea are high relative to other undeveloped Outer Continental Shelf sediments. However, the hydrocarbons in the study area are mainly derived from natural outcrops of coal and shale and from natural petroleum seeps on land that are drained into rivers and into the coastal Beaufort Sea.

Recent data on organic parameters for surficial sediments from Foggy Island Bay are summarized in Figure 2.5-5, and show total polynuclear aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPHC), and total steranes and triterpanes (total S/T). Sediments in Foggy Island Bay and along the coastal Beaufort Sea contain a mixture of primarily terrestrial biogenic hydrocarbons and lower levels of petroleum hydrocarbons. This assemblage is clearly dominated by plant wax normal (i.e., straight-chain) alkanes in the n-C27 through n-C33 carbon range (Brown et al., 2004).

The PAH distributions for most of the surficial sediments (Brown et al., 2004) show that the PAHs are primarily of a combined fossil-fuel origin (i.e., petroleum and coal) with a biogenic component (perylene), and lesser contributions of pyrogenic or combustion-related compounds (e.g., 4-, 5-, and 6-ring PAHs). The petrogenic PAHs account for approximately 90% of the Total

PAH less perylene throughout the study area. Perylene, a naturally occurring PAH, was abundant in surficial sediments, often the most abundant single PAH compound in the overall PAH distribution.

Concentrations of hydrocarbons in the sediments in Foggy Island Bay are generally within the observed historical range for these parameters in the overall study area (Brown et al., 2004). Background concentrations of total PAHs (a sum of 2- to 6-ringed parent and alkylated PAHs) in recent Alaskan surficial sediment studies range from <10 to 1,000 ppb. Typically, PAH profiles indicate levels of a fossil fuel-type signature, which appears to be sourced in organics shales brought to the sediments from river runoff and coastal peat. At one location in Foggy Island Bay (station L08), concentrations of total PHC were about 2.5 times greater than background levels, and the source of the PHC was from unknown diesel input. Based on the PAH compositional results (i.e., petrogenic PAHs vs. pyrogenic PAHs), no appreciable changes in PAH composition were observed on an annual basis at Northstar due to construction and production activities.

The PAH data were correlated with silt+clay in Figure 2.5-6 to show that concentrations of these organic substances are directly related to the abundance of higher surface area, silts and clays. Collectively, concentrations of PAH normalized to silt+clay show little evidence of localized inputs of North Slope-related petroleum hydrocarbons to the sediments in the vicinity of the Liberty Prospect, Northstar, or the coastal Beaufort Sea.

Values for the ERL and ERM have been developed for 13 individual PAH compounds and three classes of PAH (low- and high-molecular-weight PAH, and total PAH) by Long et al. (1995). A comparison of the total PAH from all ANIMIDA and cANIMIDA sediments from 1999, 2000, 2002 and 2004 (Figure 2.5-7) shows that none of the total PAH concentrations determined for Foggy Island Bay and throughout the coastal Beaufort Sea exceeded the ERL. The mean total PAH values from each study region were generally an order of magnitude lower than the ERL. Similarly, the individual PAH concentrations did not exceed the ERL for the individual 13 PAH, which could be compared directly. In summary, based on sediment quality criteria, the concentrations of PAH found in the study area sediments are not likely to pose an ecological risk to marine organisms in the area.

Data from 1999, 2000, 2002 and 2004 for total polynuclear aromatic hydrocarbons, total petroleum hydrocarbons, and steranes/triterpanes (S/T) in clams (*Astarte* and *Cyrtodaria*) and amphipods (*Anonyx*) indicate that hydrocarbons in the sediment system are not readily bioavailable, as these species exhibit little ability to bioaccumulate saturated and aromatic hydrocarbons from sediment or from the overlying water column (Brown et al., 2004, 2006). Concentrations of PAH are very low (e.g., Figure 2.5-8 from 2000), showing consistent concentrations of contaminants over time in the study area.

2.6 FRESH WATER ENVIRONMENT

2.6.1 Sagavanirktok River

Onshore access and portions of the Liberty (SDI) Project lie entirely within the Sagavanirktok River delta. The Sagavanirktok River is 180 mi long and has a drainage area of 5,750 mi^2. About half of the basin area occurs in the Brooks Range, one-third within the Foothills physiographic province, and the remainder in the Arctic Coastal Plain. The river is bordered by the Franklin Bluffs to the east and the Kuparuk and Putuligayuk river basins to the west. A summary of hydrologic data for the Sagavanirktok River is provided in Table 2.6-1.

The Sagavanirktok is braided in the lower half of the river. About 25 mi upstream of its mouth, the river bifurcates into the West and East Channels, each consisting of a number of braided subchannels ranging from 200 to 1,200 ft wide within floodplains ranging from 1,000 to 7,000 ft wide. The East Channel, identified as the Main Channel on U.S. Geological Survey (USGS) maps, generally carries about equal flows to the West Channel. Thaw-lake terrain between the East and West channels indicates that the river has not occupied the intervening area for the past 10,000 years, since the early Holocene (SAIC, 1993a).

Channel patterns in the lower Sagavanirktok and its distributaries are formed primarily during summer high-flow events, which cause bank erosion and scour, and bear heavy sediment loads. Although overbank flows occur nearly every year during breakup, frozen ground conditions result in only minor changes to the channel and floodplain during the spring flooding (USDOI, BLM, 2002).

2.6.1.1 Hydrology

North Slope rivers are classified based on the physiographic province of their headwaters (Walker, 1973). Major rivers, including the Sagavanirktok River, have headwaters in the Brooks Range, while smaller rivers and streams originate in the Arctic Foothills or on the Arctic Coastal Plain. The Brooks Range consists of rugged east-west trending mountains that rise from the foothills to elevations above 8,000 ft. In the Sagavanirktok River, the initial snowmelt from the upper basin flows over the frozen river surface and ponds behind snowdrifts and icings. As breakup progresses, small snowdrifts thaw or are overtopped, and the accumulated meltwater is released downstream until it ponds behind larger snowdrifts. The storage and release process results in a peaked hydrograph, often followed by a rapid recession.

Flows are minimal in the Sagavanirktok during winter. Streamflow begins in May or early June during spring breakup flooding. Flows continue throughout the summer and decrease or stop shortly after freeze-up in early October. The mountains of the Brooks Range trap moisture and can receive significant rainfall (Hodel, 1986), resulting in occasional rainfall-induced floods that may exceed the spring breakup flood. Average, minimum and maximum daily flows measured in the Sagavanirktok River near TAPS Pump Station 3 are shown in Figure 2.6-1.

Long-term hydrologic data for North Slope streams are sparse. Drainages near the project area for which long-term discharge data are available include the Kuparuk, Sagavanirktok and Putuligayuk rivers. Because the data are limited, statistical procedures have been applied by the USGS to the limited data to correlate peak streamflow to the physical and climatic basin characteristics (Curran, Meyer, and Tasker, 2003). For North Slope streams, the resulting equations for estimating peak streamflows are based solely on the area of the drainage basin. Watershed models, which are often used to predict river floods based on precipitation input and basin geometry, do not adequately simulate North Slope breakup floods.

2.6.1.2 Flood Frequency and Stage

Continuous water-level measurements and associated river flows have been recorded for the Sagavanirktok from 1971 to 1978, and from 1983 to present at USGS Gauge Stations 15910000 and 15908000. The present gauge site, which is about 90 mi upstream of the delta near TAPS Pump Station 3, measures flow from about 35% of the Sagavanirktok River basin. Breakup and peak flow measurements have also been performed at the Endicott Road bridge site at the West Channel during most years from 1970 to present (Earl and Wright, 1980; McDonald, 1981, 1983, 1984, 1988, 1990a, 1990b; Bell and Associates, 1993, 1995, 1997-2004). Separate flood-frequency analyses have been performed for the Sagavanirktok River Bridge (Earl and Wright, 1980; McDonald, 1984; PND, 2003) and for the upstream gauging stations near Pump Station 3 (Jones and Fahl, 1994; Curran, Meyer, and Tasker, 2003).

Although rainfall floods on the North Slope are typically smaller than the annual breakup event, the Sagavanirktok has been noted as an exception. The largest floods measured in the Sagavanirktok at Pump Station 3 occurred during rainfall events. However, this station gauges flow only from the southern third of the drainage basin, consisting of mountainous terrain characterized by increased precipitation (Kane and Carlson, 1973). In contrast to the upper gauging station, annual hydrographs at the Sagavanirktok River Bridge show behavior typical of other North Slope streams, with annual peak flows during spring breakup. In addition to larger flows, breakup floods produce higher river stages in the coastal plain than rainfall floods because parts of the channel and floodplain are occluded by snow and ice. Twenty-two years of breakup stage and discharge data have been recorded at the West Channel bridge (Table 2.6-2).

Discharge data collected from both the West and East channels of the Sagavanirktok in 1982 and from 1985 to 1990 (Gallaway and Britch, 1983; Envirosphere, 1987, 1990, 1991; SAIC, 1991, 1993a, 1993b) are particularly useful for evaluating the proportion of flow carried by the West and East channels. The peak flow in the West Channel has ranged from about 35 to 75% of the total river flow between 1982 and 1990, and averages 50% (PND, 2006a). Figure 2.6-2 shows the flow distribution in the Sagavanirktok River delta, while Figure 2.6-3 and Table 2.6-3 present breakup flood magnitudes and frequencies at the Sagavanirktok West Channel Bridge.

2.6.1.3 Erosion and Sedimentation

The Sagavanirktok River has a substantial delta, indicating a general magnitude of sediment transport in this river. Sediment transport in North Slope streams is relatively low compared to streams in more southern latitudes due to the limited open-water flow season, the occurrence of high breakup flows while the river bed and banks are still frozen, permafrost, and subsequent low summer flows (Childers and Jones, 1975; Lewellen, 1972). The majority of sediment transport occurs during annual breakup flooding and rare high-volume rainfall floods, as evidenced by gravel bed material in the larger rivers. The Sagavanirktok River is degradational for most of its length, and is only aggradational for the last 15 mi.

2.6.1.4 Ice Conditions

Icings are large bodies of ice that form when water from a river or spring seeps onto the surface during winter. Because water is stored in the icings, downstream streamflow is initially reduced (Sloan, Zenone, and Mayo, 1976). Channel ice in the Sagavanirktok River can develop thicknesses greater than the 2 m typically observed on tundra ponds (BPXA 2001) as a result of groundwater springs or winter overflow building layer upon layer of ice (Carey, 1973; Hodel, 1986). The ability of the Sagavanirktok and other large rivers to carry this thick ice downstream during breakup flooding is limited, however, by the river depth.

Ice jams at the head of the Sagavanirktok River delta during breakup can divert discharge from one channel to the other (Chezhian, 2004). Channel ice at the Sagavanirktok West Channel Bridge has been the subject of an annual ice-cutting program, depending on ice conditions, since the early 1980s, and appears to have prevented major ice jams from occurring at the West

Channel bridge. The total duration of significant ice movement in a given river reach is no more than a few days (Walker, 1973; PND, 2005).

2.6.2 Lakes

Thaw lakes dominate the landscape of the coastal plain, originating as small ponds in low-centered ice-wedge polygons (Sellman et al., 1975). The ponds coalesce to form lakes, which develop a northwest-southeast orientation over time due to wave action from winds prevailing out of the northeast. Lake recharge results from snowmelt and rainfall within the lake basin and spring breakup flooding and overbank flows from nearby streams. Lakes subject to stream overflows during breakup flooding may be replenished annually. Other lakes may have residence times as long as 25 years (USDOI, BLM, 2003). Summer evaporation measured in lakes near Prudhoe Bay averaged about 5 inches (Mendez, Hinzman, and Kane, 1998).

Lakes are a readily available fresh water source in the project area (Sloan, 1987). Shallow lakes less than 6 ft deep freeze to the bottom during most winters. Lake depth is a primary factor in winter water supply for this reason, and lakes are classified accordingly as shallow or deep. Shallow lakes that freeze completely in the winter are directly underlain by permafrost. Deep lakes, which do not freeze to the bottom, are underlain by a thaw depression in the permafrost table that generally does not exceed 20 ft (Sellman et al., 1975). Shallow lakes begin to freeze in September and become ice free by late June, up to a month earlier than most deep lakes (Hobbie, 1984).

Deep lakes, along with gravel mine sites and river channels, are potential sources for fresh water supply for ice road construction in the project area. Several lakes along the Endicott Road and Badami Pipeline alignment have been tapped for ice road water sources, primarily for Badami. In addition, manmade reservoirs in the Sagavanirktok River delta (Duck Island Mine Site), Shaviovik River delta (Shaviovik Reservoir) and lower East Badami Creek (Badami Reservoir) have been used for water supply.

2.6.3 Surface Water Quality

Rivers in the project vicinity have been sampled by the U.S. Geological Survey (Feulner, Childers, and Norman, 1971; Kemnitz et al., 1993) and as part of the Endicott Monitoring Program (Envirosphere Company, 1987). Most fresh waters in the project area are pristine, soft, dilute calcium-bicarbonate waters. Near the coast, sodium chloride (salt) concentrations predominate over bicarbonate concentrations (USDOI, BLM, 1998, 1978; Prentki et al., 1980). Water chemistry in lakes and ponds in the project area is highly variable and dependent on the distance from the Beaufort Sea, frequency of flooding, and whether the lakes and ponds are tapped (connected to river channels most of the year) or perched (isolated from rivers channels most of the year).

The arctic freeze/thaw cycle plays a controlling role in water quality. In winter, surface waters less than 6 ft deep will freeze solid (Hobbie, 1984). In such waters, major ions and other “impurities” are excluded from downward-freezing ice in autumn and forced into the underlying sediment. Most of the ions remain trapped in the sediment after melt-out the following spring, giving these waters a very low dissolved-matter concentration. During the summer, dissolved matter concentrations slowly increase as ice in the bottom sediment melts and the sediments compress (Miller, Prentki, and Barsdate, 1980). Waters deeper than about 6 ft remain unfrozen. In these waters, ions and impurities are excluded from downward-freezing ice and forced into the deeper water column or underlying sediment, with a proportionate increase in concentrations of dissolved materials. As a result, distinct off-flavor and saline taste affect the potability of water from lakes and river pools by late winter.

Water temperatures in the Sagavanirktok River exhibit a seasonal pattern of general warming in June and July followed by cooling during August through mid-September (SAIC, 1994). Monthly average temperatures for a 6-year period (1985-1990) were 46 to 55°F in June, 50 to 56 °F in July, 44 to 53 °F in August, and 36 to 44 °F in September. Based on 14 years of data, the mean date when the Sagavanirktok Delta is frozen in (used as a milestone to indicate the Sagavanirktok River was also frozen in) is October 12, ranging from October 1 to October 25 (SAIC, 1994).

2.6.3.1 Turbidity

Turbidity is a measure of water clarity and varies seasonally in the project area in relation to sediment transport by the major rivers during flooding. Rivers originating in the foothills or Brooks Range have steeper gradients and carry higher suspended-sediment loads, resulting in higher turbidity than smaller streams originating within the Arctic Coastal Plain. Nearly the entire annual sediment load in rivers is carried between May and October, with approximately 70% flowing to the river deltas during breakup in May and June, when suspended-sediment concentrations can reach above 500 mg/l (ARCO, 1997; USDOI, BLM, 1978). Later in summer, suspended-sediment concentrations decrease significantly (USDOI, BLM, 1998). Total suspended solids in the Sagavanirktok River have been measured between 0.2 and 30.0 mg/l in summer, with turbidities ranging from 0.4 to 24.0 NTU (nephelometric turbidity units).

2.6.3.2 Alkalinity and pH

Alkalinity is a measure of the acid-buffering capacity of water. Freshwaters in the arctic tundra are only weakly buffered (USDOI, BLM, 1998, 1978; Prentki et al., 1980; Hershey et al., 1995; O’Brien et al., 1995). In lakes and ponds, alkalinities during snowmelt are about twofold lower than midsummer alkalinities, which are on the order of 20 mg/l as calcium carbonate ($CaCO_3$). Alkalinities in coastal streams are higher, ranging from about 15 to 80 mg/l as $CaCO_3$ in summer, with higher values at lower flow rates. Winter alkalinities in unfrozen pools beneath the ice are on the order of 150 to 200 mg/l as $CaCO_3$.

The pH is a measure of water acidity and alkalinity. A pH of 7 indicates a neutral balance of acid and base, between 5.0 and 6.5 indicates slightly acidic water, and below 4.5 indicates acidic water. A pH between 6.5 and 8.5 is considered necessary to protect aquatic wildlife (ADEC, 2002), and is normal for most surface waters. Rainwater has a pH of 5.5 due to carbon dioxide in the atmosphere. Plants and aquatic life tend to buffer the pH of surface waters and keep the pH in the range of 6.5 to 8.5.

In shallow lakes and ponds, pH values are often depressed to below 7.0 due to snowmelt runoff. After snowmelt, their pH values usually increase to between pH 7.0 and 7.5 (Prentki et al., 1980; O’Brien et al., 1995). The initial low pH is due to acidity of snow on the North Slope, which has a median pH of 4.9 (Sloan, 1987). This low pH, which is below the pH 5.5 expected for uncontaminated precipitation, is thought to be a result of sulfate fallout from arctic air masses industrially contaminated from pollution sources in Eurasia (USDOI, BLM and MMS, 1998). In tundra brown-water streams (so-called because of the color caused by tannins) and some foothill streams, pH values can be <6.0, with acidity attributable to naturally occurring organic acids

(Hershey et al., 1995; Milner, Idrons, and Oswood, 1995; Everett, Kane, and Hinzman, 1996). In streams and rivers, pH values are higher, seasonally ranging between 6.5 and 8.5 (USDOI, BLM, 1978; Kogl, 1971).

2.6.3.3 Salinity

Salinity of coastal waters in the summer varies in the range of 20 to 6 ppt, dropping rapidly to fresh water as the river channels in the deltas are approached. Average salinity measurements are typically highest in river channels (12.5 ppt), intermediate in tapped lakes (7.2 ppt), and lowest in perched lakes (1.0 ppt) (Schell, 1975). The differences in salinity correspond with varying concentrations of dissolved minerals.

As the flows from the major rivers decrease in early fall and storm surges associated with westerly winds occur, fresh water left in the delta channels from the summer flow is gradually replaced by seawater (Schell, Kinney, and Billington, 1971). The denser saltwater flows inward along the channel bottom with accompanying outflow of fresh water on the surface. The principal result of the saltwater intrusion is to create isolated marine environments in separate channels. The extent of marine water intrusion up the river deltas depends on surge height and river flow. Storm surges, which can exceed 10 ft on the Beaufort Sea coast, are more important in the water exchange process during the summer than lunar tides, which average less than 1 ft in the project area (Norton and Weller, 1984; Selkregg et al., 1975). Lunar tides are dominant in winter, however, when ice cover restricts storm surges.

2.6.3.4 Oxygen

North Slope streams are typically near saturation with dissolved oxygen during the summer due to aeration of the flowing waters. Summer concentrations of dissolved oxygen in clear-water streams and lakes in the project area range from 8 to 12 mg/l (Kogl, 1971). Brown-water streams, ponds and lakes generally have lower dissolved-oxygen concentrations. Oxygen saturation values in ponds during the summer months generally fall below 100%, although a range between 60 and 120% has been observed (Prentki et al., 1980). Oxygen values can be much lower—<10% saturation—in vegetated shorelines or in water pooled on wet tundra (USDOI, BLM, 1998). In these locations, chemical processes in the underlying sediment deplete oxygen from the water as rapidly as the water can take up oxygen from the air.

During the winter, large streams and deeper coastal-plain lakes may become supersaturated with oxygen when dissolved oxygen is excluded from ice as it forms, and the exclusion adds more oxygen than underwater respiration by benthic organisms removes (USDOI, BLM, 1978; Prentki et al., 1980; O'Brien et al., 1995). Late winter measurements of oxygen in unfrozen pools beneath ice cover in smaller rivers indicate significant residual oxygen (9 mg/l) and 70 to 99% saturation (USDOI, BLM, 1998). Larger rivers with deep channels also maintain adequate (for fish use) to supersaturated winter-oxygen concentrations (USGS, 2003). Decreasing oxygen concentrations are more likely in ponds during the winter because aeration and photosynthesis by aquatic vegetation, which both increase dissolved oxygen concentrations, do not occur under the inhibiting effects of ice cover and darkness.

2.6.3.5 Organic Nutrients

Nitrogen and phosphorus are the primary nutrients required for algae productivity and availability of food for fish. Low nitrogen concentration is often the limiting factor in phytoplankton productivity in coastal marine water, while low phosphate concentration is the limiting factor in fresh water in the rivers. Streams have relatively high summer concentrations of nutrients until the water reaches the Beaufort Sea, where phytoplankton consume most of the nitrate. Nitrogen concentrations are generally higher in the spring than in the fall because freezing concentrates nutrients in the waterbodies. Nutrient levels in lakes and ponds are much lower than in the major rivers. Samples taken in 1971 had nitrate and nitrite concentrations that were almost undetectable in lake and pond water (Alexander, Culon, and Chang, 1975). Phosphate concentrations were also much lower in lakes and ponds than in the large rivers. Another source of organic nutrients is regeneration of ammonia through the conversion of dissolved organic nitrogen by heterotrophs under the winter ice (Schell, 1975). Phosphate concentrations in freshwater bodies are generally very low.

2.6.3.6 Hydrocarbons

The peat that underlies the North Slope carries substantial hydrocarbon content. This content is evidenced by natural sheens that occur in ponds or flooded footprints in the tundra, foam on the downwind shoreline of lakes on windy days, and elevated hydrocarbon levels in sediments with peat. These phenomena are naturally occurring and are not the result of industrial activities.

Pond waters away from development in the Prudhoe Bay area contain 0.1 to 0.2 ppb total aromatic hydrocarbons, similar to concentrations in pristine marine waters (Woodward et al., 1988). Hydrocarbons derived from the various sources are detectable as elevated levels of saturated and PAH in Colville River sediment and in Harrison Bay sediment (Boehm et al., 1987a). Additional pyrogenic PAH compounds are present in tundra soils and form a depositional record of atmospheric fallout from tundra fires. Concentrations of indicator hydrocarbons from these multiple sources are high and chemically similar to those found in petroleum, thus making it difficult to detect or distinguish anthropogenic contamination from natural background due to fires. Similarly, high levels of hydrocarbons found in other major North Slope rivers have been attributed to natural sources (Boehm et al., 1987a; Yunker and MacDonald, 1995).

2.6.3.7 Trace Metals

Lake and stream waters on the North Slope are generally low in trace metals compared to most temperate-zone fresh waters (Prentki et al., 1980). However, naturally occurring copper, zinc, cadmium, and lead have commonly been found at concentrations above the criteria established to protect aquatic life from toxic effects (ADEC, 2002; USGS, 2003). These metals come from soils in the undeveloped watersheds. The variations in water quality are part of the natural environment for fish and wildlife in the project area and do not result from manmade disturbances (U.S. Army Corps of Engineers, 1998). In measurements made in ponds near Barrow in 1971-72, dissolved copper concentrations were on the order of 1 ppb, dissolved lead 0.7 ppb, and dissolved zinc 5 ppb.

2.6.3.8 Potability

Potable water is fresh water that is free from micro-organisms, parasites, and any other substances at a concentration sufficient to present a potential danger to human health. Surface water is the primary source of potable water on the North Slope. Treatment according to State of Alaska Drinking Water Regulations (18 AAC 80) is required for any potable drinking water system. Secondary standards provide specific parameters that define allowable contaminant concentrations. Additionally, water must have a generally agreeable taste and odor to be considered potable.

Surface waters in the project area generally do not meet potable water standards without treatment. Ponds and local streams are often brown-colored from dissolved organic matter and iron (USDOI, BLM, 1998), and fecal coliform often exceeds Alaska standards. Fecal contamination from avian, caribou and lemming populations is the primary source of water quality reduction below drinking water standards in the project area (USDOI, BLM, 1998; Ewing, 1997; Gersper et al., 1980; ADEC, 2003), and cold water temperatures prolong the viability of fecal coliform. Thus, some smaller waterbodies in the project area may exceed State of Alaska standards for fecal coliform for drinking water or water recreation due to local wildlife abundance (there is no State standard applicable to growth and propagation of natural aquatic life or wildlife). Larger lakes and rivers with higher water volumes tend to be less contaminated with fecal coliform.

2.6.4 Groundwater

The availability of groundwater is limited in the project area by impermeable permafrost, which is almost continuous throughout the North Slope and extends to depths of 2,000 ft or greater in the Prudhoe Bay area (Sloan, 1987; Lachenbruch et al., 1988). Groundwater occurs in thawed zones above, within and beneath the base of this permafrost. Water occurring within the 1- to 4-ft-thick seasonal thaw zone (active layer) is directly connected to and part of the surface water resource.

2.6.4.1 Shallow Groundwater

Shallow groundwater is present in localized unfrozen layers, or *taliks*, within the permafrost beneath deep rivers and lakes. Large rivers and lakes deeper than about 6 ft do not freeze to the bottom in winter and transfer heat downward, allowing a layer of unfrozen sediments to develop (Sloan, 1987). These unfrozen zones beneath and connected to surface waterbodies are called "open" taliks and are recharged from surface snowmelt and precipitation. Recoverable quantities of groundwater may be present where the thaw zone occurs in high-permeability gravel or sand sediments. Such shallow groundwater is likely to be present in the project vicinity beneath areas of the Sagavanirktok River and deep, large lakes.

Groundwater is also found in confined "closed" taliks within the permafrost. These formations can result from groundwater flow, or when lakes fill in with sediment, reducing the heat input and allowing the surface to freeze over and encase the unfrozen zone. The volume of groundwater that can be recovered from closed taliks is limited because they are cut off from recharge sources. Dissolved salts within the groundwater prevent freezing, but also make the water potentially harmful to surface vegetation and unsuitable for drinking without treatment (USDOI, BLM, 2003; Williams, 1970).

2.6.4.2 Deep Groundwater

Wells drilled in the Prudhoe Bay area of the North Slope indicate that the base of permafrost is approximately 2,000 ft deep (Lachenbruch et al., 1988). Deep groundwater beneath the permafrost (subpermafrost water) is recharged slowly from areas to the south in the Arctic Foothills and the Brooks Range by infiltration of meltwater (Nelson and Munter, 1990).

Subpermafrost groundwater from wells drilled near Barrow and Prudhoe Bay have encountered highly mineralized groundwater (Sloan, 1987; Kharaka and Carothers, 1988). Based on this data, it is likely that subpermafrost groundwater beneath the project area will be brackish or saline, and not suitable for human consumption or surface use (Williams and Van Everingdon, 1973).

2.7 BENTHIC AND BOULDER PATCH COMMUNITIES

2.7.1 Plankton Communities

Primary production in the Beaufort Sea is considerably lower than other oceans of the world. In Stefansson Sound, annual production is typically 5 to 20 grams (g) of carbon per square meter (Schell et al., 1982). Although phytoplankton abundance is greatest in nearshore waters <5 m in depth, per-unit-area production is actually higher offshore where waters are less turbid and there is greater penetration of sunlight. Phytoplankton abundance is highest in late July and early August when sunlight is the strongest. Because of the low primary production, zooplankton communities are characterized by low diversity and low biomass (Cooney, 1988). More than 100 species of zooplankton have been reported in the Alaskan Beaufort Sea, with copepods being, by far, the most dominant taxon (Horner, 1981; Richardson, 1986).

2.7.2 Benthic Communities

The marine benthic community in Prudhoe Bay in areas outside of the Boulder Patch is characterized by an infauna assemblage of polychaete worms, tiny mollusks, and benthic amphipods (Feder and Schamel, 1976; Broad et al., 1979; WCC, 1979; Griffiths and Dillinger, 1981; Feder and Jewett, 1982; Carey, Scott and Walters, 1984). A review of arctic invertebrate literature indicates that many of these nearshore benthic marine invertebrates are circumpolar (Carey et al., 1974). Stable infaunal communities occur seaward of the 1.8-m isobath. This is approximately the maximum depth to which landfast sea ice forms in 1 year. Lack of water in the areas shoreward of 1.8 m, plus the scouring effect of the ice during breakup, prevents establishment of permanent communities. Most stations within the 1.8-m contour are comprised of sediments dominated by fine sand, while the sediments deeper than 1.8 m contained more silt.

The nearshore Arctic Coast, including Prudhoe Bay, was explored using grabs and trawls as part of the National Oceanic and Atmospheric Administration (NOAA) Outer Continental Shelf Environmental Assessment Program (OCSEAP) (Broad et al., 1978, 1979, 1981). Broad et al. (1979) reported mean biomass values at three Prudhoe Bay sites as 4.93, 27.6, and 34.08 g/m^2. Polychaete worms and small mollusks were the predominant infaunal organisms. Dominant epifaunal organisms included the isopod *Saduria entomon* and *S. sabini*, nemerteans, and benthic amphipods. Mollusks consisted of 75 to 80% of total biomass, and polychaetes, 10 to 15%. *Portlandica arctica* and *Macoma* spp. were the most abundant bivalves.

From August 1974 until present, benthos in Prudhoe Bay has been sampled and monitored as various docks, causeways, and production islands have been constructed in the area. In the summers of 1974 and 1975 sampling occurred in the west side of Prudhoe Bay in the West Dock vicinity (Feder and Schamel, 1976; Feder et al., 1976; Feder, Shaw, and Naidu, 1976). A total of 38 invertebrate species in eight phyla were collected, with polychaetes and amphipods being the dominant groups. Extensive sampling covering much of Prudhoe Bay occurred in August, 1978, in connection with the Waterflood Project (ARCO Oil and Gas Co.), when a total of 6,430 individuals representing 91 taxa were collected (WCC, 1979). The ten most abundant species, primarily polychaete worms and amphipod crustaceans, accounted for 75% of the specimens collected. Distribution of the species was patchy; only ten taxa occurred in 20% or more of the samples. The seven most abundant and widespread animals were *Pontoporeia affinis* and *Onisimus glacialis* (amphipods), *Ampharete vega*, *Scolecolepides arctius, Pygospio elegans*, *Prionospio cirrifera*, and *Chaetozone setosa* (polychaetes) and *Saduria entomon* (isopod). During additional Waterflood Project sampling in July 1981, 6,378 individuals were obtained in 86 taxa (Feder and Jewett, 1982). The five most abundant species were the polychaetes *Prionospio cirrifera, Tharyx* sp., *Ampharete vega, Pygospio elegans*, and *Chaetozone setosa* which accounted for 73% of the total number of individuals recorded.

Dominant motile invertebrates that live near the seafloor include amphipods, mysids, copepods, and other swimming crustaceans. They are food for some fishes, birds, and marine mammals. Other invertebrates, such as bivalves, snails, crabs, and shrimp, are food for some marine mammals such as whales and bearded and ringed seals (Frost and Lowry, 1984).

2.7.3 Boulder Patch Communities

The Stefansson Sound Boulder Patch, located 20 km northeast of Prudhoe Bay in the Alaskan Beaufort Sea (Figures 2.7-1 and 2.7-1a), supports the only known kelp bed on the Alaskan Arctic Coast that is characterized by abundant red and brown algae and a diverse assortment of invertebrate life attached to a collection of boulders, cobbles, and pebbles (Dunton, Reimnitz and Schonberg, 1982). The estimated area of Boulder Patch with >25% rock cover is 35.7 km^2 and 10 to 25% rock cover is 32.9 km^2 (Gallaway, Martin and Dunton, 1999). This area of hard substrate was discovered in Stefansson Sound, Alaska, by marine geologists during the summers of 1971 and 1972. It lay unexplored until the summer of 1978 when joint geological and biological investigations revealed it was clearly the richest and most diverse biological community yet discovered in the Alaskan Beaufort Sea (Reimnitz and Ross, 1979; Dunton, 1979; Dunton and Schonberg, 1981; Dunton, Reimnitz and Schonberg, 1982; Toimil and England, 1982; Toimil and Dunton, 1983; Busdosh et al., 1985). The Boulder Patch kelp community is a unique feature on the northern Alaskan shelf, which is blanketed predominantly by silty sands and mud (Barnes and Reimnitz, 1974) with an infaunal assemblage dominated by polychaete worms, small mollusks and crustaceans (Feder and Schamel, 1976; Broad et al., 1978; WCC, 1979; Griffiths and Dillinger, 1981; Feder and Jewett, 1982). Although gravel makes up the substrate around the bases of the barrier islands (Beehler et al., 1979a, 1979b), the surface sediment covering most of Prudhoe Bay and adjacent coastal shelf areas is composed of 21% fine silt, 16% silt, 20% very fine sand, and 28% fine sand (Chin et al., 1979).

2.7.3.1 Arctic Kelp

The arctic kelp *Laminaria solidungula* is a predominant member of the Boulder Patch kelp bed community and serves as both food and shelter for a diverse assemblage of marine invertebrate fauna (Dunton, Martin and Mueller, 1992). The growth and productivity of *L. solidungula* is related to its underwater light environment, which varies considerably on both spatial and temporal scales. Continuous measurement of the amount of photosynthetically active radiation (PAR) reaching the plants was examined in August 1984 and continuously from August 1986 to August 1991. Maximum daytime levels of PAR showed large seasonal differences, ranging from 0 to 15 µmol photons per m^2 per sec during the ice-covered period to between 0 and 250 µmol photons per m^2 per sec during the open-water season (Dunton et al., 1992). Periods of decreased water transparency during the summer and large patches of turbid ice in winter were the major causes of low or undetectable levels of PAR. The lowest annual quantum budget for *L. solidungula* ranges from 45 to 50 mol per m^2 per yr, which represents only about 0.2% of total surface PAR. Although *L. solidungula* possesses a very low light requirement for net photosynthetic carbon production, data indicate that this species is living at its physiological limits in the Beaufort Sea Boulder Patch.

Polar marine plants have a variety of adaptive responses that help compensate for lower irradiances at high latitudes. For example, the endemic arctic kelp *Laminaria solidungula* completes over 90% of its annual linear growth during the dark 9-month ice-covered winter period (Dunton and Schell, 1986). Kelp use carbon reserves accumulated during the previous summer when waters are predominantly free of ice and light is available (Chapman and Lindley, 1980; Hooper, 1984; Dunton, 1985; Henley and Dunton, 1995; Dunton and Schell, 1986). Photosynthetic production during the open-water period is usually sufficient to compensate for respiratory demands and allow accumulation of carbon storage compounds. Suspended sediments decrease water transparency and may significantly reduce annual kelp productivity (Dunton, 1990; Best et al., 2001).

Growth and production of the endemic arctic kelp *Laminaria solidungula* is regulated primarily by PAR during the open-water period. Variation of underwater PAR caused by changes in water transparency can have significant effects on the annual productivity of this species (Dunton, 1990). *L. solidungula* has been found to thrive at low light levels and is thus well adapted to the Arctic. It has the lowest irradiance saturation level (38 µmol per m^2 per sec) of any member of its genus and is photoinhibited at irradiance levels of 123 µmol per m^2 per sec (Dunton and Jodwalis, 1988). Its compensation level (2.1 µmol per m^2 per sec) is well below the levels of 5 to 9 µmol per m^2 per sec for other congeneric species (Dunton and Schonberg, 1990). *L. solidungula* benefits from light increases up to 38 µmol per m^2 per sec, but no beneficial effect occurs above this level. However, the plants benefit fully from any increases in light received during the winter-spring period because ambient light levels are usually well below the saturation level (Dunton and Jodwalis, 1988).

In low-light environments, plant production is more a function of exposure to saturating levels of PAR than to the total amount of photons received over the course of a growing season. In 1988, annual quantum budgets for *L. solidungula* varied from 45 to 50 mol per m^2 per sec, near the annual minimum light requirement reported in other studies for the lower limit of *Laminaria* spp. However, the time the plants were exposed to saturating levels of PAR in 1988 was considerably less than in other years. This was correlated with significant reductions in thallus tissue density and carbon content during the summer open-water period in 1988. Percentage of dry to wet weight (tissue density) dropped from about 16 to 10%, and carbon content, from 35 to 28%. The drop in both indices indicated that 1988 summer open-water PAR was insufficient for maintaining maximum photosynthetic carbon fixation. The decreased storage of carbohydrate reserves, which are used for tissue expansion during the dark ice-covered period, resulted in significantly reduced linear growth in all plants the following year (1989). Under saturating irradiances, young and adult plants exhibited similar rates of carbon fixation on an area basis, but under light limitation, fixation rates were highest in adult plants for all tissues. Continuous measurement of in-situ quantum irradiance made in summer showed the maximum PAR can be less than 12 µmol per m^2 per sec for several days when high wind velocities increase water turbulence and decrease water transparency (Dunton and Jodwalis, 1988).

Continuous measurements of photon flux fluence rate (PFFR) made during the ice-covered spring months, when the sun's duration above the horizon is increasing toward 24 hours a day, reveals a transmittance ranging between 0.001 to 0.6% of surface PFFR. This is well below the lower light limit of kelp growth (0.5 to 1.0%) suggested by Lüning and Dring (1979), Lüning (1981) and Hiscock (1986), and corresponds to an average maximum of about 1 µmol per m^2 per sec, which is nearly seven times lower than reported for the same period by Chapman and Lindley (1980) in the Canadian High Arctic. The great variation in PFFR beneath the ice canopy among years and among sites is directly related to density of sediment inclusions within the ice, supporting the diving observations noted by Dunton, Reimnitz, and Schonberg (1982), Dunton (1984), and Reimnitz and Kempema (1987) on the large-scale heterogeneity of turbid ice in Stefansson Sound. The absence of any consistent pattern of under-ice PAR among years and between sites in Stefansson Sound reflects the random occurrence of this phenomenon on both temporal and spatial scales, one that has broad implications with respect to the productivity in *Laminaria solidungula* (Dunton and Schell, 1986).

There are few quantitative estimates of kelp biomass in the Boulder Patch. In areas of >25% rock cover, Dunton, Reimnitz and Schonberg (1982) recorded a biomass of 262 g per m^2 compared to 67 g per m^2 in areas of 10 to 25% rock cover. Accurate estimates of kelp biomass are critical, since these values are used in models to predict changes in areal net production in response to changes in water column transparency. Measurements of annual production in arctic kelp based on in situ measurements of blade production are 6 to 10 $g/m^2/yr$ carbon (Dunton and Schell, 1986). Linear kelp growth from 1997 through 2004 was measured at seven sites within the Boulder Patch (Aumack, 2003; Dunton, unpublished data). These growth data are comparable to previous studies (Dunton, 1990; Martin and Gallaway, 1994). Annual *Laminaria solidungula* elongation displayed spatial and temporal variability (Figure 2.7-3). The substantial decrease at all sites except Dive Site (DS)-11 in kelp blade elongation in 2000 reflects reduced water transparency during summer 1999, especially near the shoreline. High light attenuation from elevated TSS levels was most likely the result of a series of major storm events that occurred in August and October 1999 (Weingartner and Okkonen, 2001). Consistently high blade elongation rates recorded in *L. solidungula* plants collected from DS-11 reflect both the offshore location of this site relative to other sites and its higher percentage of rock cover (Martin and Gallaway, 1994). Linear growth over 8 years at the seven sites ranged from 16 cm (nearshore site L-2) to 28 cm (offshore site DS-11), with an overall mean of 20 cm. The summers of 2001 and 2002 were the highest light years as reflected in the greatest blade elongation during the following winter (an average of 33 and 28 cm, respectively). An extremely low amount of growth was measured following the stormy summer of 2003 (mean elongation, 6 cm) (Dunton, unpublished data). Dunton's unpublished data from almost 4 decades of annual kelp growth measurements indicate that summers with very low amounts of growth have occurred frequently during the past decade.

The contribution by kelp to overall coastal productivity is therefore considerable and can account to 50 to 75% of the total productivity of the system (Dunton, Reimnitz and Schonberg, 1982). This energy is passed on to other trophic levels either directly through herbivory or indirectly through bacterial transformation of particulate detritus. Direct evidence for the incorporation of kelp carbon into nearshore arctic is documented by Dunton and Schell (1986, 1987). Distinct seasonal changes in the stable carbon isotope ($\delta^{13}C$) values of several animals indicated a diet shift to an increased dependence on kelp carbon during the dark winter period when phytoplankton were absent. For example, up to 50% of the body carbon of mysid crustaceans, which are key prey species for birds, fishes, and marine mammals, was composed of carbon derived from kelp detritus during the ice-covered period. The $\delta^{13}C$ values of macro-algal herbivores (snails and chitons) reflected their algal food preference, while the majority of species appear to eat a combination of algae and phytoplankton. The selective suspension-feeding bryozoans and hydrozoans reflected a phytoplankton-based diet.

2.7.3.2 Boulder Patch Epifauna

The number of species, numerical abundance and total biomass of the epilithic faunal assemblage of the Boulder Patch is significantly greater than reported from any area along the Alaskan Arctic Coast and represents nearly every major marine taxonomic phylum (Dunton and Schonberg, 1979, 1980, 1981; Dunton, 1979; Dunton, Reimnitz and Schonberg, 1982; Dunton, 1984; Dunton, Martin and Gallaway, 1985; Martin and Gallaway, 1994, Gallaway and Martin, 1987; Gallaway, Martin and Dunton, 1988; LGL Ecological Research Associates, Inc. and Dunton, 1989, 1990, 1991, 1992; Martin and Gallaway, 1994; Dunton and Schonberg, 2000). Nearly all boulder and cobble surfaces are covered by algae and epilithic invertebrates. Many organisms found in the Boulder Patch are previously unreported from the Alaskan Beaufort Sea because they require hard substrate for attachment. About 158 epilithic taxa were collected with an average abundance of 18,441 organisms per m^2 and average biomass of 283 g/m^2 (Table 2.7-1). The wet-weight biomass of the epilithic community is dominated by red and brown macroscopic algae (59% of total), with invertebrates and fishes constituting about 41% of the total biomass.

The most conspicuous member of the community is the kelp *Laminaria solidungula*, although less common kelp species also occur. Beneath this kelp overstory are several species of red algae (*Phycodrys rubens*, *Phyllophora truncata*, *Neodilsea integra*, *Odonthalia dentata*, *Rhodomela confervoides* and the encrusting algae *Lithothamnium*). The predominant faunal groups by weight (Figure 2.7-2) are fishes (9%), porifera (9%), mollusks (7%), bryozoans (5%), cnidarians (4%), and polychaetes (3%) (Dunton and Schonberg, 2000). Sponges and soft corals are the most conspicuous invertebrates due to their large size, abundance, and striking shapes and colors. Two sponges (*Choanites lutkenii* and *Phakellia cribrosa*) and a pink soft coral (*Gersemia rubiformis*) are widespread throughout the Boulder Patch. The chiton *Amicula vestita* constitutes the greatest percentage of molluskan biomass and is one of the few species that grazes directly on the kelp. Clams, mussels, snails, chitons, bryozoans, hydroids, tubicolous polychaetes, sea stars, sea anemones, and sea squirts are common on the rocks or attached to other biota. Interspersed between the rocks were lyre and hermit crabs. Several species of bottom-dwelling fishes are present in the Boulder Patch that include the fourhorn sculpin, great sculpin, snailfish, prickleback, eelpout, arctic flounder. Arctic cod and motile crustaceans (mysids, amphipods, and isopods) are common in the water column adjacent to the Boulder Patch community (Dunton, Reimnitz and Schonberg, 1982).

2.7.3.3 Boulder Patch Infauna

The sediments between boulders and cobbles within the Boulder Patch support a richer infaunal community than sediments from areas outside the kelp beds in Stefansson Sound. These differences in infaunal abundance and biomass between the Boulder Patch and peripheral sediment areas reflect the contribution of algal carbon to the benthic system. Benthos from samples taken between rocks in a densely populated area (site DS-11) included 140 taxa with mean density estimates of 4,830 per square meter and biomass estimates of 30 g/m^2 (Dunton and Schonberg, 2000). Benthos in bottom grab samples from the western fringes of the Boulder

Patch exhibited abundances of 3,800 individuals per square meter and biomass estimates of 46 g/m^2 (Toimil and Dunton, 1983).

Measurements of $\delta^{13}C$ also demonstrated the contribution of algal carbon to the community in the Boulder Patch. Measurements of $\delta^{13}C$ were used to assess the importance of kelp carbon versus phytoplankton carbon to resident fauna in the Boulder Patch (Dunton and Schell, 1987). Individuals of the same species were collected from three types of areas: center of kelp bed (site DS-11), fringe, and outside Boulder Patch. In nearly all cases, the $\delta^{13}C$ values at the kelp DS-11 were 1.5% heavier than the same animals collected at the fringe or outside the kelp community, which supports the hypothesis that many organisms assimilate carbon derived from kelp. Other studies have also documented the importance of benthic macroalgae and algal epiphytes as carbon sources for consumers (Fry, 1984; Kitting, Fry and Morgan, 1984). Approximately 98% of the carbon produced annually in the Boulder Patch comes from kelp and phytoplankton. Dunton (1984) estimates that benthic microalgae contribute about 2% of the annual carbon produced in the Boulder Patch. It also demonstrates that although most kelp carbon is channeled through the detrital food web, its abundance and high nutritional value ensure its relatively efficient transfer throughout the benthic community.

2.7.3.4 Boulder Colonization

Recolonization studies of benthic boulders and cobbles addressed how quickly the benthic community would recover from disturbance. The results of recolonization studies show that development of an epilithic assemblage of organisms is a slow process in the Arctic. Fourteen $0.05\text{-}m^2$ plots of rock at DS-11 were denuded with paint scrapers at 3-month intervals beginning in August 1978 and ending in May 1979. After 3 years, at least 50% of the substratum remained bare on all plots, but most were more than 75% bare (Dunton, Reimnitz and Schonberg, 1982). The recolonization that occurred was by encrusting coralline algae, a foliose red alga, hydroids, and tiny tube-dwelling polychaetes. The factors influencing establishment of epilithic community on the denuded boulders in the Arctic are similar to those identified as important in the establishment and development of communities in temperate regions by Dayton (1971), Dunton (1977), and Osman (1977). They include the stability of the substratum; temporal variability in the composition and abundance of larvae and spores; biological interactions such as predation, herbivory, and competition; and the growth rates of species that settle. In the Boulder Patch, most of the colonizing organisms first appeared in the early winter months. This may be due to the lack of sediment covering the plots at that time. The sediment cover was substantial on the denuded plots during summer and fall, and if small organisms existed, they could not be seen.

Colonization of bare boulders placed at sites in the Boulder Patch in August 1984 also occurred slowly. Colonization in 1986 and 1987 was described as negligible (Martin et al., 1988), although there was early episodic colonization dominated by the polychaete *Spirorbis* sp. In 1990, 6 years after deployment, a boulder placed at site DS-11 had five colonizing species. Two taxa that were evident in the 1989 photograph of this boulder were not seen in 1990, possibly due to heavy siltation of the rock. Finally, a more recent recolonization experiment which began in summer 2002 revealed nearly identical results compared to previous studies (Brenda Konar, University of Alaska, Fairbanks, pers. comm.). It is likely that the naturally occurring periodic inundation by sediment in the Boulder Patch adversely affects the process of recolonization by effectively blocking larvae or spores from reaching the rock surface, or by smothering epilithic biota with a stature <1 or 2 millimeters (mm) (Dunton, Reimnitz and Schonberg, 1982). The availability of primary substratum for recolonization is thus substantially limited during periods of sedimentation.

2.7.3.5 Sedimentation

Although the Sagavanirktok River delta discharges about 6 mi southwest of the Boulder Patch, the boulders do not appear to have been buried over time by riverine sediments. Currents are predominantly wind-driven during the open-water period, when easterly winds dominate. Therefore, the net drift is westward during the summer, moving riverine sediments away from the Boulder Patch (Barnes, Reimnitz and McDowell, 1977; Matthews, 1981). Peak discharge occurs in June following river breakup, but very little sediment accumulates within the sound during this period (Reimnitz and Ross, 1979). The rivers discharging into Stefansson Sound supply only sand-size and finer materials into the water column (Dunton and Schonberg, 2000). Some of the sandy materials have accumulated in an alongshore berm just offshore of the causeway. Sedimentation traps showed that silt constituted the highest percentage (58.5%) of the suspended material collected between May and August, 1981. Clay (38.3%) and sand (3.2%) constituted the remaining fractions (Dunton, Reimnitz and Schonberg, 1982). The percentage of organic matter of the sediment was 8.4%.

In the Boulder Patch, sedimentation is potentially greatest during late summer and early fall when 1 to 5 mm of sediment accumulate on the seafloor and coat the biota (Dunton, Reimnitz and Schonberg, 1982). The changes in water transparency, particularly the very poor conditions, are predominantly products of storms and associated shifts in wind-induced currents. Benthic sediments are lifted from the Boulder Patch and resuspended during severe storms, preventing burial of the rich biological community. The sediments remain suspended for long periods and settle slowly following freezeup in October (Dunton, Reimnitz and Schonberg, 1982). Other studies (Dunton, 1984; Dunton and Schell, 1986) have demonstrated that low winter levels of PAR are related to high sediment concentrations in the ice canopy. These sediments are almost entirely incorporated into the ice canopy during freeze-up in October (Reimnitz and Dunton, 1979; Barnes and Fox, 1982; Dunton, Reimnitz and Schonberg, 1982). Due to the inclusion of fine sediments and particulates into the ice canopy, light transmission into the water column can be completely blocked even during periods of 24-hour daylight which occur in spring. The spring bloom of ice microalgae, which is common in most arctic coastal areas (Alexander, 1974; Hsiao, 1980), does not occur under turbid ice. Turbid ice also blocks light from reaching much of the benthic macroalgal community except during open-water season. The distribution of turbid ice is widespread in the vicinity of the Boulder Patch.

Niedoroda and Colonell (1991) described sediment transport patterns in Stefansson Sound based upon sediment, oceanographic, and meteorological data from 1986. During west winds (~30% of the time), they found that sediment from the nearshore was moved eastward and offshore. Greatest deposition occurred on the upper shoreface, particularly at depths between 2 and 4 m. During east winds (~60% of the time), sediment transport was to the west. Overall, these findings suggest that the event-scale patterns of erosion and deposition in Stefansson Sound are dominantly in the cross-shore direction out to depths of 2 to 4 m. There is a substantial westward net transport of sediments as a result of the greater frequency of east winds.

Water depths in Stefansson Sound do not exceed 10 m and range from 3 to 9 m within the Boulder Patch, but this shallow benthic environment is largely protected by the offshore islands and shoals from gouging by deep-draft ice. The circulation dynamics vary seasonally and in response to the formation and disappearance of the landfast ice. The winter ice field within

Stefansson Sound is landfast, with minimal movement from mid-October through June (Weingartner and Okkonen, 2001). Currents are very weak (<2 cm/sec to undetectable) from mid-October through June, the period of total ice cover (Matthews, 1981). Sedimentation decreases though the winter, with <1.25 mm accumulated on the seafloor between mid-November and late February. Little or no sedimentation was documented between February and May, when maximum water visibility (>20 m) was observed. Freezeup is usually complete by mid-October, with ice reaching a maximum thickness of 2 m by early May. Breakup of most landfast ice in Stefansson Sound occurs before mid-July, although it can occur as early as late June. Breakup is usually followed by a rapid increase in light levels, which remain elevated throughout most of July and August. Winds and currents are strongly correlated during the open-water season, when current speeds typically exceed 10 cm/sec (Weingartner and Okkonen, 2001).

2.7.3.6 Total Suspended Solids

Growth and productivity of kelp within the Stefansson Sound Boulder Patch community are regulated primarily by photosynthetically active radiation (PAR) availability during the summer open-water period. During the 2001-2002 summer periods, the inherent optical properties (IOPs) of Stefansson Sound waters were measured in conjunction with suspended sediment concentrations for input into a radiative transfer equation (RTE) (Aumack, 2003). Highest total suspended solid (TSS) levels were in nearshore areas during both summers and were coincident with increased light attenuations. Lower TSS concentrations and attenuations were measured offshore. Data input to the RTE provided a TSS-concentration-specific attenuation coefficient to be used in conjunction with a productivity model. Using this technique, researchers estimated daily and annual kelp productivities throughout the Boulder Patch. Results suggest that light availability during the summer open-water period is heavily influenced by suspended sediment concentrations in the water column and that higher kelp productivities occur offshore, a result of lower sediment concentrations.

PAR availability in the summer open-water period is not constant and is largely a function of water transparency, measured by the amount of total suspended solids in the local area (Henley and Dunton, 1995). TSS are particles in the water column that diminish subsurface irradiance. These particles include clay, silt, sand, decaying vegetation and animals, or any inanimate particulate matter (Kirk, 1983). TSS originates from erosion, industrial or natural discharge, run-off, dredging, and flocculations. As these suspended particulates move through the water column, they reflect and absorb sunlight, thereby reducing light availability for macroalgal photosynthesis and biomass production. Ultimately, reduced kelp production means less food and habitat for organisms dependent on the kelp forest.

TSS interpolations throughout Stefansson Sound reflect higher water turbidity characteristic of eroding coastlines. TSS measurement along the SDI and Endicott Island shorelines were often three to four times higher (23.0 to 24.2 mg/l) than those at more seaward locations. Values of TSS in the Boulder Patch ranged from 4.2 to 14.3 mg/l (mean 6.8 mg/l), and offshore areas near Narwhal Island measured 2.6 to 2.8 mg/l (Aumack, 2003). Results show a strong relationship between water column TSS and light attenuation at all measured wavelengths. High attenuation coefficients and consequent low light penetration were found near the SDI and Endicott Island. Low attenuation, or high light penetration, corresponds directly to low TSS levels in northern and eastern Stefansson Sound. Offshore waters, typically associated with lower TSS values, had higher light penetration through the water column. The majority of the Boulder Patch, including areas with dense kelp population (>25% rock cover), is found predominantly in offshore waters where attenuation measurement were consistently <3.6/m (Aumack, 2003).

Coastal regions receiving high river discharge or shallow waters with unconsolidated sediments often have high b:a ratios (>30), a direct result of increased TSS. Absorption (a) occurs when photons are absorbed throughout the water column by colored dissolved organic matter (CDOM), biological organisms, suspended sediment, and the water itself (Kirk, 1983; Van Duin et al., 2001). Scattering (b) does not remove any photons but increases the effective path length traveled by a photon, thereby increasing the probability of the photon being absorbed (Kirk, 1983; Van Duin et al., 2001). High ratios of scattering coefficient to absorption coefficient (b:a) are typically associated with areas of increased turbidity (Kirk, 1994). Coastal regions receiving high river discharge or shallow waters with unconsolidated sediments often have high b:a ratios (>30), a direct result of increased TSS, which is typically correlated with photon scattering rather than absorption (Kirk, 1994). Connections between PAR, TSS, and kelp production have been quantified using a production model which is based on a clear-sky irradiance model designed by Gregg and Carder (1990). An RTE and concentrations-specific attenuation coefficients were inserted into the model using data collected in 2001 and 2002. The RTE, *Laminaria solidungula* production vs. irradiance calculations, and annual/hourly TSS and irradiance insertions combined the work of several different parties and can be made available (Dunton, pers. comm.). However, the accuracy of the model requires application of real in-situ (terrestrial and underwater) light data and better estimates of kelp biomass under different concentrations of rock cover.

Spatial and temporal TSS variations alter the number of hours kelp are exposed to levels of saturating irradiance (H_{sat}). The number of hours saturating irradiance has been reached for *Laminaria solidungula* in the Boulder Patch has ranged from as low as 39 hours to as high as 171 hours in a single summer (Dunton, 1990). The highest TSS levels (23.0 to 24.2 mg/l) occurred in nearshore areas during summer 2001 and were coincident with increased light attenuation (11.4 to 14.0/m) (Aumack, 2003). Results clearly demonstrate that suspended sediment concentrations have varying but substantial effects on light availability and subsequent kelp production during the summer open-water period. Increasing average TSS concentrations from 1 to 10 mg/l within ranges measured in situ decreased annual production by an order of magnitude.

2.7.3.7 Supplemental Information

The information above from the EIA overlooks some information on the kelp recovery time after disturbance, the nearshore distribution of marginal kelp, and the results of some recent MMS-funded research. The recovery time after disturbance is important to MMS assessments, because the MMS significance criteria are based partly on the rates of recovery. The EIA submitted as a component of the 2007 Liberty DPP summarizes information on the rate of blade growth for Boulder Patch kelp (Section 2.7.3.1) and, specifically, Section 2.7.3.4 includes information on kelp colonization of boulders. The kelp recolonization rates also are summarized in the Liberty DPP FEIS (USDOI, MMS, 2002:Section IV.A.5.b). The summary explains that recolonization would occur very slowly over a period of about a decade. Effects that would persist for more than 3 decades (3 generations or recolonization periods) would be classified as significant.

The distribution of the Stefansson Sound Boulder Patch kelp community is illustrated in Figure 2.7-1. The figure is a widely accepted one, illustrating the distribution of boulders and cobbles on which the kelp grows. The figure distinguishes the distribution of areas with more than 25% boulders and cobbles from those with 10-25% boulders and cobbles. The figure and the text do not explain that a small amount of kelp grows in nearshore areas in which the concentration of boulders and cobbles is <10%. An example of those nearshore areas with <10% boulders and cobbles is shown in Figure III.C-1 of the Liberty DPP FEIS (USDOI, MMS, 2002).

A recent MMS-funded study examined the recovery and recolonization rates of organisms in the Boulder Patch kelp community (Konar, 2006). The study specifically examined the effect of predators (grazers) on the recovery rate. It concluded that the recovery rate was slightly faster in the absence of predators.

Another study summarized the long-term monitoring at some research sites in the Stefansson Sound Boulder Patch kelp community (Dunton, Funk, and Iken, 2005). The biological diversity at some sites, such as DS-11, have been measured regularly since 1984 (Dunton, 2005), and annual kelp growth rates have been measured since 1977 (Dunton, unpublished).

Two other studies examined the epontic organisms that grow on the bottom surface of the ice (Gradinger and Bluhm, 2005; Bluhm, 2005). These studies examined the effect of suspended sediments (disturbance) on the epontic organisms.

2.8 FISH

A total of 28 species of fish have been identified in the freshwater and coastal marine habitats of the central Alaskan Beaufort Sea (Table 2.8-1). Detailed biological and ecological background descriptions of these species are provided in USDOI, MMS (2002) and USDOI, BLM (2005). USDOI, MMS (2002) describes Beaufort Sea fish as either freshwater, marine, or migratory.

- **Migratory Fishes:** Migratory fishes can be further segregated into anadromous and amphidromous species. Anadromous fishes are hatched and initially reared in freshwater river systems before migrating to sea where they spend most of their lives before returning to their natal streams as adults to spawn (Myers, 1949; Craig, 1989). Arctic cisco are considered anadromous because, although they overwinter in major river systems, non-spawners are believed to remain in brackish water deltas and do not move far upriver into strictly freshwater habitats (Morrow, 1980). Amphidromous fishes cycle annually between freshwater and coastal marine environments (Myers, 1949; Craig, 1989). They spawn and overwinter in rivers and streams but migrate out into coastal waters for several months each summer to feed. The utility of amphidromy is that it allows fish to take advantage of the more plentiful food resources present in arctic coastal waters during summer.
- **Freshwater Fishes:** Freshwater species largely remain within river, stream, and lake systems year round, although they may venture out during summer into coastal areas where waters are brackish.
- **Marine Fishes:** Marine fishes spend their entire lives at sea, although some species may migrate into nearshore coastal waters during summer.

The following descriptions of key fish species found in the proposed development area are extensions of descriptions found in USDOI, MMS (2002).

2.8.1 Freshwater Fishes

Freshwater species may be found in coastal waters during summer in areas of low salinity but typically occur in low numbers (Fechhelm et al., 2005). Greater concentrations of fish would be found in rivers and streams proximal to the development area; however, most species are dispersed widely across the drainage systems of the North Slope. That proportion of any freshwater population falling within the Liberty (SDI) Project area would constitute a minor fraction of the overall stock.

2.8.2 Marine Fishes

Of the marine species that occupy nearshore Beaufort Sea waters during summer, most occur sporadically and typically in very low numbers (Fechhelm et al., 2005). The exceptions are arctic cod, arctic flounder, and fourhorn sculpin. Fourhorn sculpin and arctic flounder are demersal species that have circumpolar nearshore distributions in brackish and moderately saline nearshore waters (Scott and Crossman, 1973; Morrow, 1980). Neither species is found far offshore (Morrow, 1980). Both species migrate into brackish coastal habitats during summer to feed, and may travel considerable distances up rivers. Fourhorn sculpin have been reported as far as 144 km upstream in the Meade River (Morrow, 1980). A background synopsis of arctic cod may be found in USDOI, MMS (2002).

2.8.3 Migratory Fishes

2.8.3.1 Anadromous Fishes

The most abundant anadromous species found in the Liberty (SDI) Project area is the arctic cisco. Despite anecdotal accounts that there may be small spawning runs of arctic cisco in Alaska (USDOI, MMS, 2002), none have been documented. Beaufort Sea arctic cisco are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al., 1983). Newly hatched fish are transported westward by wind-driven coastal currents and take up residence in the Sagavanirktok and Colville rivers (Fechhelm et al., 2005). Beginning at about age 5, fish enter the Colville River subsistence fishery (Moulton and Seavey, 2004). Arctic cisco remain associated with the Colville River until the onset of sexual maturity beginning at about age 7, at which time they are believed to migrate back to the Mackenzie River to spawn (Gallaway et al., 1983). The coastal dispersal corridor for young arctic cisco initially moving from Canada to the Sagavanirktok and Colville rivers passes through the Liberty (SDI) Project area. Adults migrating back to the Mackenzie River to spawn likewise would pass through the area.

Arctic cisco appear to be truly anadromous in that, except for spawning, they may spend most of their life in brackish to marine waters, including during the winter (Scott and Crossman, 1973; Morrow, 1980). In Alaska, adult arctic cisco overwinter in the lower reaches of the Colville River where salinities are brackish (Moulton and Seavey, 2004). During summer they migrate along the coast to feed and are one of the most abundant species found in the coastal waters of Prudhoe Bay and vicinity (Fechhelm et al., 2005). The Liberty (SDI) Project area lies well within the coastal foraging range of the Alaskan arctic cisco population.

2.8.3.2 Amphidromous Species

The Sagavanirktok River is believed to support one of the larger Dolly Varden populations in Arctic Alaska (Yoshihara, 1972). Amphidromous Dolly Varden also spawn in many of the “mountain streams” between the Sagavanirktok and Mackenzie rivers (Craig, 1989). Amphidromous Dolly Varden migrate considerable distances along the coast during the summer, and the extensive alongshore and open-water migrations reported for this species suggest they may be more tolerant of marine conditions than other arctic amphidromous species. Dolly

Varden have been taken as far as 15 km offshore in the Alaskan Beaufort Sea (Thorsteinson, Jarvala, and Hale, 1990), and dietary evidence has led to speculation that Dolly Varden feed offshore among ice floes in mid- and late summer (Fechhelm, 1999). The Sagavanirktok population is characterized by a large out migration soon after breakup and a return migration in late August and September (Fechhelm et al., 2005). The Sagavanirktok River delta is, therefore, the principal migratory pathway for this stock to and from foraging and overwintering grounds.

Amphidromous least cisco in the Alaskan Beaufort Sea occur in “tundra” rivers that lie west of and include the Colville River (Craig, 1989). There are no known spawning populations associated with the Sagavanirktok River or the “mountain” rivers that lie along the 600 km of coastline between the Mackenzie and Colville rivers (Craig, 1984). Least cisco are one of the principal species targeted in the fall Colville River subsistence fishery (Moulton and Seavey, 2004). Amphidromous least cisco from the Colville River disperse long distances along the coast during summer and are one of the most abundant species found in the Prudhoe Bay area (Fechhelm et al., 2005). Adults can disperse as far east as Brownlow Point (Griffiths et al., 2002). The Liberty (SDI) Project area is well within the summer feeding dispersal range of this species.

The Sagavanirktok River harbors a disjunct spawning population of broad whitefish (Gallaway et al., 1997; Patton et al., 1997). Juveniles appear to be intolerant of high salinities and typically remain in close proximity to the Sagavanirktok River delta (Fechhelm et al., 1992). Adults undergo more extensive coastal migrations (Morris, 2000) and during summer may disperse as far east as Brownlow Point (Griffiths et al., 2002). Because of the restricted range of juvenile fish, the Sagavanirktok Delta can be considered the primary nursery area for the stock. For adult fish, the Liberty (SDI) Project area lies well within their summer foraging range.

Humpback whitefish spawn and overwinter in the Colville River but not in the Sagavanirktok River (Fechhelm, 1999). Like broad whitefish, humpback whitefish are intolerant of high salinity conditions and remain in brackish nearshore waters and river deltas during summer. Prior to the 1996 installation of a 200-ft breach in the West Dock Causeway, few humpback whitefish were caught in coastal waters east of the structure. Since its installation, adult humpback whitefish are much more abundant in the Sagavanirktok Delta and probably range short distances east of the delta’s eastern edge (Fechhelm et al., 2005). Small humpback whitefish are rare in Prudhoe Bay, suggesting that the Liberty (SDI) Project area is well outside their Colville River foraging range.

2.8.4 Essential Fish Habitat

A background discussion of the Magnuson-Stevens Fishery Conservation and Management Act of 1996 (MSA) and Essential Fish Habitat (EFH) is provided in USDOI, MMS (2002) and USDOI, BLM (2005). Pursuant to NOAA, NMFS (2005), the *Preliminary Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska*, it is the current position of the National Marine Fisheries Service (NMFS) that pink salmon and chum salmon are the only two species of fish found in the Beaufort Sea that are amenable to EFH regulation and consideration (John Kurland, Director, NMFS Habitat Conservation Division, Juneau, pers. commun.; Lawrence Peltz, NMFS Habitat Conservation Division, Anchorage, pers. commun.; and Jeff Childs, formerly with MMS, pers. commun.). The MSA defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” [MSA §3(10)]. EFH pertains to habitat “required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem.” A healthy ecosystem is defined as an “ecosystem where ecological productive capacity is maintained, diversity of the flora and fauna is preserved, and the ecosystem retains the ability to regulate itself. Such an ecosystem should be similar to comparable, undisturbed ecosystems with regard to standing crop, productivity, nutrient dynamics, trophic structure, species richness, stability, resilience, contamination levels, and the frequency of diseased organisms" (50 CFR Part 600).

Pacific salmon fisheries in Alaska are managed under a combination of domestic and international regulations and treaties (NOAA, NMFS, 2004). Salmon fisheries are managed by ADF&G within State waters, where most of Alaska's commercial fishing occurs. Commercial fishing within the Exclusive Economic Zone (EEZ) is limited to Southeast Alaska and to three historic commercial net fisheries: in Cook Inlet, near the mouth of the Copper River, and near False Pass. Federal management at these locations is deferred to the Alaska Department of Fish and Game (ADF&G). Federal management of salmon stocks is largely directed by fishery management plans designed to limit the bycatch of salmon in non-salmon-directed fisheries within the North Pacific EEZ (NOAA, NMFS 2004).

Presently, there appear to be small spawning runs of pink and chum salmon in the Colville River, possibly in some Beaufort Sea rivers to the west, and in rivers along the Chukchi Sea. There is no evidence of successful spawning stocks associated with the Sagavanirktok River or Alaskan watersheds to the east of the Liberty (SDI) Project area. However, the ADF&G Fish Distribution Database and Anadromous Waters Catalogue does indicate that adult pink and chum salmon previously have been documented in the Sagavanirktok and Canning rivers, while adult pink salmon have been noted in the Staines and West Canning rivers. A successful run of chum salmon is established in the Mackenzie River in Canada.

The Colville River chum and pink salmon stocks occupy the extreme northern range of the species' spawning distribution in Alaska. Current theory holds that, upon emergence into coastal waters, the salmon that are spawned in the Colville River and rivers west migrate to the warmer waters of the Bering Sea and do not return to the Beaufort Sea until time of spawning (Craig and Haldorson, 1986). The few adults that have been caught in the Liberty (SDI) Project area occur in late summer and are either adult spawners returning to the Colville River or possibly straying salmon whose eventual reproductive success is questionable.

The coastal waters in and around the Liberty (SDI) Project area consistently have been treated by MMS as if they were EFH for chum and pink salmon, despite these species marginal presence in the Alaskan Beaufort Sea. Based on available data, EFH for the Liberty (SDI) Project area would include all waters of the Colville River and Delta, and the nearshore marine waters stretching from Foggy Island Bay and Stefansson Sound westward along the coastline to the Bering Sea and into the North Pacific Ocean. There are no federally managed commercial salmon fisheries in the Beaufort or Chukchi seas. The entire Arctic EEZ is closed to commercial salmon fishing under the salmon Fishery Management Program. The low numbers of pink and chum salmon that regularly migrate from the Beaufort Sea to the Bering Sea likely constitute a minor component of the commercial fisheries there. There are no federally managed fisheries for other species within the Beaufort and Chukchi seas.

In recent years, concern has been expressed that arctic warming could allow southern stocks of Pacific salmon from the Bering Sea to expand northward into arctic waters, where they might establish spawning populations (Babaluk et al., 2000; Stephenson, 2006). Such an expansion would depend on a number of physical and biological factors, the relevance and importance of which are highly problematic and speculative. Even if such a future expansion does take place, it is more than likely to occur beyond or toward the end of the production life of the Liberty (SDI) Project.

2.9 MARINE MAMMALS

The Liberty DPP FEIS, Lease Sale 202 EA, Lease Sale 193 EIS (USDOI, MMS, 2002; 2006b; 2007b) and BPXA (1998) describe seals and polar bears in the U.S. Arctic Ocean, and these descriptions are summarized and incorporated herein by reference. The Liberty (SDI) Project could affect ringed and bearded seals and polar bears, which are common in the area. Other species that are uncommon in the project area include beluga whales and walruses. Bowhead whales and polar bears are addressed under endangered species (Section 2.13).

2.9.1 Ringed Seals

Widely distributed throughout the Arctic, ringed seal is the most abundant seal species in the Beaufort Sea. Aerial surveys have been conduced in May and June as ringed seals become visible when they haul out on sea ice. Satellite-linked time-depth recorders have been used to evaluate the time spent basking on sea ice. Bengtson et al. (2005) reported that ringed seal density in the eastern Chukchi Sea ranged from 1.62 to 1.91 seals/km^2 based on surveys conducted in 1999 and 2000. These density estimates were made using a correction factor to allow for seals that were not hauled out and thus not visible during the surveys. Ringed seal density was greater in nearshore fast and pack ice than in offshore pack ice. Frost et al. (2004) reported ringed seal densities ranging from 0.81 to 1.17 seals/km^2 in the Beaufort Sea during surveys conducted from 1996 to 1999. Moulton et al. (2005) reported slightly lower ringed seals densities ranging from 0.39 to 0.83 seals/km^2 in the central Beaufort Sea during surveys near the Northstar project form 1997 to 2001. Ringed seal densities during aerial surveys can be affected by a number of factors including water depth, location of ice edges, time of day, weather conditions (i.e., cloud cover, temperature, wind conditions), and survey date (Frost et al., 2004; Kelly et al., 2005). Seal densities reflect changes in the ecosystem's overall productivity in different areas (Stirling and Oritsland, 1995). There is some evidence from recent surveys that ringed seal numbers in the central Beaufort Sea may be reduced compared to those reported in the early 1980s (Moulton et al., 2002). Moulton et al. (2002) suggested that ringed seals in the central Beaufort Sea may prefer areas with intermediate water depth around 10 to 20 m and that few seals occur in areas with water depths <3 m.

Ringed seals probably are a polygamous species. When sexually mature, they establish territories during the fall and maintain them during the pupping season. Pups are born in late March and April in lairs that seals excavate in snowdrifts and pressure ridges. During the breeding and pupping season, adults on shorefast ice (floating fast-ice zone) usually move less than individuals in other habitats; they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. During nursing (4-6 weeks), pups usually stay in the birth lair. This species is a major resource that subsistence hunters harvest in Alaska, and a prey source for polar bears.

2.9.2 Bearded Seals

Bearded seals are found throughout the Arctic and usually prefer areas of less stable or broken sea ice, where breakup occurs early (Cleator and Stirling, 1990). Early estimates of the Bering-Chukchi Sea bearded seal population range from 250,000 to 300,000 animals (Popov, 1976 and Burns, 1981 in Angliss and Outlaw, 2005). During aerial surveys in the eastern Chukchi Sea in 1999 and 2000, Bengtson et al. (2005) reported bearded seals density estimates ranging from 0.07 to 0.14 seals/km^2. These estimates were not corrected for seals that were undetectable during the surveys, and it was not possible to calculate a population estimate for the Bering-Chukchi Sea population. Estimates on the abundance of bearded seals in the Beaufort Sea and in Alaskan waters currently are unavailable, although bearded seals are reported annually during aerial surveys for other marine mammals (Treacy, 2002a, 2000b). Consequently, there is no current reliable population estimate for the Alaskan bearded-seal stock. Bearded seals stay on moving ice habitat in the Beaufort Sea. Their densities in the western Beaufort Sea and in the Liberty (SDI) Project area are highest during summer and lowest during winter. Their most important habitat in winter and spring is active ice or offshore leads.

Pupping takes place on top of the ice from late March through May mainly in the Bering and Chukchi seas, although some pupping takes place in the Beaufort Sea. Bearded seals do not form herds but sometimes form loose groups. Bearded seals are a secondary subsistence food for Barrow residents and provide a relatively low percentage of the total subsistence diet (Braund, 1993).

2.9.3 Walruses

The North Pacific walrus population was estimated at about 201,000 animals in 1990 (Gilbert et al., 1992), comprising about 80% of the world population. In general, most of this population is associated with the moving pack ice year-round. Walruses spend the winter in the Bering Sea; the majority of the population summers within certain areas of the Chukchi Sea, including the westernmost part of the Beaufort Sea. Although a few walruses may move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season, the majority of the Pacific population occurs west of 155° W. longitude north and west of Barrow, with the highest seasonal abundance along the pack-ice front.

Nearly all the adult females with dependent young migrate into the Chukchi Sea during the summer, while a substantial number of adult males remain in the Bering Sea. Spring migration usually begins in April, and most of the walruses move north through the Bering Strait by late June. Females with calves comprise most of the early spring migrants. During the summer, two large arctic areas are occupied—from the Bering Strait west to Wrangell Island and along the northwest coast of Alaska from about Point Hope to north of Point Barrow. With the southern advance of the pack ice in the Chukchi Sea during the fall (October-December), most of the walrus population migrates south of the Bering Strait. Solitary animals occasionally may overwinter in the Chukchi Sea and in the western Beaufort Sea. Walruses are uncommon in the Liberty (SDI) Project area.

2.9.4 Beluga Whales

The beluga whale, a subarctic and arctic species, is a summer seasonal visitor throughout offshore habitats of the Alaskan Beaufort Sea. Based on a correction factor of 2 to account for bias related to animals that may be underwater and unavailable to count during surveys, the most recent estimate for the Beaufort Sea beluga stock is 39,258 animals (Angliss and Outlaw, 2005). Most of this population migrates from the Bering Sea into the Beaufort Sea in April or May; however, some whales may pass Point Barrow as early as late March and as late as July. The spring-migration routes through ice leads are similar to those of the bowhead whale. A major portion of the Beaufort Sea population concentrates in the Mackenzie River estuary during July and August. The eastern Chukchi Sea beluga stock currently is estimated to be at a minimum of about 3,710 whales (Angliss and Lodge, 2004). In the Arctic, belugas feed primarily on arctic and saffron cod, whitefish, char, and benthic invertebrates (Hazard, 1988).

Fall migration through the western Beaufort Sea occurs in September or October. Although small numbers of whales have been observed migrating along the coast, surveys of fall distribution strongly indicate that most belugas migrate offshore along the pack-ice front (Frost, Lowry, and Burns, 1986; Treacy, 1988-1998). Beluga whales are an important subsistence resource of Inuit Natives in Canada and also are important locally to Iñupiat Natives in Alaska. The mean annual harvest of beluga whales by Alaska Natives in the Beaufort Sea was 53 whales between 1999 and 2003 (Angliss and Outlaw, 2005 and references therein). The mean annual take of Beaufort Sea beluga whales in Canadian waters was 99 whales during the same time period. The Beaufort Sea beluga-whale stock is not considered to be "depleted" under the Marine Mammal Protection Act, or "threatened" or "endangered" under the Endangered Species Act.

2.9.5 Underwater Acoustics

Measurements of underwater ambient noise and sound transmission loss were made at the Liberty prospect during summer 1997 (Greene, 1998), and winter measurements were made during exploratory drilling at Liberty in winter 1997 (Greene, 1997). (Note that sounds were recorded at the proposed Liberty Island location and the currently proposed Liberty SDI location.) The results are summarized here. Comparisons are presented with similar measurements made near the Northstar prospect in 1996-1997 and at the Seal Island (Davis, Greene, and McLaren, 1985) and Sandpiper (Johnson et al., 1986) prospects in the 1980s.

2.9.5.1 Ambient Noise

Ambient noise was measured in 30-second segments every 15 minutes from August 1 to September 13, 1997 at two seafloor recorders 570 m apart. Ambient noise varied with average hourly wind speed measured from a barge that was usually located within 55 km (30 n. mi.) of Liberty. The correlation coefficients between the wind speed and the broadband (20 to 5000 Hz) ambient noise level were r = 0.831 based on the northwest recorder and r = 0.746 for the southeast recorder. For wind speeds of 0, 10, 20 and 30 kt, typical overall ambient noise levels in the 20 to 5000 Hz band were 85, 94, 104 and 114 dB re 1 µPa, respectively. The overall median levels approximated the levels expected for Sea States 0 to 2, based on the standard Knudsen fiducials extended to low frequency. The 5th percentile levels were below those expected for Sea State 0 at all frequencies below 3150 Hz, and the 95th percentile levels varied between those expected for Sea States 2 and 6. For the data from both recorders taken together, the median 20 to 5000 Hz band level for the 44 days was 97 dB re 1 µPa, or 9 dB above the corresponding level for Knudsen's Sea State 0. The 5th and 95th percentile levels were 78 and 110 dB re 1 µPa, respectively. The levels were consistent with other ambient noise measurements made in similar locations at similar times of the year.

These summer measurements complemented winter measurements made during February 1996. The measured ambient levels in winter (Greene, 1997) were generally lower than those measured in summer.

To study the short-term variability of the ambient noise in relation to longer term averages, 10 segments were selected from the seafloor recorder data. These segments were selected from times of low, high, and moderate noise levels. In 9 of the 10 cases, the 0.25-second averages were less than the 30-second average for over half the time. The one exception was the minimum noise case when the median 0.25-second average equaled the 30-second average. This indicates that if an animal is capable of recognizing sounds during short periods (on the order of 1/4-second in duration), it probably could hear a sound that is slightly weaker than the average (long-term) noise level. It could do so during periods when the ambient noise level is lower than average. This result is consistent with similar observations made northeast of Pt. Barrow during May (Greene, Hanna, and Richardson, unpubl.).

The frequency distribution of ambient noise was studied by observing the distribution of 1/3-octave band levels. When the ambient noise is predominantly attributable to wind and waves, the 1/3-octave band levels decrease at about 2 dB/octave with increasing frequency. However, the results from the Liberty seafloor recorders showed median levels decreasing with increasing frequency from 20 to 50 Hz but increasing with frequency from 50 to 1000 Hz. It is likely that sources other than wind and waves (such as distant vessels) contributed to the general ambient noise at Liberty.

2.9.5.2 Sound Transmissions

Acoustic transmission loss was measured on July 31, 1997, using as sources a four-element sleeve gun array and a minisparker. Both were tethered to a tug anchored at Liberty. Received sounds were recorded quantitatively at distances up to 8.1 km southeast and 10.1 km north of Liberty. Acoustic transmission loss was determined from those recordings.

For both sources, the broadband spreading losses were close to spherical, i.e., -20 log (R), over distances to 350 m. At greater ranges, the sounds from the array of sleeve guns diminished generally according to -25 log (R) while the minisparker sound diminished at approximately -10 log (R), corresponding to cylindrical spreading. This difference is attributed to the sleeve-gun array being a relatively low frequency source (63 to 800 Hz) compared to the minisparker (315 to 3150 Hz). Besides these logarithmic spreading losses, there was an additional linear loss of about -0.0020 dB/m for the sleeve gun array and -0.0033 dB/m for the minisparker. The higher linear loss rate for the minisparker corresponds to higher absorption and scattering losses at higher frequencies.

Propagation loss rates varied with frequency. There were some consistent trends in the relationships between frequency and loss rates; however, there were also some patterns that were not explained by a simple physical model.

The results of this study can be used to predict the received levels vs. distance of sounds from industrial sound sources that will operate at Liberty during construction and operation of oil production facilities. Those received levels can be compared to the expected range of ambient noise levels, thereby determining distances beyond which the industrial sounds will probably be masked.

2.9.5.3 Comparisons with Related Ambient Noise

There have been numerous other measurements of ambient noise in different parts of the Beaufort Sea during various times of year. Simultaneously with the 1997 Liberty prospect study, a 6-day series of measurements was obtained offshore of the barrier islands 60 km northwest of Liberty in water 25 m deep (Greene, Norman, and Hanna, 1998), offshore from Northstar. The 5th percentile and 95th percentile levels were generally higher offshore from Northstar. At frequencies below 125 Hz, median levels offshore were generally lower than those at Liberty. Conversely, above 125 Hz, the offshore medians tended to be higher than those at Liberty. The shallower water at Liberty (6.4 vs. 25 m) is important in limiting low frequencies and therefore resulting in less ambient sound at low frequencies.

The median levels at Liberty were between the idealized spectra for Sea States 0 and 2, while the Northstar medians at frequencies <100 Hz were below those expected for Sea State 0.

Ambient noise in the Northstar area (25 km northwest of Prudhoe Bay) in a water depth of 12 m was also studied in fall 1984. Ambient noise was received by three hydrophones on the bottom near Seal Island, at the site that became Northstar (Davis, Greene, and McLaren, 1985). The median and 95th percentile levels from Seal Island show that the ambient noise was high-pass filtered at about 60 Hz by the shallow water channel. Components of ambient noise below about 63 Hz were weak. At a water depth of 12 m, 60 Hz is the frequency for which the water depth is equal to one-half wavelength. At higher frequencies, the negative slope of the spectrum levels with increasing frequency parallels the nominal sea-state spectra. The medians are at levels corresponding to about Sea State 1.

Ambient noise was also studied offshore of the barrier islands during 8 days in fall 1985. Ambient noise was recorded via a single bottom hydrophone 450 m from Sandpiper Island (Johnson et al., 1986) at a water depth of 15 m. Sandpiper Island is about 16 km from Northstar and 66 km northwest of Liberty. During the recording period, no storms with winds about 20 knots occurred at Sandpiper, but the 5th percentile levels were notably higher than those in the shallower water at Liberty. A drill rig on Sandpiper was in cold standby—a generator was running for camp power.

Ambient noise was also studied northeast of Pt. Barrow in May during 4 years: 1989-91 and 1994. Sounds were recorded from sonobuoys and from hydrophones deployed over the edges of ice floes (Greene, Hanna, and Richardson, unpublished). Ice cover varied from 75 to 100%. The median levels measured at the Pt. Barrow and Liberty sites tend to agree across a range of frequencies despite the wide variety of water depths and the high percentage of ice cover northeast of Pt. Barrow in spring compared to the shallow open water at Liberty.

In comparison with the other data, the natural background noise at the Liberty site was relatively low in winter and high in summer.

The proposed SDI expansion is located in and adjacent to water depths of 1 to 10 m to maximum depths of 6 to 10 m between the SDI and the barrier islands. Ambient noise is expected to be similar to or less than the original Liberty site, due to the shallow water depth and underwater topography forming a shallow valley (6 to 10 m) between the SDI and the shallow (<3-6 m) inlets between the barrier islands.

2.10 MARINE AND COASTAL BIRDS

About 70 species of birds may occur in the Liberty (SDI) Project area (USDOI, MMS, 2002). Nearly all species are migratory, inhabiting Arctic Slope or Beaufort Sea habitats from May to September. Major groups that are common in this area during all or part of this period include loons/ waterfowl, shorebirds, seabirds, and passerines. Raptors and owls are less common.

Shorebirds and passerines are the most abundant species groups in the Liberty area. Loons, waterfowl and seabirds commonly use nearshore coastal waters (20-m depths or less) during spring and fall migrations, during broodrearing, and for molting (Fischer and Larned, 2004). River deltas, tundra habitats and coastal lakes and ponds are used by all bird species during summer. Birds that may overwinter in the onshore development area include raptors, owls, ptarmigan and the common raven.

The spectacled eider, Steller's eider, Kittlitz's murrelet, and the yellow-billed loon are discussed in Threatened and Endangered Species (Section 2.13.1 Birds).

2.10.1 Annual Cycle

2.10.1.1 Spring Migration

Waterfowl migrate eastward across northern Alaska along a broad front over land and sea during mid-May to mid-June. Exposed habitats, mainly in river deltas, attract some birds early during migration. The availability of open water leads offshore (mainly within 10 km of barrier islands) largely determines seaduck migration routes and timing. Between 250,000 and 1,000,000 long-tailed ducks nesting in western arctic North America migrate through the Beaufort Sea region each spring (Dickson and Gilchrist, 2002; Robertson and Savard, 2002), along with king eiders, common eiders and many other Arctic nesting species. Many migrants follow offshore lead systems and would not cross the coastal area where the Liberty development will be located.

Loons and eiders gather in spring runoff water in river deltas during late May and early June until local nesting areas are free of snow, and gather in river channels near nesting habitat until open water develops around the margin of lakes and ponds used for nesting. Most shorebirds are first noted dispersed across tundra breeding areas as soon as snow-free areas appear. Gulls and some ducks may arrive during late April in the Point Brower area of the Sagavanirktok River delta (USDOI, MMS, 2002). Migratory raptors and owls generally depart wintering areas in March to early April and arrive on the Arctic Coastal Plain in late April to early May. Migrant Lapland longspur and snow buntings arrive as snow-free areas become available, probably during May in most years.

Like many shorebirds, buff-breasted sandpipers leave wintering grounds in early February to mid-March and begin to migrate north (Lanctot and Laredo, 1994). Most shorebirds arrive on arctic breeding grounds during late May or early June.

2.10.1.2 Nesting and Broodrearing Periods

Lesser snow geese and brant nest on Howe and Duck islands in the Sagavanirktok River Delta and common eiders, glaucous gulls and arctic terns nest on nearshore delta islands and barrier islands in the Liberty (SDI) Project area (see Maps 6 and 7 in USDOI, MMS, 2002). Loons, tundra swans, greater white-fronted geese, Canada geese, and other waterfowl nest, forage, rear their broods, and molt in wetland habitats in the river deltas and across the onshore portion of the proposed Liberty (SDI) Project area (see Maps 6 and 7 of USDOI, MMS, 2002). Important broodrearing areas for snow geese and brant from early July to Late August are salt marsh and coastal sedge habitats throughout Foggy Island Bay, including the eastern Sagavanirktok River Delta, Kadleroshilik River delta, and Shaviovik River delta (Johnson, 2000a; Johnson, 1998). In the area between Prudhoe Bay and the Badami development, nest densities for several species (including Pacific loon, Canada goose, black-bellied plover, pectoral sandpiper, dunlin, stilt sandpiper, and red phalarope) reach their highest levels in coastal habitats surrounding the lower Kadleroshilik River (TERA, 1995).

The most abundant shorebirds were semipalmated sandpiper, pectoral sandpiper, dunlin, red phalarope and red-necked phalarope (TERA, 1995). The highest shorebird nesting densities generally occur in areas of mixed wet and dry habitats, whereas birds often move to wetter areas for brood rearing.

Nesting areas at the Endicott Causeway are mid-way between the Prudhoe and the Kadleroshilik River areas sampled by TERA (1995). Nest density for all birds combined was 60-70 nests/km^2.

2.10.1.3 Post-Nesting Period

From mid-July to early September, long-tailed ducks (and lesser numbers of eiders and scoters) aggregate in coastal lagoons to feed and molt before migrating westward in the fall. Many waterfowl depart the coastal areas by the middle or end of August, but some loons and tundra swans may be found in remaining open-water areas through September, long-tailed ducks through October, and some king and common eiders remain into early November (Johnson and Herter, 1989).

Among phalaropes and some sandpipers, the non-incubating members of pairs leave nesting areas on the tundra (early July), soon after the eggs are laid, and concentrate in coastal habitats. The other parent and fledged young follow in several weeks. In mid-August, juveniles form large flocks on coastal and barrier island beaches, foraging intensively on outer beaches, lagoon shorelines, and mudflats. Shorebirds move widely on a daily basis during staging, and residency time within a staging are may range from 10 to 25 days (Powell, Taylor, and Lanctot, 2005). Most shorebirds have departed the area by mid-September. Large flocks of glaucous gulls and black-legged kittiwakes migrating from nesting areas in the Canadian arctic also pass through the Liberty (SDI) Project area during September. By mid to late September most seabirds have left the Arctic Coastal Plain, although some juvenile and adult gulls may remain at landfills through November. In late August to mid September, arctic peregrine falcons and gyrfalcons forage in coastal areas, often preying on juvenile shorebirds. Passerines tend to flock following breeding, and some migrants may remain in the Liberty (SDI) Project area into September.

2.10.2 Habitats

2.10.2.1 Offshore Marine Waters

Eiders migrated westward through offshore waters from early July to November (Johnson and Herter, 1989). Bird densities generally are low in offshore areas, with long-tailed ducks less than or equal to ($\leq$)11 birds/km^2 seaward of the barrier islands east of Foggy Island Bay, and $\leq$3 birds/km^2 farther offshore (Fischer and Larned, 2004). During aerial surveys in 1999-2001, common eiders, king eiders, and long-tailed ducks dominated in late June and king eiders were most abundant offshore (Fischer and Larned, 2004). By late August, king eiders still were numerous, but long-tailed ducks also occurred in large numbers, mainly <50 km of the coast.

2.10.2.2 Nearshore Marine Waters

In the Liberty area, shallow waters in Foggy Island Bay and salt marsh habitat along the Sagavanirktok, Kadleroshilik, and Shaviovik river deltas provide the most protected areas for molting, feeding and brood-rearing geese. Shallow lagoons provide important feeding and staging habitat, particularly for post-breeding molting long-tailed ducks, eiders, and scoters (Truett and Johnson, 2000). Simpson Lagoon-Gwydyr Bay in the west, and Leffingwell Lagoon in the east, support tens of thousands of postbreeding long-tailed ducks (Fischer and Larned, 2004). Pacific loons primarily use shallow water close to shore, but may occur up to 60 km from shore (Fischer and Larned, 2004). Red-throated loons have been observed more than 50 km from shore, primarily use nearshore waters (Fischer and Larned, 2004). In the Alaskan Beaufort Sea shallow nearshore waters, Pacific loons were most abundant from Cape Halkett to Prudhoe Bay and red-throated loons were most abundant between Oliktok Point and Brownlow Point (Fischer and Larned, 2004).

2.10.2.3 Barrier Islands

These sparsely vegetated gravel islands provide nesting habitat for common eiders, glaucous gulls, and arctic terns. Barrier islands provide nesting habitat for common eiders, especially islands with accumulated driftwood and free of predators (Johnson, 2000b). Cross Island, Pole Island, and Lion Point (gravel spit northwest of Tigvariak Island) have been especially important islands for nesting common eiders (Johnson, 2000b). Very high densities of molting/feeding long-tailed ducks occur along the leeward (south) sides of barrier islands, particularly in the Jones-Return Island group, and the Stockton-Maguire-Flaxman island group (Fischer and Larned, 2004). Notable numbers of molting common and king eiders also aggregate near Flaxman, Pole, and Belvedere islands (Fischer and Larned, 2004). High densities of staging shorebirds may use the inner shores of barrier islands (Powell, Taylor, and Lanctot, 2005). The occurrence of many species on barrier and other islands in particular has been noted by Native residents (USDOI, MMS, 2002).

2.10.2.4 Tundra

Shorebirds are likely to be found in any type of tundra (Troy, 2000). The most numerous shorebird species in the Liberty (SDI) Project area prefer wet tundra habitats (sandpipers, phalaropes) or nest on or near well-drained gravelly areas (plovers). Tundra habitats available to shorebirds include dry, moist and wet tundra, flooded tundra, sparsely vegetated areas, ponds, and lakes. In general, the highest nest densities tend to occur in drier areas (moist or wet tundra) and in areas with extensive micro-relief (polygon rims, strangmoor). Seabirds such as arctic terns, Sabine’s gulls and glaucous gulls nest individually or in small colonies in tundra habitats often associated with large thaw lake basins, especially those with complex lake shorelines and small islands. Short-eared owl and snowy owl nest on tundra across the Arctic Coastal Plain, but the number of the breeding birds probably reflects the abundance of their primary microtine food (lemmings) (Pitelka, Tomich, and Treichel, 1955). The northern harrier, also a ground nesting species, is a fairly common visitant on the Arctic Coastal Plain (Johnson and Herter, 1989) and may occasionally nest there (Burgess et al., 2003).

2.10.2.5 Other Habitats

Saltmarsh and sedge habitats in river deltas in the outer Sagavanirktok, Kadleroshilik, and Shaviovik deltas are heavily used by molting geese, especially snow geese and brant from the Sagavanirktok Delta, and local and molt migrant white-fronted and Canada geese (Johnson, 2003; Johnson, 2000a). River deltas in the Liberty (SDI) Project area (outer Sagavanirktok and Shaviovik), particularly the outer mudflats, are heavily used by shorebirds (Andres, as cited in Nickles et al., 1987); this probably also is true of the Kadleroshilik. Vegetated river bars are used by many tundra-nesting species including black-bellied plover, American golden plover, ruddy turnstone, rock ptarmigan, and Lapland longspur (USDOI, MMS, 2002).

Buff-breasted sandpipers use drier habitat than most other shorebirds and depend on drier sloping areas or polygonal-featured tundra for nesting (Lanctot and Laredo, 1994). The number of adults counted on breeding grounds varies dramatically year to year. Nest densities at Milne

Point ranged from 0.3 to 1.3 nests/km^2 and at Prudhoe Bay ranged from 0.5 to 1.0 nests/km^2, and post-season densities were 0.0 to 2.4 birds/km^2 (Gotthardt and Lanctot, 2002).

Male buff-breasted sandpipers have been observed occupying a lek (where males were observed giving "wing flash" territorial displays) on a riverine island in the lower Kadleroshilik River (USDOI MMS, 2002).

Gyrfalcons, peregrine falcons, golden eagles, and rough-legged hawks may forage on the Arctic Coastal Plain during summer. Peregrine falcons and rough-legged hawks have also bred near the coast using artificial substrates/structures for nesting (Ritchie, 1991; Ritchie, Schick, and Shook, 2003). Ravens nest on towers and buildings.

2.10.2.6 Abundance

Red-throated and Pacific loons were most abundant offshore areas around the Liberty (SDI) Project area during July and August 1999-2000 (Fischer, Tiplady, and Larned, 2002), but these numbers were typically low. Relative densities for red-throated and Pacific loons in the Liberty (SDI) Project area were <0.01 to 0.21 loons/km^2 based on breeding pair surveys from 1998 to 2001 (Mallek, Platte, and Stehn, 2002).

Broodrearing snow geese concentrate in the Sagavanirktok, Kadleroshilik, and Shaviovik river deltas (Johnson, 2000a). Some of the broodrearing areas are at the site of the proposed Duck Creek mine site (see Map 6 in USDOI, MMS, 2002). Broodrearing areas for brant in the Liberty (SDI) Project area were primarily east and west of the Endicott Causeway (see Map 7 in USDOI, MMS, 2002).

Post-breeding long-tailed ducks were most abundant in offshore area around the Liberty (SDI) Project site in late July through August 1999-2000 (Fischer, Tiplady, and Larned, 2002). Large flocks of molting long-tailed ducks concentrated on the leeward sides of barrier islands ~20 km from the South Drilling Island (Fischer, Tiplady, and Larned, 2002). The barrier islands were an important broodrearing and molting area for common eiders and lesser numbers of king eiders and scoters (Fischer and Larned, 2004; USDOI, MMS, 2002:Map 7).

Glaucous gulls are the most abundant seabird in the Liberty (SDI) Project area (Fischer and Larned, 2004; Fischer, Tiplady, and Larned, 2002). Densities of glaucous gulls in offshore Alaskan Beaufort Sea marine waters were higher in areas with low ice cover and ranged from 0.04 to 0.08 gulls/km^2 within the 10-20-m contours (barrier islands to 30 km from shore) and from 0.01 to 0.08 gulls/km^2 beyond the 20-m depth contour (beyond 30 km from shore) (Fischer and Larned, 2004).

Historically buff-breasted sandpipers were common in North America. The small total North American population of 15,000 individuals and an apparently declining population trend have raised concerns about this species. The status of the buff-breasted sandpiper population was reviewed by Gotthard and Lanctot (2002), which resulted in their being listed as "highly imperiled" in 2004 (USDOI, FWS, 2004). Northern Alaska breeding grounds support 20% of the 25,000 worldwide population and 50% of the Western Hemisphere breeding population of buff-breasted sandpipers.

2.10.3 Population Status

Arctic Coastal Plain breeding pair surveys indicate that Pacific loons have remained stable at a population index of about 29,000 individuals and red-throated loons have increased by about

3.3 % per year from 1985 to a population index of 5,142 in 2006 (Mallek, Platte, and Stehn, 2007).

Population trends for most waterfowl species have remained unchanged since 1986 or 1992; notable exceptions are long-tailed duck, which has significantly declined, and tundra swan and arctic tern, which have significantly increased (Mallek, Platte, and Stehn, 2006). Both Fischer and Larned (2004) and Johnson et al. (2005) also documented significant declines in long-tailed duck density in nearshore molting areas in the central Alaskan Beaufort Sea. Long-tailed duck populations in northwestern Canada have also declined (Dickson and Gilchrist, 2002; Robertson and Savard, 2002).

The snow goose colony on Howe Island in the Sagavanirktok River Delta area, west of Liberty, increased steadily through the early 1990s, but declined markedly due to egg predation by grizzly bears and foxes during 1994-2003 (Johnson and Noel, 2005). A sharp increase in the number of nesting snow geese and brant was noted on Howe Island in 2004 and this snow goose colony has continued to increase (Rodrigues, McKendrick, and Reiser, 2006) after food-conditioned grizzly bears from nearby industrial areas were destroyed (Johnson and Noel, 2005).

Mallek, Platte, and Stehn (2006) conducted breeding pair surveys across the Arctic Coastal Plain 1982-2006. Glaucous gulls appeared to be slowly increasing to a population index of about 19,000 in 2006. Increases in the population index for Sabine’s gulls reached a population index of 16,531 in 2006. Similarly, arctic terns appear to be increasing to a population index of 24,329 in 2006. Jaegers, however, despite the highest population index on record in 2006, have a slight decreasing population trend (1986-2006).

Dunlin regularly occur in the project area and are listed as “Species of High Concern” in the Alaska Shorebird Conservation Plan (USDOI, FWS, 2004). Troy (2000) reported that dunlin were exhibiting a persistent directed declining trend in abundance in the Prudhoe Bay area 1981-1992.

2.11 TERRESTRIAL MAMMALS

Among the terrestrial mammals that occur in the Liberty area, the caribou, muskoxen, grizzly bear, and arctic fox are the species that could be affected by development. Mammals likely to occur in the project area are listed in Table 2.11-1.

2.11.1 Caribou

The Central Arctic Caribou Herd ranges within the project area. Its summer range extends from Fish Creek, just west of the Colville River, east to the Katakturuk River and from the Beaufort Sea coast inland south approximately 48 km (Figure 2.11-1; Lenart, 2005a; Arthur and Del Vecchio, 2004). Central Arctic Herd caribou winter in the northern and southern foothills and mountains of the Brooks Range (Lenart, 2005a). Some caribou of the Porcupine Caribou Herd may occur on the coastal plain near the Liberty (SDI) Project during summer, but few calve there or use the area after calving (Griffith et al., 2002). Calving by the Central Arctic Herd occurs in early June, usually within 30 kilometers of the Beaufort Sea coast. There are two calving groups, based on the locations of the calving-concentration areas. One calving area is east of, and one west of the Sagavanirktok River (Arthur and Del Vecchio, 2004; Lenart, 2005a; Cronin et al., 1997). The Liberty (SDI) Project is near the eastern calving and postcalving ranges of the Central Arctic herd. Mid-June calving densities in the area bounded by the Beaufort Sea coast south to 69° 54.5’ N.latitude between the Sagavanirktok River and Bullen Point ranged from 0.62 caribou/km^2 to 2.38 caribou/km^2 during 2000 to 2003 with most caribou 5 km or more from the coast in the 1,487 km^2 survey area (Figure 2.11-2; Noel and Cunningham, 2003; Jensen, Noel, and Ballard, 2003; Jensen and Noel, 2002; Noel and Olson, 2001).

Caribou calving in the eastern area may occur within the Liberty (SDI) Project area during late June, July and August (Arthur and Del Vecchio, 2004; Lenart, 2005a). Caribou densities between the Sagavanirktok River and Bullen Point south to 70° N.latitude ranged from 0.01 caribou/km^2 to 8.43 caribou/km^2 during 2000 to 2003 within the 1,043 km^2 survey area (Noel and Cunningham, 2003; Jensen, Noel, and Ballard, 2003; Jensen and Noel, 2002; Noel and Olson, 2001). The most consistent pattern of caribou distribution within this area during July was use of riparian and coastal insect-relief habitats, typically sandbars, spits, river deltas, gravel river bars, and some barrier islands, by large groups (mean group size 50 to 500) of caribou (Figure 2.11-2; Noel and Cunningham, 2003).

The Central Arctic Herd increased from 5,000 animals in the 1970s to 13,000 in the early 1980s to 23,000 in the early1990s and then declined to 18,000 in the mid 1990s. The decline in the mid 1990s has been attributed to decreased productivity related to changes in calving distribution and increased energy expenditure during the insect season for cows in the eastern portion of the calving range caused by oil field infrastructure (Cameron et al., 2005). However, other factors may be responsible for the changes in herd numbers (e.g., winter mortality, emigration/immigration, Cronin et al., 1997; Cronin, Whitlaw, and Ballard, 2000). The Central Arctic Herd was last estimated at 31,857 caribou in July 2002, a 17% increase from the July 2000 estimate of 27,128 and a 61% increase from the July 1997 estimate of 19,730 caribou (Lenart, 2005a). This increase has been attributed to high parturition rates, high early summer calf survival and low adult mortality (Lenart, 2005a).

Wolves, grizzly bears, and golden eagles prey on caribou, although predation during calving and post-calving may be low for the Central Arctic Herd (Murphy and Lawhead, 2000). Winter mortality may have been higher in the 1990s, because more Central Arctic Herd caribou wintered south of the Brooks Range where wolves may be more abundant and snowfall is heavier (Lenart, 2005a). Harvest and hunting pressure on the Central Arctic Herd increased in the early 1990s due to hunting restrictions on interior Alaska herds and increased access to the Central Arctic Herd with opening of the Dalton Highway to public traffic. Total reported harvest has increased from an average of about 331 in the 1990s to about 470 in the 2000s, with an estimated harvest (reported and unreported) of 813 to 863 in 2004 to 2005 (Lenart, 2005a).

2.11.2 Muskoxen

Muskoxen were extirpated from northern Alaska by the late 1800s (Allen, 1912; Lent, 1998). From 1969 to 1970, 64 muskoxen from Greenland were reintroduced to northeastern Alaska, mostly in the Arctic National Wildlife Refuge (ANWR) but some also near the Kavik River (Jingfors and Klein, 1982). Since that time, the population has expanded its range east into Canada, west into the National Petroleum Reserve-Alaska (NPR-A), and south to areas near the Yukon River (Lenart, 2005b). The Alaskan North Slope population increased in size until the mid 1990s, appeared to stabilize around 550 animals until 2000, and then declined to about 195 by 2005 (Lenart, 2005b). The recent decline in total numbers can be attributed to a localized decline in the ANWR, as aerial counts in 1990 documented 332 and 122 muskoxen in the ANWR and between the Canning and Colville Rivers, respectively, and then 9 and 186 muskoxen in the same respective areas in 2005 (Lenart, 2005b). While emigration from the ANWR may have caused some of the decline in that area, reduced net productivity and recruitment were also evident (Reynolds, Wilson, and Klein, 2002; Lenart, 2005b). Predation by bears or variability in weather that affects forage availability may have been responsible for reduced survival of young and adults (Reynolds, Wilson, and Klein, 2002; Reynolds, Shideler, and Reynolds, 2002).

Muskoxen occur on the Arctic Coastal Plain year-round and use habitats along river corridors, floodplains, foothills, and bluffs in all seasons (Reynolds, Wilson, and Klein, 2002). Muskoxen usually produce single calves and overall have low reproductive potential relative to most ungulate species (Lent, 1988). Most females sampled from northeastern Alaska first bred successfully at 3 years of age, experienced reproductive pauses between calves of 2 or 3 years, and stopped calving by 15 years of age (Reynolds, 2001); these numbers may indicate less production than average for the species (Klein, 2000). Calves are usually born from April through June (Lent, 1988).

Muskoxen eat sedges, forbs, and willow leaves in summer and primarily sedges in winter (Klein, 2000). Spatial habitat models may be used to identify local areas likely to be selected seasonally by muskoxen such as wetter low-lying areas in summer and drier more rugged areas in winter (Lent, 1988; Danks and Klein, 2002). During summer, muskoxen form relatively small groups and travel more widely than during winter when groups tend to be larger and more sedentary (Reynolds, Wilson, and Klein, 2002; Lenart, 2005b). Lenart (2005b) noted a female that moved about 100 miles in a 2-month period during spring, traveling with a larger group for at least half that distance. Aerial surveys have documented relatively small groups near the coast between the Sagavanirktok River and the Badami Unit during spring and summer. Groups of muskoxen were located near the coast next to the Sagavanirktok, Kadleroshilik, Shaviovik, and Kavik Rivers and also on Tigvariak Island (Figure 2.11-3). Group sizes ranged from 1 to 18, with a total of 98 muskoxen observed, though many individuals were likely recounted among surveys. The greatest number of muskoxen documented during a single survey period was 28 individuals among 3 groups on June 1-14, 2002. Calves were present in 1 of these groups near the Kadleroshilik River (Jensen, Noel, and Ballard, 2003).

Grizzly bears kill calf and adult muskoxen, and may become more efficient with experience (Reynolds, Shideler, and Reynolds, 2002). Muskoxen have been legally hunted east of the Canning River since 1982 and between the Canning and Colville Rivers since 1990 (Lenart, 2005b). Subsistence hunting was preferentially allowed until 1998 when registration and drawings hunts were initiated (Lenart, 2005b). The annual harvest has been <4% of the population size and has primarily targeted bulls (Lenart, 2005b).

2.11.3 Grizzly Bears

Alaskan grizzly bears range north to the Beaufort Sea coast, but the coastal plain is considered marginal bear habitat due to severe climate, short growing season, and limited food resources (Shideler and Hechtel, 2000). Grizzly bears have low reproductive potential compared to other North American terrestrial mammals (Pasitschniak-Arts and Messier, 2000). Shideler and Hechtel (2000) reported lower cub mortality for bears feeding on anthropogenic food sources in North Slope oil fields relative to those feeding on natural food sources alone, but higher postweaning human kills may have compensated for greater initial net production. The population trend of grizzly bears between the Colville and Canning rivers is probably stable (Shideler and Hechtel, 2000; Stephenson, 2003). Densities of grizzly bears tend to be lower on the coastal plain (0.5 to 2 bears/1,000 km^2) than in the foothills of the Brooks Range (10 to 30 bears/1,000 km^2; Carroll, 1995), but densities in the oil fields were relatively high with about 60 to 70 resident bears or 4 per 1,000 km^2 (Shideler and Hechtel, 2000).

Because of permafrost, grizzly bear den sites on the coastal plain are generally restricted to well-drained habitats such as pingos, stream banks, hillsides, and sand dunes where insulating snow cover tends to accumulate in the southwestern lee of prevailing winds. Dens are typically used only once (Shideler and Hechtel, 2000). In the North Slope region, bears enter dens between late September and early November and exit between March and May (Shideler and Hechtel, 2000). Cubs are born sightless and helpless in the den during mid-winter (Pasitschniak-Arts, and Messier, 2000). Bears may select well-drained riparian habitats for vegetative forage in spring; wetter herbaceous meadows, riparian habitats, and ground squirrel mounds in summer; and inland areas with berries during the fall (Shideler and Hechtel, 2000). Grizzly bears frequently prey on ground squirrels, and also on bird eggs and nestlings, rodents, fox pups, caribou calves, adult and calf muskoxen, and marine mammal carcasses. Anthropogenic food sources may also be used when available (BPXA, 1998). The average annual home range for 5 radio-collared adult females was about 3,000 km^2; they may travel up to 50 km per day (Shideler and Hechtel, 1995, 2000). Combined field and genetic studies show that bears move across the North Slope, with considerable gene flow among bears in the western Brooks Range, the Prudhoe Bay region, and ANWR (Cronin et al., 2005).

Spring and summer aerial surveys of the coastal area between the Sagavanirktok River and the Badami Unit from 1998 to 2003 documented the presence of grizzly bears (Figure 2.11-3). Spring and summer surveys of the same area in 2001 and 2002 documented 19 bears among 10 groups. Juveniles were present in at least 2 groups (Jensen and Noel, 2002; Jensen, Noel, and Ballard, 2003). Most of the 10 groups were near riparian corridors such as the Shaviovik, Kavik, and Kadleroshilik rivers and were at least 10 km from the coast. The greatest number of bears observed during a single survey period was 5 bears among 3 groups on June 13-14, 2002 (Jensen, Noel, and Ballard, 2003).

Human hunting is the primary source of mortality of adult grizzly bears (Pasitschniak-Arts and Messier, 2000). Wolves and wolverines can kill bear cubs but are not present in appreciable numbers on the Arctic Coastal Plain (Shideler and Hechtel, 2000). Adult male bears may also kill cubs (Ballard et al., 1993). The Alaska Department of Fish and Game manages a sustainable annual harvest of about 5% of the North Slope bear population between the Colville and Canning rivers (Stephenson, 2003). Most bears are taken during the fall by resident hunters. The annual harvest consists mostly of males and has averaged 13.5 bears per year from 1989 to 2002 (Stephenson, 2003). A relatively large number of bears was taken in defense of life or property in 2001, perhaps as a result of reduced anthropogenic food availability in the oil fields (Shideler and Hechtel, 2000; Stephenson, 2003).

2.11.4 Arctic Foxes

Arctic foxes are typically found north of the foothills on Alaska's North Slope (Burgess, 2000). Reproductive potential of the arctic fox is highest among carnivores but influenced by availability and variability of food resources that include rodents, nesting birds and eggs, marine mammal carcasses, and seal pups (Smith, 1976; Quinlan and Lehnhausen, 1982; Tannerfeldt and Angerbjorn, 1998; Anthony, Barten, and Seiser, 2000). Fox populations may cycle in response to prey populations such as lemmings, but anthropogenic or marine resources may buffer against such oscillations (Burgess, 2000; Roth, 2003). Periodic rabies epizootics may also affect arctic fox populations (Ballard et al., 2001; Mork and Prestrud, 2004). Foxes often cache food, may readily switch between prey sources, and are capable of removing over 1,000 eggs per fox per year from nesting bird colonies (Stickney, 1991; Samelius and Alisauskus, 2000).

Arctic foxes may move onto the Beaufort Sea ice in winter to scavenge from polar bear kills, but stable anthropogenic food sources may reduce seasonal movements (Eberhardt, Garrott, and Hanson, 1983b). Similarly, natal den densities were higher within the oil fields near Prudhoe Bay (1/15.2 km^2) than on adjacent undeveloped tundra (1/28.1 km^2; Ballard et al., 2000). Undeveloped areas east of Prudhoe Bay have even lower den densities (Burgess, 2000). Arctic fox dens tend to be fixed features on the landscape and are often located in pingos and low ridges, and next to streams in well-drained sandy soils where snow accumulation is minimal (Chesemore, 1967; Burgess, 2000). Foxes may also den in culverts and road embankments, and underneath buildings (Eberhardt, Garrott, and Hanson, 1983a; Ballard et al., 2000). Many dens are not used in a given year, and the proportion used appears to rely on availability of local food resources (Chesemore, 1967; Eberhardt, Garrott, and Hanson, 1983a).

Spring and summer aerial surveys of the coastal area adjacent to the Liberty (SDI) Project between the Sagavanirktok River and the Badami Unit in 2001 and 2002 documented the presence of arctic foxes and active dens (Figure 2.11-3; Jensen and Noel, 2002; Jensen, Noel, and Ballard, 2003). Locations of foxes were distributed widely both north to south and east to west across the study area. Dens were also distributed widely across the study area, but two were within 1 km of the Badami pipeline west of the Kadleroshilik River. The greatest number of foxes observed during a single survey period was six individuals (4 at dens) on June 17, 2001 (Jensen and Noel, 2002).

Predators of foxes near the project area are mainly brown bears and golden eagles that primarily take pups (Garrott and Eberhardt, 1982; Burgess, 2000). Harvest data for arctic foxes are not available for northeastern Alaska, but indications from trapper reports are that foxes remain common, and trapping pressure has decreased since the late 1980s due to low fur prices (Stephenson, 2001).

2.12 VEGETATION AND WETLANDS

The proposed Liberty (SDI) development will occur by expanding the existing Endicott SDI located on the Endicott Causeway to support ultra extended reach drilling. No terrestrial vegetation will be directly affected by the expansion of SDI. Support for the expansion of SDI will include the development of a gravel mine source located along the Endicott road, approximately 7.5 mi northeast of the Deadhorse Airport. The proposed mine site is adjacent to the existing Duck Island Mine Site. Refer to the Gravel Mine Site and Rehabilitation Plan found at Appendix I of this EA.

The coastal plain in the development area is a vast expanse of wetlands dominated by permafrost landscape features; patterned, polygonized ground and wind-driven thaw-lake complexes. Topographic relief is subtle, giving rise to broadly meandering streams and expansive braided river systems. The gravel mine source and associated ice road route is located on the east side of the western most channel of the Sagavanirktok River delta.

The braided channel system of the Sagavanirktok forms an extensive delta region that supports diverse plant communities. Calcareous sediments transported from the Brooks Range have a regional influence on soil conditions (Walker and Everett, 1991). In contrast to the acidic soils found across much of Alaska’s North Slope, loess deposits from the Sagavanirktok River are evident in the slightly alkali soil pH in this region. This gradient is also manifest at the species level within plant communities of the area (Walker, 1985).

The location of the mine and ice road can be generally described as a complex of wet and moist sedge meadow communities dominated by *Carex aquatilis* and *Eriophorum angustifolium*. *Arctophila fulva* is often present in wetter areas and shallow flooded habitats. Drier habitats support species of *Dryas*, other forbs and grasses, as well as several species of *Salix*. Seasonal flooding and sloughs are common and give rise to barren or sparsely vegetated habitats.

To precisely define and quantify vegetative communities, land cover mapping of the mine area and potential ice road routes occurred in August 2007. To remain consistent with existing land cover maps in the Prudhoe Bay region, the area was mapped using Walker's vegetation and land cover classification scheme. Walker's approach involves categorizing sites with respect to site moisture regime and dominant plant growth forms (and landform type when plant cover is very sparse or nonexistent). The complete vegetation and land cover survey is located in this EA as Appendix H.

2.13 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) of 1973 defines an endangered species as any species that is in danger of extinction throughout all or a significant portion of its range, and a threatened species as any species that is likely to become endangered within the foreseeable future. The bowhead whale (endangered), the Steller's eider (threatened), the spectacled eider (threatened), and the Kittlitz's murrelet (a candidate species) may occur in the general area of the Liberty (SDI) Project (USDOI, MMS, 2002). The MMS conducted Section 7 consultations on these species with the NMFS and FWS for the proposed Liberty (SDI) Project. The consultations are provided at Appendices C and D of this EA.

Two other species (the yellow-billed loon and the polar bear) are addressed in this section as they are being evaluated for listing under the ESA and could be listed while the Liberty (SDI) Project is operational.

2.13.1 Birds

2.13.1.1 Spectacled Eider

The spectacled eider is a seaduck that nests in arctic Russia and western and northern Alaska, and winters in the Bering Sea. The Alaska breeding population has declined markedly especially on the Yukon-Kuskokwim Delta (Stehn et al., 1993) leading to listing under the Endangered Species Act as threatened throughout its range (58 FR 27474). Subsequent research has revealed the species to be widespread on the North Slope (Larned, Stehn, and Platte, 2005).

An estimated 6,731 spectacled eiders seasonally occupy the Arctic Coastal Plain (Larned, Stehn, and Platte, 2006). This value is an index unadjusted for eiders undoubtedly present but undetected. Abundance of spectacled eiders decreases from west to east across the Arctic Coastal Plain. Most high-density areas are west of Harrison Bay, and relatively few pairs are found east of the Shaviovik River. The Liberty (SDI) Project is located near the eastern limit of the North Slope spectacled eider range where spectacled eiders breed in low densities (Larned, Stehn, and Platte, 2005).

Spectacled eiders return from wintering grounds in the Bering Sea to the Arctic Coastal Plain in late May or early June and can be found in the Liberty (SDI) Project area during that entire time. Routes traveled during their spring migration are not well-known, but the North Slope segment may be overland (TERA, 1999). Some spectacled eiders trapped in June near Deadhorse continued on to the Kadleroshilik River, supporting an overland migration for this portion of the route (Troy, 2003).

Spectacled eiders are dispersed nesters (Petersen, Grand, and Dau, 2000). Breeding-pair surveys indicate spectacled eiders may be present across most of the Liberty (SDI) Project area (Larned, Stehn, and Platte, 2005). Nesting has been confirmed at many sites in the Prudhoe Bay oil field (TERA, 1993, 1997) and in the vicinity of the Kadleroshilik and Shaviovik rivers (USDOI, MMS, 2002). Few spectacled eiders are found in the area east of the Shaviovik River (Larned, Stehn, and Platte, 2005; TERA, 2002), but nesting may occur at least as far east as the Okpilak River in ANWR.

Larned et al. (2006) reported on spectacled eider surveys conducted when males and females are on the breeding grounds. Males depart the breeding grounds for coastal areas when the clutch is complete and the hen begins nest incubation. Relative nesting density of spectacled eiders is variable. Larned, Stehn, and Platte (2005) reported an estimated nesting density of 0.61 nesting eiders/km^2 around the proposed gravel pit site. Nesting density appeared lower in 2006 (Larned, Stehn, and Platte, 2006).

Migrant and staging spectacled eiders may occur in offshore waters from late June to September. Postbreeding males depart tundra-nesting areas and may move to nearshore marine habitats during mid- to late June, at the onset of incubation. Females leave from late June through mid-September, depending on their breeding success—failed breeders depart earliest. Shipboard surveys (August to mid-September, Divoky, 1984) and aerial surveys (mid July to early September, Fischer, Tiplady, and Larned, 2002) detected many eiders but no spectacled eiders within the Liberty area. Results from satellite tracking suggest that relatively few postbreeding male spectacled eiders use the Beaufort Sea, and the few that do use it are restricted to the limited ice-free areas such as river deltas (Troy, 2003).

Female spectacled eiders were found to make extensive use of the Beaufort Sea post-breeding, with the highest use area near Smith Bay. The second most important area in the Beaufort Sea for female spectacled eiders was near the Stockton Islands offshore of the eastern end of the Liberty (SDI) Project area (Troy, 2003). Telemetry data from a relatively small number of female spectacled eiders indicated use of marine habitats offshore of the Liberty (SDI) Project area. Given the relatively small proportion of the North Slope population of spectacled eiders breeding east of the Sagavanirktok River, however, it is unlikely that more than 100 spectacled eiders occur in marine waters around the Liberty (SDI) Project area at any one time.

After leaving the coastal plain, spectacled eiders molt in a few locations in arctic and eastern Russia or Ledyard Bay in northwestern Alaska before continuing on to staging areas near St. Lawrence Island and wintering areas in the central Bering Sea (Petersen, Larned, and Douglas, 1999).

2.13.1.2 Steller's Eider

The Alaska breeding population of Steller's eider was listed as threatened in 1997 (59 FR 35896), because of substantial decreases in population and nesting range (Quakenbush et al., 2002). Although historical data suggest that Steller's eiders formerly occurred across much of the Alaska Arctic Coastal Plain, including in the Liberty area, there have been no recent (post-1970) sightings between the Sagavanirktok River and the Alaska–Canada border (Quakenbush et al., 2002) and the species is considered a casual (i.e., not annual) visitant in the Liberty area.

Although there are numerous recent sightings of this species in the Prudhoe Bay area, and a record of a flight-capable brood near Prudhoe Bay in 1993 (Quakenbush et al., 2002), there are no unequivocal records of nesting east of Prudhoe Bay (e.g., Rodrigues, 2002; TERA, 2002; Ritchie, Schick, and Shook, 2003). Aerial surveys for eiders on the Arctic Coastal Plain indicate a wide distribution, but with only a few sightings between the Colville and Sagavanirktok rivers (Quakenbush et al., 2002) and none east of the Sagavanirktok River (W. Larned, FWS, pers. commun.; Larned, Stehn, and Platte, 2005). The extent of offshore use by Steller's eiders is poorly known (USDOI, MMS, 2002). A dark-plumaged Steller's eider observed near Northstar in early October 2004 (R. Day, ABR, pers. commun.) may be the only offshore record in this part of the Beaufort Sea.

2.13.1.3 Kittlitz's Murrelet

The Kittlitz's murrelet (*Brachyramphus brevirostris*) is a small alcid seabird found in discontinuous populations in both the east and west North Pacific Ocean and adjacent Arctic waters. Major population centers are Prince William Sound and Glacier Bay. Presence in the Beaufort Sea has not been confirmed, but it is possible they occur there in small numbers (USDOI, FWS, 2006b).

Kittlitz's murrelets are typically associated with glacially influenced inlets (Day, Kuletz, and Nigro, 1999; USDOI, FWS, 2004) on most parts of their range where they prefer waters within about 200 m of shore. There are no glacial inlets along the Chukchi or Beaufort sea coastlines. Divoky (1987) found Kittlitz's murrelets had pelagic distribution from approximately 21 km to 213 km offshore, with the farthest distance offshore found during the 24 August-22 September survey period.

Spring migration for Kittlitz's murrelets in the nearby Chukchi Sea is unknown, but it could be assumed they follow the retreating ice front in spring. Kittlitz's murrelets may follow offshore leads north to take advantage of the abundant under ice plankton blooms and the large biomass of forage species associated with those blooms. Kittlitz's murrelets seen along the Chukchi Sea coast in summer probably move south with the advancing ice front. Postbreeding distribution is poorly understood, but is likely farther offshore than prebreeding season. Winter distribution is poorly understood, but is probably pelagic in the Bering Sea.

The average age of first breeding for marbled murrelets is also not known, but based on other alcids of similar size, it is assumed to be between 2 and 5 years, with 3 years as a likely average (DeSanto and Nelson, 1995; Beissinger and Nur, 1997; Boulanger et al., 1999). Little is known about the reproductive strategy of the Kittlitz's murrelet because nesting sites are difficult to find (Day et al., 1999). Birds appear to be paired upon arrival to the breeding grounds. Egg-laying ranges from mid-May to mid-June depending on the population and range. One egg per clutch with one clutch per year is speculated. Both parents incubate and feed their young. Fledging in northern populations is generally during August.

Nests have been found at the distal end of the Delong Mountains south near Cape Thompson (USDOI, FWS, 2004). The Center for Biological Diversity (CBD) believes the species nests as far north as Cape Beaufort between Cape Lisburne and Point Lay (CBD, 2001).

The diet of the Chukchi summer residents is unknown, but Kittlitz's murrelets along the Chukchi coast during summer may be feeding on Arctic cod (*Boreogadus saida*), Pacific sand lance (*Ammodytes hexapterus*), capelin (*Mallotus villosus*), or euphausiids that are relatively abundant in some localities. Similar to other small seabirds, Kittlitz's murrelets may be living close to their bioenergetic threshold most of the year and must forage with regularity to survive.

Recent population estimates for more southern populations are available (USDOI, FWS, 2004), but estimates for the nearby Chukchi Sea population are dated. The Center for Biological

Diversity estimates the Kittlitz's murrelet population along the Chukchi Sea coastline (including Wrangel Island) was 450 in 1993 and 171 in 2000 (CBD, 2001). The number of murrelets using the Liberty (SDI) Project area is unknown, but would be expected to be very small, if they occur there at all.

2.13.1.4 Other Species That May be listed under ESA Within the Life of the Project

The yellow-billed loon (*Gavia adamsii*) occurs in the Liberty (SDI) Project area. This species was petitioned for listing under the ESA on March 30, 2004 (CBD, 2004). Since that time, a status assessment and Conservation Agreement have been developed (Earnst, 2004; USDOI, FWS, 2006a). The draft 90-Day Finding on the petition was expected to be published in the *Federal Register* (*FR*) in early June 2007 (USDOI, FWS, 2007). The yellow-billed loon is included in this section because of the high potential that it will receive protection under the ESA during the life of the Liberty (SDI) Project.

Yellow-billed Loon

The total world-wide population of yellow-billed loons is estimated at 16,000 individuals, of which the northern Alaska breeding grounds support on average 3,369 individuals, including <1,000 nesting pairs/year. No declining trend was apparent in the number of yellow-billed loons estimated from breeding-bird surveys on the Arctic Coastal Plain, but survey variability was high and the power to detect trends was low (Earnst, 2004).

Yellow-billed loons first arrive in northern Alaska during the last 10 days of May. Individuals and small groups gather in open river channels, and larger flocks gather in marine bays until sufficient open water develops around the margin of lakes and ponds used for nesting. Loons generally nest and lay eggs during mid- to late June, with hatch in mid- to late July and young can fly by mid- to late September (Earnst, 2004).

Most yellow-billed loons nest between the Meade and Colville rivers on the Alaskan Arctic Coastal Plain, although they may also breed sparsely east of the Colville River to the Canning River (Earnst, 2004). Relative density of yellow-billed loons in the Liberty (SDI) Project area was <0.01 loons/km^2 based on breeding-pair surveys during July 1998-2001 (Mallek, Platte, and Stehn, 2002). Yellow-billed loons require nesting and broodrearing lakes that are large enough to allow takeoff from open water, form an ice-free moat around shore in early spring that protects nests from wind-blown ice and allow adults to take off, support a substantial population of small fish, have a section of gently sloping shoreline for nesting and brooding, and have sheltered areas where young chicks can rest and hide (Earnst, 2004).

Adult yellow-billed loons with territories near the coast as well as nonbreeding individuals may travel to marine waters to forage (Earnst, 2004). In the shallow nearshore waters of the Alaskan Beaufort Sea, yellow-billed loons were most abundant in Harrison Bay during July (Fischer and Larned, 2004).

Adults leave their territories during late August to mid September and successful breeders leave soon after their chicks can fly. Yellow-billed loons sometimes remain in open rivers until forced out by ice in late September to early October. Adults may migrate separately from offspring, and may migrate following leads in the pack ice far from shore in the Chukchi Sea and Beaufort Sea. Yellow-billed loons reach wintering sites off the coast of Japan, North Korea, and the Yellow Sea between North Korea and China where they remain by the end of November (Earnst, 2004).

2.13.2 Mammals

2.13.2.1 Bowhead Whale

The bowhead whale was listed as endangered on June 2, 1970. The Bering-Chukchi-Beaufort Seas bowhead whale also is classified as a strategic stock, because it is listed as endangered under the ESA and also is designated as depleted under the Marine Mammal Protection Act (MMPA). No critical habitat has been designated for the species, although the National Marine Fisheries Service (now NOAA Fisheries) recently received a petition to designate critical habitat for bowhead whales.

The Western Arctic stock of bowhead whales was estimated to be 8,000 individuals in 1993 with a range between 6,900 and 9,200 individuals with a 95% confidence interval (Zeh, George, and Suydam, 1995; Hill and DeMaster, 1999). Zeh, Raftery, and Schaffner (1995) subsequently revised this population estimate by incorporating acoustic data that were not available when the earlier estimate was developed. The revised estimate of the population was between 7,200 and 9,400 individuals in 1993, with 8,200 as the best population estimate, and the estimate recognized by the International Whaling Commission. This revised population estimate also was the population estimate used by NOAA Fisheries in their stock assessments (Hill and DeMaster, 1999; Angliss, Lopez, and DeMaster, 2001). An alternative method produced an estimate of 7,800 individuals with a 95% confidence interval of 6,800 to 8,900 individuals. Zeh, Raftery, and Schaffner (1995) estimated that the Western Arctic stock increased at a rate of 3.2% per year from 1978 to 1993. Recently George et al. (2004) reported that the Western Arctic bowhead population numbered approximately 10,470 animals in 2000. The minimum population estimate calculated by Angliss and Lodge (2004) for the Western Arctic bowhead stock is 8,886 whales. Angliss and Outlaw (2007) indicate the most recent minimum population estimate to be 9,472 bowhead whales, using the 2001 abundance estimate. The increase in the estimated population size is most likely due to a combination of improved data and better censusing techniques, along with an actual increase in the population. The historic population before commercial whaling was estimated at 10,400 to 23,000 whales in 1848, compared to an estimate of between 1,000 and 3,000 animals in 1914 near the end of the commercial-whaling period (Woody and Botkin, 1993).

Information on many aspects of bowhead-whale natural history is discussed in the Liberty DPP FEIS (USDOI, MMS, 2002). Topics discussed include wintering areas and habitats, spring and fall migration routes, tagging studies that describe bowhead movements and speed, effects of oceanographic conditions on bowhead migration, results of aerial survey data collected in the Liberty (SDI) Project area, traditional knowledge of bowhead movements, and aging techniques. The Liberty DPP FEIS points out that little is known about natural mortality in the Bering, Chukchi, and Beaufort seas, or about age at sexual maturity or mating behavior and timing.

The Liberty DPP FEIS also contains a lengthy discussion of bowhead feeding behavior and prey availability. Based on contents of stomach samples, some level of feeding occurs during spring migration and the area west of Barrow may be an important feeding area in some years. Bowhead feeding has also been reported in the eastern Beaufort Sea and the Amundsen Gulf region in Canada during the summer and in the Beaufort Sea during fall migration, but the importance of these areas in the annual activity budgets of bowheads is not known. A study by Richardson (1987) concluded that food consumed in the eastern Beaufort Sea did not contribute significantly to the overall bowhead whale population's annual energy needs, although the area may be important to some individual whales in some years. The amount of feeding that occurs in the Beaufort Sea during fall migration appears to vary from year to year.

More recently, Lee et al. (2005) studied stable isotope in bowhead baleen and suggested that the Western Arctic population of bowhead whales acquires the bulk of its annual food intake from the Bering-Chukchi system, where the whales spend much of the fall plus the winter and early spring. The data indicate that bowheads acquire only a minority of their annual diet from the eastern and central Beaufort Sea where they spend the summer. However, subadults apparently feed in the central and eastern Beaufort Sea more frequently than adults. Lee et al. (2005) indicate that their conclusions are based on some uncertainties and that additional sampling would be valuable in refining the present estimates and the overall understanding of seasonal feeding by bowheads.

Near Kaktovik in the fall, bowheads apparently feed primarily on copepods and to a lesser extent on euphausiids (Lowry and Sheffield, 2002). However, in the western Beaufort Sea near Barrow fall bowhead whale diet was dominated by euphausiids. Stomach samples of 14 whales taken in spring at Barrow contained almost entirely euphausiids and 6 had nearly all copepods (Lowry and Sheffield, 2002). Significantly more copepods were reported in spring versus fall bowhead-stomach samples.

Bowhead whales migrate parallel to the north coast of Alaska during fall. Fall migration typically begins out of the Canadian Beaufort Sea in late August and early September (Schick and Urban, 2000) and continues through the Alaskan Beaufort Sea throughout October. A peak in the number of whales transiting through the Beaufort Sea typically occurs in the middle of September. Inupiat whalers from Kaktovik and Nuiqsut (based from Cross Island) each harvested 4 bowhead whales near the middle of September 2006 (Pausanna, 2006).

During the westward autumn migration bowhead whales are generally seaward of the barrier islands with annual variability in the mean distance offshore (Treacy, 2002a). The mean distance of migrating bowheads from shore in the Beaufort Sea west of Prudhoe Bay in 2000 (17.7 km) was less than for any single year (1982-2000) and much less than the cumulative mean (35.4 km; Treacy, 2002a). Blackwell et al. (2004) also reported interannual variability in the proximity of migrating bowheads to shore in the southern portion of the bowhead migration corridor near Prudhoe Bay. The migration corridor tended to be closer to shore in 2003 than the previous 2 years. Bowheads appear to migrate farther offshore during heavy-ice years and nearer shore during years of light sea-ice (Treacy, 2002b; Monnett and Treacy, 2005).

2.13.2.2 Polar Bears

Denning female polar bears could be impacted by noise from the SDI expansion. Polar bears sometimes choose terrestrial den sites near the coast, along lakeshores, on riverbanks, and in other areas with unique topographical features (Durner, Amstrup, and Ambrosius, 2001; Durner, Ambrosius, and Fischbach, 2003). Durner, Amstrup, and Ambrosius (2001) identified large areas along the coast and adjacent areas along the Sagavanirktok River near the SDI that are suitable for terrestrial maternal-den sites. Additionally, the proportion of maternal dens in terrestrial versus pack-ice habitats appears to be increasing in recent years. Fischbach, Amstrup, and Douglas (2007) reported that the proportion of dens on pack ice declined from 62% during 1985 to 1994 to 37% during 1998 to 2004. Changes in ice quantity and quality related to climate change could result in increased numbers of terrestrial maternal-den sites near the Liberty (SDI) Project in future years (Fischbach, Amstrup, and Douglas, 2007).

Note: This section was originally prepared by a contractor for BPXA. Much of the text was taken directly from the 2002 Liberty FEIS. This section updates information generated since the 2002 Liberty FEIS and provides site-specific information for the current Liberty (SDI) Project.

The MMS has revised this section to a limited extent for accuracy, clarity, completeness, and consistency with other MMS NEPA documents.

On February 16, 2005, the CBD petitioned the FWS to list the polar bear as a threatened species under the ESA because of melting of their sea ice habitat (CBD, 2005). In June 2005, the IUCN/SSG (World Conservation Union/Species Survival Commission) Polar Bear Specialist Group (PBSG) concluded that the IUCN Red List classification of the polar bear should be upgraded from Least Concern to Vulnerable, based on the likelihood of an overall decline in the size of the total world polar bear population by more than 30% within the next 35 to 50 years. The principal reason for this projected decline is "climatic warming and its consequent negative effects on the sea ice habitat of polar bears" (IUCN/SSG, Polar Bear Specialist Group, 2005). On February 7, 2006, the 90-day finding by the FWS determined that the CBD petition contained sufficient information indicating that listing polar bears as threatened may be warranted. The FWS conducted a 12-month status review of the species to determine whether listing was warranted and concluded the status review with a positive finding. On January 7, 2007, the FWS proposed to list the polar bear as a threatened species under the ESA.

Per the FWS *Federal Register* notice dated January 9, 2007, entitled *Endangered and Threatened Wildlife .... Proposed Rule To List the Polar Bear (Ursus maritimus) as Threatened Throughout Its Range* ... the following statment regarding oil and gas activities is quoted:

> Historically, oil and gas activities have resulted in little direct mortality to polar bears, and that mortality which has occurred, has been associated with human bear interactions as opposed to a spill event. However, oil and gas activities are increasing as development continues to expand throughout the United States Arctic and internationally, including in polar bear terrestrial and marine habitats. The greatest concern for future oil and gas development is the effect of an oil spill or discharges in the marine environment impacting polar bears or their habitat.

Polar bear seasonal distribution and local abundance vary widely in the Alaskan Beaufort Sea. Sea ice and food are the two most important natural influences on polar bear distribution. Polar bear use of coastal areas during the fall open-water period has increased in recent years (Kochnev et al., 2003; Schliebe et al., 2005). Nearshore densities of polar bears can be two to five times greater in autumn than in summer (Durner and Amstrup, 2000). For example, aerial surveys flown in September and October from 2000 to 2005 have revealed that 53% of the bears observed along the coast have been females with cubs, and that 73% of all bears observed were within a 30-km radius of the village of Kaktovik, on the edge of the ANWR (Schliebe et al., 2005). Congregations of more than 60 polar bears and as many as 12 brown bears have been observed feeding on whale carcasses near Kaktovik in recent years during the fall open-water period (Miller, Schliebe, and Proffitt, 2006). These observed changes in polar bear distribution have been correlated with the distance to the pack ice at that time of year. The farther from shore the leading edge of the pack ice is, the more bears are observed onshore in fall (Kochnev et al., 2003; Ovsyanikov, 2003; Schliebe et al., 2005; Kochnev, In prep.).

Drifting pack ice off the coast of the Alaskan Beaufort Sea probably supports more polar bears than either shorefast ice or polar pack ice, probably because young seals are abundant in this habitat. Durner et al. (2004) studied polar bear use of sea-ice habitats and reported that female polar bears preferred areas with relatively shallow water and high ice concentration. Polar bears sometimes concentrate along Alaska's coast when pack ice drifts close to the shoreline, at bowhead whale-carcass locations such as Cross and Barter islands (Kalxdorff et al. 2002), and when shorefast ice forms early in the fall. During fall and winter, polar bears occur along the Beaufort Sea coast and on barrier islands. Kalxdorff et al. (2002) reported 97 polar bear sightings during four aerial surveys along the mainland coast and barrier islands between Harrison Bay and Kaktovik during fall 2001. Moulton and Williams (2003) reported 46 sightings of polar bears during spring aerial surveys while monitoring marine mammals for BPXA's Northstar development in 2002. Most of the sightings were located near and north of Cross Island, and no sightings were reported in the Liberty area. Polar bears are mobile and bears from the Chukchi and northern Beaufort seas often occur in the southern Beaufort Sea (Amstrup, McDonald, and Durner 2004).

Pregnant and lactating females with newborn cubs are the only polar bears that occupy winter dens for extended periods. Durner, Amstrup, and Fischback (2003) reported that dens in northern Alaska were constructed in ice and snow and usually consist of a simple chamber with a single entrance/egress tunnel, although multiple chambers and tunnels were reported at some dens. Dens were located on or associated with pronounced landscape features such as coastal and river banks, lake shores and an abandoned oil field gravel pad. Durner, Amstrup, and Ambrosius (2001, 2006) mapped the locations of suitable polar bear denning habitat on the Alaskan Arctic Coastal Plain including the Liberty (SDI) Project area.

In addition to being protected by the MMPA and proposed to be listed under the ESA, polar bears and their habitats are covered further by the International Agreement on the Conservation of Polar Bears. This 1976 agreement among Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States addresses protection of "habitat components such as denning and feeding sites and migration patterns." A bilateral agreement between the United States and Russia to conserve polar bears in the Chukchi/Bering seas also was signed in October 2000.

In 1988, the Inuvialuit Game Council from Canada and the North Slope Borough from Alaska implemented the Polar Bear Management Agreement for the Southern Beaufort Sea, a voluntary agreement that limited the total harvest from the SBS population to within sustainable levels (Brower et al., 2002).

2.14 CULTURAL RESOURCES

Cultural resources in and/or near the Liberty (SDI) Project area may include sites and materials of prehistoric Native American (e.g., habitation sites, lithic scatters, and isolated finds), historic European and Euro-American, and historic Iñupiat origin (e.g., traditional cabin and subsistence sites, campsites, burial grounds, and other traditional land-use areas, landscapes, symbols, and place names).

Sources for information about cultural resources include:

- The Alaska Heritage Resources Survey (AHRS) maintained by the Alaska Department of Natural Resources, Office of History and Archaeology (ADNR, OHA, 2005);
- The Traditional Land Use Inventory (TLUI) maintained by the North Slope Borough (NSB, 2003); and
- Reports associated with oil and gas exploration and development. In particular, the Liberty Project Environmental Report (LGL, WCC, and Applied Sociocultural Research, 1998) and the Liberty DPP FEIS (USDOI, MMS 2002) provided relevant information.

The TLUI is a list of important cultural sites and subsistence use areas, with the core information being the traditional knowledge and accounts of elders applied to the land use history and patterns of individual communities including the village of Nuiqsut (e.g., NSB, 1976, 1978; Hoffman, Libbey, and Spearman, 1988; Brown, 1979; Ito-Adler and Hall, 1986; and IAI, 1990a); Kaktovik (e.g., Jacobson, No date; Jacobson and Wentworth, 1982; Pedersen, Coffing, and Thompson, 1985; and IAI, 1990b); and overviews of cultural resources in the Beaufort Sea region (e.g., NSB, 1977, 1980, 1981, No date.; Nielson, 1977; Hall, 1981; Libbey, 1981; Okakok, 1981; Pedersen, No date, 1995; Galginaitis et al., 1984; Pedersen and Coffing, 1984; Coffing and Pedersen, 1985; IAI, 1985, 1990a). Research pertaining to cultural resources in the Beaufort Sea region is included in lease sale EIS's (e.g., USDOI, BLM, 1979, 1982; USDOI, MMS, 1984, 1987, 1990a, 1990b, 1996a, 1990b, 1997); development EIS's (e.g., USDOI, BLM, 2004a, 2004b, 2005; USDOI, MMS, 2002; U.S. Army Corps of Engineers and ERT, 1984); and focused survey reports conducted as part of the permitting process for individual wells and other exploratory/development projects including the Liberty Development Project (e.g., Lobdell, 1980, 1985, 1986, 1990, 1991, 1993, 1995, 1996, 1998a, 1998b, 1998c; Lobdell and Lobdell, 1999, 2000a, 2000b; WCC, 1981; Duane Miller and Associates, 1997; Watson Company, 1999; Reanier, 2000, 2002, 2003). Lobdell (1998a, 1998b) conducted cultural resources surveys for the Liberty Project area in 1997 and 1998. No previously unknown or unrecorded cultural resources were identified during these surveys, and while no cultural resources were within the project footprint originally proposed, two historic sites were located within 1 mi of originally proposed project components.

The area of potential effect of the alternatives originally considered in the Liberty DPP FEIS included an area that encompassed a manmade gravel island located in Foggy Island Bay with full production facilities, subsea pipeline, the area around the landfall of this pipeline from the production facility, and the tie-in of this pipeline with the Badami Sales Oil Pipeline. The Liberty (SDI) Project now includes an expansion of the existing Endicott Satellite Drilling Island for the well pad and existing infrastructure. Two alternatives (well pads located at Pt. Brower and near the Kadleroshilik River and using Endicott and Badami, respectively, as processing hosts) are onshore developments that take advantage of existing infrastructure. These onshore alternatives do not expand the potentially affected area.

Section 4.2.1 contains details on the permitting process that will be followed to assure the avoidance or mitigation of cultural resources, including in the new gravel mine site planned for the project.

2.14.1 Prehistoric Resources

BPXA contracted with Reanier & Associates, Inc. to conduct an archaeological and cultural resources reconnaissance survey of the current Liberty (SDI) Project that included onshore gravel source sites and the expanded SDI footprint. The survey was completed in August 2007, and no new cultural resources were discovered. There are no previously known sites within the proposed Liberty (SDI) Project area.

2.14.2 Historic Resources

The MMS, after consulting the State of Alaska AHRS database, has identified no cultural and archaeological sites offshore, nearshore, or onshore within the proposed Liberty (SDI) Project area.

2.15 SOCIOECONOMICS

2.15.1 Economy

The discussion of economics addresses the affected environment in a national, State, and local (particularly Alaska North Slope) context. This section incorporates by reference the relevant material on economics contained in the original Liberty Project Environmental Report (LGL, WCC, and Applied Sociocultural Research, 1998), Liberty DPP FEIS (USDOI, MMS, 2002), other North Slope EIS's completed since 2002, including the Alpine Satellite Development Plan (USDOI, BLM, 2004a); the Northwest National Petroleum Reserve-Alaska Final Amended Integrated Activity Plan (USDOI, BLM, 2004b); the Northeast National Petroleum Reserve-Alaska Final Amended Integrated Activity Plan (USDOI, BLM, 2005); the Proposed OCS Lease Sales 193 (USDOI, MMS, 2006a), 195 (USDOI, MMS, 2004), and 202 (USDOI, MMS, 2006b; see also USDOI, MMS, 2003); the TAPS Right-of-Way Renewal (USDOI, BLM, 2002); and the National Research Council (NRC) study of the cumulative effects of oil and gas activities on Alaska's North Slope (NRC, 2003).

The description of the affected environment from an economic perspective can be summarized simply as follows: domestic crude oil production is critically important at the national, State, and local (North Slope Borough) levels.

2.15.1.1 National Level

As recently as the end of World War II, the United States was self-sufficient in crude oil. Since then, the rate of increase of U.S. crude oil consumption greatly outpaced that for domestic production and the U.S. has become a net importer. Current projections (EIA, 2005) indicate that U.S. dependence on foreign oil producers will grow to 70% of U.S. demand by 2025. Additional imports adversely affect the balance of trade, exacerbate domestic inflation, reduce the gross domestic product, and increase reliance on imports from countries that are unstable and/or unfriendly to the United States.

2.15.1.2 State Level

Petroleum contributes substantially to gross state product, employment (and high-paying employment), and revenues. For example, the combination of petroleum taxes and royalties since production began on the North Slope annually contributed between 60 and 90% of total State unrestricted fund revenues. Since the Liberty FEIS was completed in 2002, these revenues from the North Slope have approximately tripled from approximately $1 billion to $2.8 billion (Alaska Department of Revenue, Revenue Sources Book, 2006).

Petroleum also is important to the State economy, because it is the funding source for Alaska's largest financial asset—the Alaska Permanent Fund. The Permanent Fund was established in 1978 to be a savings account to hold a share of the royalties (petroleum production owned by the State of Alaska) received by the State. The rationale for its establishment was that the fund would grow over time as production declined, and the earnings of the fund eventually would substitute for oil production as a source of revenues to help support necessary public spending on education and other public programs. Since the fund's inception, the Alaska constitution has required that 25% of royalties be deposited into the fund. In addition, annual deposits to offset the erosion of the value of the fund due to inflation have been made since the early 1980s, and on occasion, special deposits have also been added to the principal, which cannot by law be spent. The fund is invested in a diverse portfolio of stocks, bonds, and real estate, and has grown in value to nearly $33 billion as of the end of June 2006 (http://www.apfc.org/theapfc/faq.cfm).

2.15.1.3 Local Level

The Liberty FEIS provides data on the contribution of taxes on petroleum facilities to the North Slope Borough. According to the 2005 NSB Annual Financial Report, nearly $200 million of the $315 million total NSB revenues came from property taxes, almost exclusively on oil industry facilities. This same report (page iii) stated:

> Since 1968, oil and gas exploration and development on Alaska's North Slope has become the principal industry in the Borough and the employer of the bulk of the Borough's workforce. The other service providers, including the government sector, exist primarily due to the presence of the oil and gas industry (NSB, http://www.north.slope.org/nsb/default.htm).

The NSB communities have also been affected by growth in the capacity of State government to provide services to local communities as a result of the petroleum revenues flowing to the State although recent developments, such as the suspension of State revenue sharing with local communities, have created difficulties in funding infrastructure in many smaller villages. Enhancement of the quality of primary and secondary education is the most obvious example of service improvement, but others such as health care, transportation infrastructure, and public safety have also benefited. These services produce additional jobs and income for local residents. Petroleum revenues have also allowed the State to keep the tax burden on Alaskan households low, and along with the Permanent Fund Dividend, have substantially increased the discretionary income of all Alaskan households, supporting a large number of jobs in this and other regions of the State. As noted by MMS (USDOI, MMS, 2002): "Social services have increased dramatically since 1970, with increased Borough budgets and grants acquired early on by the Iñupiat Community of the Arctic Slope, and later by the Arctic Slope Native Association and other borough nonprofits."

Revenues from the oil industry have been important to the success of Native corporations, such as the Arctic Slope Regional Corporation. This success, in turn, provides jobs for Alaskan Natives and dividends for shareholders, although local hire in the oil patch remains low. In 1992, Natives employed at Prudhoe Bay comprised less than 1% of the 6,000 North Slope oil industry workers. This pattern is confirmed by 1998 data showing only 10 NSB Inupiat residents as employed in the oil industry (see, e.g., USDOI, MMS, 2003; NRC, 2003).

In short, all levels of government stand to gain economically from increased domestic crude oil production and other measures (e.g., conservation initiatives and the development of alternative energy sources) to reduce dependence on imported oil. Higher crude-oil prices adversely affect the national government, but benefit Alaska. Development of the Liberty (SDI) Project will not solve the Nation's energy problem, but is fully consistent with the National Energy Strategy. Liberty is one of the projects included in the State's projections of future oil production and revenues. Quantitative estimates of the economic impacts associated with development of the Liberty (SDI) Project are provided in the discussions of the economic impacts of the proposed action and no-action alternative.

2.15.2 Sociocultural Systems

"Sociocultural systems" as used in the Liberty FEIS (USDOI, MMS, 2002) encompass: "…the social organization and cultural values of a society." Included under this rubric, the FEIS provided a profile of the sociocultural systems that characterize the North Slope communities of Barrow, Nuiqsut, and Kaktovik—communities that might be impacted by this development. The quantitative data included in this section were based largely on the results of the 1990 Census. Results of the 2000 Census are now available and several EIS's incorporate these data, including the Alpine Satellite Development Plan (USDOI, BLM, 2004a); the Northwest National Petroleum Reserve-Alaska Final Amended Integrated Activity Plan (USDOI, BLM, 2004b); the Northeast National Petroleum Reserve-Alaska Final Amended Integrated Activity Plan (USDOI, BLM, 2005); the Proposed OCS Lease Sales 193, 195, and 202 (USDOI, MMS, 2006a, 2004, 2006b; see also USDOI, MMS, 2003); the TAPS Right-of-Way Renewal (USDOI, BLM, 2002); and the NRC study of the cumulative effects of oil and gas activities on Alaska's North Slope (NRC, 2003). Another useful report published since the Liberty FEIS was written by Northern Economics, Inc. (2006). All are incorporated by reference.

2.15.2.1 Demographics

Although new Census data are available, these data do not materially alter the findings and conclusions presented in the Liberty FEIS. Selected demographic information in summary form includes:

- The NSB is the largest borough in Alaska, accounting for 15% of the area of the State. Were the NSB a State, it would rank 12th in area (at 89,000 mi^2 in area, this borough is slightly larger than the State of Minnesota). The borough includes eight villages: Anaktuvuk Pass, Atqasuk, Barrow, Kaktovik, Nuiqsut, Point Hope, Point Lay, and Wainwright.
- Table 2.15-1 provides additional demographic information on the NSB communities including year incorporated, land and water area, population (in total and by gender), median age, median 1999 household income, percentage of families below the poverty level, selected housing characteristics, available health services, schools, transportation and communications, and alcohol restrictions. The Census of 2000 counted 7,367 persons as residents of the NSB, for an average population density of approximately 1 person/12.1 mi^2.
- Ethnically, more than 70% of the NSB population is all or partially Iñupiat. The NSB accounts for approximately 4.6% of the Alaska Native population of the State (Goldsmith et al., 2004). As shown in Table 2.15-1, there are substantial ethnicity differences among the NSB villages; Barrow's population is approximately 64% Iñupiat, whereas this percentage is consistently higher in the seven smaller villages. As noted in USDOI, MMS (2002), the ethnicity of Barrow has changed in recent years: "In 1970 the Iñupiat population of Barrow represented 91% of the total population…. By 1990, Iñupiat representation had dropped to 63.9%." For comparison, the percentages of American Indian and Alaskan Native persons in Alaska and the total U.S. are 15.6% and 0.9%, respectively (http://quickfacts.census.gov/qfd/states/02000.html).
- For the most part, communities in the NSB have younger populations than the U.S. as a whole. For example, according to 2000 Census estimates, the median ages of residents of Barrow, Kaktovik, and Nuiqsut were 28.8, 32.1, and 23.8 years of age, respectively.

Median ages of all Alaskan residents and all U.S. residents were 32.4 and 35.3 years of age, respectively (USDOC, Bureau of the Census, 2001). Goldsmith et al. (2004) show that Alaska Natives are a young population compared with other Alaskans and other Americans.

- Median household incomes for Barrow, Kaktovik, and Nuiqsut were $67,097, $55,625, and $48,036, respectively, reflecting enhanced earning opportunities in Barrow compared to the other two communities. Corresponding figures for Alaska and the United States were $51,571 and $41,449, respectively (http://quickfacts.census.gov/qfs/states/02000.html). These figures need to be interpreted with care, however, as costs of living are higher in the NSB than in the major cities of Alaska or the other states (see e.g., Goldsmith et al., 2004).
- Table 2.15-1 provides 2000 Census data on the percentage of housing units lacking complete plumbing facilities, kitchen facilities, and telephone service for the NSB communities. These percentages are greater than corresponding percentages for the rest of the United States, which reflects the remoteness of the region and the cost and logistical difficulties of providing certain services in the Arctic.

2.15.2.2 Social Organization and Cultural Values

The Liberty FEIS (USDOI, MMS, 2002) provides an in-depth discussion of the nature of Iñupiat life. Key points are discussed below.

Kinship is the foundation for social organization in Iñupiat communities and plays an important role in all aspects of Iñupiat life. Iñupiat households were historically comprised of large extended families and were part of a larger community kinship unit. An Iñupiat household on the North Slope may contain a single individual or group of individuals who are related by marriage or ancestry. Iñupiat households generally depend on the regular involvement of extended family members in providing economic support. Iñupiat social organization includes not only household and family kinship ties, but a larger social network of friends and kin. These networks are linked through overlapping memberships and are involved in the organization of formal and informal subsistence groups. Iñupiat social networks determine how subsistence resources are harvested, distributed, and consumed. Sharing is a regular and expected part of maintaining strong kinship bonds, and a generous person is regarded with esteem in the community.

Traditional Iñupiat cultural values focus on a close relationship to the land, natural resources, the supernatural, and the community, its needs, and its support of individuals. Historically and traditionally, survival in the Arctic centered on the pursuit of subsistence resources and the knowledge needed to find, harvest, process, store, and distribute the harvest. Iñupiat culture depends on the intergenerational transmission of traditional knowledge and beliefs about subsistence resources including observations of game behavior, how to use those observations to successfully locate and harvest game, and how hunters and their families should behave to ensure successful future harvests. Despite recent economic, technological, and social changes in the region, subsistence remains an essential and vital part of Iñupiat life and provides the basis for cultural values and social organization. The process of obtaining, refining, and passing on subsistence skill is inextricably linked to the Iñupiat culture, which is based on interdependent family groups and a tradition of sharing harvested resources. The majority of North Slope residents self-identify as subsistence hunters and harvesters, and they continue to participate in subsistence activities throughout the year.

Subsistence activities play an important role in defining Iñupiat cultural values such as social organization, cooperation and sharing, and the formation of kinship ties (USDOI, MMS, 2002). Cultural values are exemplified by bowhead whale hunting, which has been a central part of Iñupiat culture for at least 1,000 to 1,500 years. Bowhead whale hunting remains the center of Iñupiat spiritual and emotional life; it embodies the values of sharing, association, leadership, kinship, arctic survival, and hunting prowess; and it is at the core of Iñupiat cultural identity. The whale hunt encompasses key Iñupiat values and provides the basis for social organization in many Iñupiat communities (Galginaitis and Funk, 2004). Individual organization of whaling crews is often an indicator of a larger organizational pattern within the Iñupiat community and often defines social ties and leadership roles (USDOI, MMS, 2002). The whale hunt is a village-wide cooperative event. In addition to the boat crews who participate in yearly whale hunts, most people in the villages are involved in other aspects of support, such as butchering and processing (Richardson and Thomson, 2002). Structured sharing of subsistence resources is evident both within and among communities, forming kinship bonds and social networks between individuals and villages. These relationships are essential to maintaining cultural values and social structure. Disruptions to individual harvest success could potentially affect the Iñupiat system of sharing, a process which is vital to the social structure of Iñupiat communities (USDOI, BLM, 2005).

While Iñupiat lands are important for the harvest areas and resources they provide, they also hold a deeper meaning to the residents of the North Slope communities. Traditionally, areas were named for the extended family groups that inhabited them, and eventually, the Iñupiat divided the area into people of the land (Nunamiut) and people of the coast (Taermiut) (Spencer, 1976 as cited in USDOI, BLM, 2005). For example, some of the people who resettled Nuiqsut identified themselves as Kuukpikmuit, or "people of the Colville River Delta." Maintaining a connection to this land is a priority for residents in these Iñupiat communities.

2.15.2.3 Institutional Organization of the Communities

The Liberty FEIS (USDOI, MMS, 2002) provides information on organizations operating in or around the North Slope Borough. Key points include:

- The majority of community services in North Slope communities are provided by the NSB, which is also the largest employer of North Slope residents and provides local services such as public safety, public utilities, fire protection, and some public health services. NSB revenues, primarily from oil industry taxation, fund these services. (See the section on economics.)
- The Arctic Slope Regional Corporation, which was formed under the Alaska Native Claims Settlement Act, runs a number of subsidiary corporations on the North Slope and throughout Alaska. Most communities also house local governments that provide varying degrees of services to North Slope villages. These include village corporations, Traditional Village Councils, Indian Reorganization Act (IRA) Councils, and city government. Village corporations are important entities for the local economy (e.g., Ukpeagvik Iñupiat Corporation in Barrow, Kuukpik Corporation in Nuiqsut and Kaktovik Iñupiat Corporation in Kaktovik). The role of Native Corporations is discussed at length in a recent report prepared for MMS (Northern Economics, Inc., 2006).
- Nongovernmental organizations include the Alaska Eskimo Whaling Commission, the Iñupiat Community of the Arctic Slope, and the Kuukpikmiut Subsistence Oversight

Panel, Inc. These organizations, particularly the former, have recently become more active and visible in regional governance (USDOI, MMS, 2002).

2.15.2.4 Other Ongoing Sociocultural Issues

The Liberty FEIS (USDOI, MMS, 2002) notes that current sociocultural systems are undergoing change and strain. This conclusion is shared in more recent EIS's. Previous EIS's discussed issues pertaining to changes in employment, increased income, decreased Iñupiaq fluency, and increased crime and substance abuse rates (e.g., USDOI, MMS, 1987, 1990a, 1996, 1998; USDOI, BLM, 1998). Despite relative economic well-being, North Slope residents have come under increased stresses on social well-being as well as cultural integrity and cohesion (USDOI, MMS, 2002; USDOI, BLM, 2004a,b, 2005).

2.15.3 Subsistence and Area Use Patterns

Subsistence is a key element of the Iñupiat lifestyle. The ideology, tradition, and practice of subsistence resource harvest, use, and sharing are crucial underpinnings of Iñupiat society today. The associated systems of rules and practices constitute a body of knowledge that underlies Iñupiat peoples' behavior and defines who they are as a people. Subsistence activities are a key determinant of Iñupiat conceptions of the universe and their role in it. While many Iñupiat people participate in the wage economy, use modern equipment and tools, and wear imported clothing, these new items are incorporated, used, and conceived of in intrinsically Iñupiat ways integral to their culture.

Information on subsistence was summarized in the original Liberty Development Project Environmental Report (LGL, WCC, and Applied Sociocultural Research, 1998) and the Liberty FEIS (USDOI, MMS, 2002). Subsistence has been extensively discussed in more recent EIS's and EA's, including the Alpine Satellite Development Plan (USDOI, BLM, 2004a); the NE NPR-A Final Amended Integrated Activity Plan (USDOI, BLM, 2005), the Proposed OCS Lease Sales 193, 195, and 202 (USDOI, MMS, 2006a, 2004, 2006b; see also USDOI, MMS 2003); the TAPS Right-of-Way Renewal (USDOI, BLM, 2002); and the NRC study of the cumulative effects of oil and gas activities on Alaska's North Slope (NRC, 2003). The material in these publications is incorporated by reference. Key content is summarized below.

2.15.3.1 Subsistence Areas

The Liberty FEIS (USDOI, MMS, 2002) provides a short description of the subsistence areas for Nuiqsut, Kaktovik, and Barrow. These are summarized in the map shown in Figure 2.15-1. (Figure 2.15-2 provides more detail for Nuiqsut.) The Liberty reservoir (also shown in this figure) is near the Nuiqsut and Kaktovik subsistence areas, which are discussed below.

Nuiqsut

Nuiqsut hunters harvest resources over an expansive area of the North Slope. Nuiqsut's subsistence marine-resource harvest area includes the Beaufort Sea from Cape Halkett in the west to Flaxman Island in the east, and up to 30 mi offshore (Figure 2.15-1). Cross Island is the center of Nuiqsut's subsistence bowhead-whale hunting.

Nuiqsut whalers have accompanied Kaktovik whalers when conditions near Cross Island have been extremely unfavorable for whaling (heavy ice). Before oil development at Prudhoe Bay, the onshore area from the Colville River delta in the west were historically important to the

Iñupiat for subsistence harvests of caribou, waterfowl, furbearers, fish and polar bears. More recently, safety and security concerns in certain developed areas, including Prudhoe Bay, have placed access limits on Iñupiat subsistence users. Access policies vary among oil field units (see e.g., U.S. Army Corps of Engineers, 1997).

Kaktovik

Kaktovik is located on Barter Island on the northern edge of the Arctic National Wildlife Refuge. Kaktovik subsistence users use an area of up to 11,400 mi^2 extending along the coast from Demarcation Point to Foggy Island, including the offshore barrier islands, and to the foothills and low passes of the Brooks Range via several river drainages (Pederson, 1990) (Figure 2.15-1). Summer resource harvests tend to take place along the coast and barrier islands, while winter harvests tend to take place inland along river courses such as the Hulahula, Shaviovok, and Sadlerochit rivers (Pederson, 1990).

Barrow

As with other communities adjacent to the planning area, Barrow residents enjoy a diverse subsistence resource base that includes both marine and terrestrial animals (Alaska Dept. of Community and Economic Development [ADCED], 2005). Barrow harvesters' lifetime subsistence-harvest area as documented in Pederson (1979) can be seen in Figure 2.15-1.

2.15.3.2 Cultural Importance of Subsistence

Subsistence is part of a rural economic system, often termed a mixed, subsistence-market economy, wherein families invest their resources in small-scale, efficient technologies to harvest wild foods (Alaska Department of Fish and Game [ADF&G], 2000). Subsistence resource harvests provide a reliable economic base for domestic family units who have invested in equipment and transportation to conduct these important activities. Subsistence resource harvests support extended families and others through redistribution to elders, coworkers, and other channels. These activities also support collective harvest activities associated with participation in whaling crews, and the cycle of public events based on whaling traditions (Bodenhorn, 2003). In practice, wage employment is a means to support subsistence activities, although the two are mutually interdependent.

Subsistence meets the self-limiting needs of families and small communities, not primarily on commercial market production. Participants in this mixed economy in rural Alaska augment their subsistence production by cash employment. Cash wages provide the means to purchase the equipment, supplies, and fuel used in subsistence activities.

Subsistence activities, particularly bowhead whale hunting, continue to be the basis for Iñupiat culture, values, and tradition (Bodenhorn, 2003). The Iñupiat maintain connections to their traditionally used lands and resources through elder-directed, multigenerational use and re-use of camps, cabins, and areas of importance. The Iñupiat continue to base their social calendar on solitary and cooperative hunting of seasonally available subsistence resources. Subsistence users continue to share their resources through kin-based networks over an even greater area than in the historic period, transporting subsistence foods to relatives in urban Alaska and beyond (Stephen R. Braund & Associates and Institute of Social & Economic Research [SRB&A and ISER], 1993). Elders are valued for their knowledge and insight, and are cared for and respected by their communities. Iñupiat celebrations and festivals are still important local and regional events and some celebrations, previously suppressed or abandoned, are being organized and held again (SRB&A and ISER, 1993). More recent recurring events, including basketball tournaments and the World Eskimo Indian Olympics, function to maintain and enhance contacts between communities and regions.

2.15.3.3 Annual Cycle of Harvest Activities

Each of the NSB villages has a broadly similar annual cycle of harvest activities. Those for Barrow, Kaktovik, and Nuiqsut are given in NRC (2003).

2.15.3.4 Subsistence-Harvest Seasons and Harvest Success Profile

Two major subsistence-resource categories occur on the North Slope: the coastal/marine and the terrestrial/aquatic (USDOI, MMS, 2002). In the coastal/marine group, the food resources harvested are whales, seals, walrus, waterfowl, and fish, while in the terrestrial/aquatic group, the resources sought are caribou, freshwater fish, moose, Dall sheep, grizzly bear, edible roots and berries, and furbearers. Each of the NSB villages has a characteristic subsistence harvest pattern, although there is substantial year-to-year variability. Although subsistence harvests differ from community to community, the resource combination of caribou, bowhead whales, and fish was identified as the primary grouping of resources harvested (USDOI, MMS, 2002).

Specific data on subsistence harvests for Barrow, Kaktovik, and Nuiqsut have been published (Brower and Opie, 1997; USDOI, BLM, 2004a, 2005; USDOI, MMS, 2002, 2003, 2004, 2006a, 2006b; U.S. Army Corps of Engineers, 1999) and are incorporated by reference. Because Nuiqsut is the closest village to the proposed Liberty Development Project and might be expected to experience greater effects, more detailed data are provided for this community below.

A diverse seasonal abundance of terrestrial mammals, fish, birds, and other resources is available in the Nuiqsut area, where traditional subsistence activities revolved around caribou, marine mammals, and fish, with moose, waterfowl, and furbearers as important supplementary resources. The Colville River is the largest river system on the North Slope and supports the largest overwintering areas for whitefish (Craig, 1987). Nuiqsut is geographically remote from its whaling camp on Cross Island, necessitating a long trip through the barrier islands to West Dock and then due north to whaling camp (Brown, 1979).

The seasonal availability of many important subsistence resources controls the timing of subsistence harvest activities (Table 2.15-2).

The ADF&G collected subsistence harvest data for Nuiqsut in 1985 and 1993, selecting 1993 as the most representative year for subsistence harvest data (Tables 2.15-3 and 2.15-4) (ADF&G, 2001). Estimates of Nuiqsut’s total annual subsistence harvests in recent years were 160,035 pounds in 1985, 150,196 pounds in 1992, and 267,818 pounds in 1993 (Table 2.15-3). The 1993 harvest of 742 pounds per capita of wild resources represents approximately 2 pounds per day per person in the community. In 1985, fish and land mammals accounted for 86% of Nuiqsut’s total subsistence harvest, and marine mammals contributed 8%. In 1993, fish, land mammals, and marine mammals accounted for approximately one-third each (Table 2.15-3). The importance of subsistence to Nuiqsut residents is shown in high participation rates for 1993 in households that use (100%), harvest (90%), try to harvest (94%), and share (98%) subsistence resources (Table 2.15-4).

Nuiqsut landed no bowheads in 1985 or 1994. The community harvested two bowheads in 1992 and three in 1993. In years when bowhead whale, fish, and terrestrial mammal subsistence harvests are successful, such as 1992 and 1993, each of these resources may provide nearly one-third of the subsistence resource harvest (Tables 2.15-3 and 2.15-4 and Figures 2.15-3 and 2.15-4) (Fuller and George, 1999). In 1992, bowhead whales (32%), caribou (22%), and fish (25%) comprised 79% of Nuiqsut's annual subsistence harvest. In 1993, bowhead whales (29%), whitefish (29%), and caribou (31%) comprised 88% of Nuiqsut's annual subsistence harvest in terms of edible pounds (Table 2.15-4 and Figure 2.15-4) (Fuller and George, 1999).

Bowhead Whales

Since completion of the Liberty FEIS (USDOI, MMS, 2002) additional information on bowhead whale harvests and effort has been developed for Nuiqsut. This new information is summarized below.

Even though Nuiqsut is not located on the coast (it is approximately 16 to 17 mi inland and 18 to 33 mi via the river, depending on which channel is taken to the Beaufort Sea), bowhead whales are a major subsistence resource for this community. Bowhead whaling is usually undertaken between late August and early October from Cross Island, with the exact timing depending on ice and weather conditions. Variable ice conditions may extend the season to 2 months or contract it to <2 weeks. Nuiqsut whalers use aluminum or fiberglass boats, 18 to 24 ft long, with outboard motors to hunt bowheads in open water in the fall, unlike spring whaling in Barrow where the hunt is staged from the edge of ice leads using skin boats. Nuiqsut residents report that they harvest bowhead whales most frequently within 10 mi of Cross Island, but hunters often travel much farther from the island.

Historically, the entire coastal area from Nuiqsut east to Flaxman Island and the Canning River delta has been used for whaling, but whaling to the west of Cross Island has not been as productive as hunting closer to the island, and whaling too far to the east requires long tows of the whales back to Cross Island for butchering, creating the potential for meat spoilage (Impact Assessment, Inc.[IAI], 1990a). The recent Nuiqsut subsistence bowhead whale (aġviq) hunting area is depicted in Figure 2.15-5. The general Nuiqsut harvest area for bowhead whales is located off the coast between the Kuparuk and Canning rivers.

Whalers currently travel to Cross Island to conduct fall bowhead whaling. They have also used Pingok and Narwhal islands as bases and may still have structures on Narwhal Island. Cross Island has cabins for the crews to stay in and equipment for hauling up and butchering the whales. Nuiqsut hunters typically travel out either the Nigliq or the main Colville channel of the Colville River delta (depending on water levels) and travel along the coast inside or just outside the barrier islands. Depending on conditions, whalers usually stop at West Dock for coffee before heading due north for Cross Island. In the past, work groups may start fishing and hunting other species to support the whalers after setting up camp (USDOI, BLM, 2004a), but in the last several years most of the whalers' energy has been directed towards whaling (Galginaitis and Funk, 2003a, 2003b, 2004, Galginaitis, 2005a, 2005b). A successful whale harvest may contribute up to a third of Nuiqsut's entire subsistence harvest by weight for all resources. The meat and muktuk are shared with other rural Alaskan communities and cities, contributing a valued identity food to Iñupiat who reside away from the North Slope.

A summary of whale harvest by Nuiqsut crews is presented in Table 2.15-5. Nuiqsut whalers attribute at least part of their relative lack of success in the 1970s and 1980s to interference from oil and gas exploration, as well as poor weather and ice conditions in some years, and a difficult logistical situation. These factors are also evident in the 3 years with the greatest incidence of "struck and lost" whales (1989-1991 or 1992). Once Cross Island was established as a logistical center for Nuiqsut whaling and Nuiqsut whalers gained experience there, harvest success became more regular. Cross Island is a low, sandy barrier island with a raised area built from gravel for past oil and gas exploratory drilling. Cross Island is about 3 mi long and 450 ft wide, and is constantly changing due to erosion and redeposition.

Summary characteristics for the 2001-2004 whaling seasons are presented in Table 2.15-6 (Galginaitis and Funk 2003a,b, 2004, 2005; Galginaitis 2005b). Additional information is provided in the Lease Sale 202 EA (USDOI, MMS, 2006b).

Figure 2.15-5 displays Global Positioning System (GPS) tracks for most scouting activity for Nuiqsut whalers for 2001, 2002, and 2003 by year. The density of the tracks indicates that boats typically (but not always) tend to stay close to each other. This reflects the cooperation that Nuiqsut whalers generally display. The similarities from one whaling season to the next in terms of number of crews and boats, length of season, days of scouting, and harvest are fairly high.

Caribou and Caribou Use Areas

Because oil development is associated with onshore pipelines, roads, and production facilities, it is important to consider terrestrial as well as marine subsistence resources. Nuiqsut hunters harvest several large land mammals, including caribou and moose. Caribou may be the most preferred land mammal in Nuiqsut’s diet, and during periods of high availability, they provide a source of fresh meat throughout the year. Subsistence caribou harvest data are shown in Table 2.15-4 (ADF&G, 2001; Brower and Hepa, 1998). In 1985, Nuiqsut hunters harvested an estimated 513 caribou, providing approximately 60,000 edible pounds of meat or 38% of the total subsistence harvest (ADF&G, 2001). Fuller and George (1999) estimated that 278 caribou were harvested in 1992. A 1993 ADF&G subsistence study estimated a harvest of 672 caribou, providing approximately 82,000 edible pounds of meat or 31% of the total subsistence harvest (ADF&G, 2001). In 1993, 74% of Nuiqsut’s households harvested caribou, 98% used caribou, 79% shared caribou with other households, and 79% received caribou shares (ADF&G, 2001).

A subsistence harvest survey covering the period from July 1994 to June 1995 reported that 258 caribou were harvested by Nuiqsut hunters, or 58% of the total subsistence harvest in edible pounds (Brower and Hepa, 1998) (Table 2.15-4). Brower and Hepa (1998) note that this was a relatively low number of caribou harvested compared to reported harvests for earlier years, and that no bowheads were taken that year. Subsistence harvest data are variable and it is difficult to pinpoint “assignable causes” given this variability. Explanations offered by local hunters for the decreased harvest were: (1) the need to travel longer distances to harvest caribou than in the past, (2) the increasing numbers of musk ox that hunters believe keep caribou away from traditional hunting areas, (3) restricted access to traditional subsistence hunting areas due to oil exploration and development in these areas, and (4) disruption of caribou migration into traditional Nuiqsut harvest areas (Brower and Opie, 1997; Brower and Hepa, 1998).

Geographic and seasonal variation in caribou harvests are depicted in the recent Alpine Satellite Development Plan (ASDP) EIS (USDOI, BLM, 2004a), which illustrates the intensity of harvest effort for caribou for numerous locations used by Iñupiat subsistence hunters. Harvest areas are often associated with TLUI sites, cabins, camps, and Native allotments that often have harvest locations for other species nearby. These harvest locations may be used in winter (October through May), summer (defined as the open water period, including June through September), or both, and they may be accessed by foot, boat, all-terrain vehicle and snowmachine.

Fish and Fish Use Areas

Nuiqsut has the largest documented subsistence fish harvest on the Beaufort Sea coast (Moulton, 1997; Moulton, Field and Brotherton, 1986). Fish provide the most edible pounds per capita of any subsistence resource harvested by Nuiqsut (Table 2.15-3). Fish, a traditional staple of both coastal and terrestrial Iñupiat, may vary in numbers seasonally and from year to year, but normally provide a substantive contribution to subsistence resource harvests. Subsistence harvests of fish are not subject to seasonal limitations under federal fisheries management, and no permit is required for rural harvesters.

Nuiqsut resource users have a long history of subsistence fishing in the Colville River and its tributaries from the Colville River delta to the confluence with the Ninuluk Creek, the Nigliq Channel, and nearby Fish and Judy creeks and the innumerable lakes in the region. Nuiqsut fishermen also use coastal areas east to the Kuparuk River and fish around several barrier islands, including Thetis and Cross islands. Families set nets near Nuiqsut in the Nigliq Channel when time, transportation needs, or funds do not permit longer trips from town, particularly during the school and work year.

Figures 2.15-6 and 2.15-7, derived from Moulton (2002), show the highly variable nature of the subsistence fish harvest in the Colville River delta and Nigliq areas. Fishing effort ranged by area from 19 to 1,407 net-days, although there is no clear correspondence between the harvest and harvest effort, because low efforts brought more fish as in 1993, while high efforts as in 2002 resulted in few fish harvested even considering the reduced number of sites sampled. As shown in the Moulton data, the arctic cisco harvest at the five monitored set-net harvest sites in that study range from a 1993 peak of nearly 47,000 to a 1988 low of approximately 6,100, nearly one-eighth the number of the peak. This variability demonstrates the importance of having alternative species and harvest strategies available should poor fish harvests coincide with reduced terrestrial or marine mammal harvests.

Seals and Seal Use Areas

Seals are hunted nearly year-round (Table 2.15-2), but the majority of the seal harvest occurs during the open-water season. In the spring, seals may be hunted once the landfast ice goes out. Present day sealing is most commonly done at the mouth of the Colville River when it begins flooding after ice breakup in June. Seal meat is eaten, but the dietary importance of seals comes primarily from seal oil, which is served with almost every meal that includes subsistence foods. Seal oil is also used as a preservative for meats, greens, and berries. Seal meat and oil are traded to residents of Anaktuvuk Pass for dried caribou and other products. Seal skins are important in the manufacture of clothing and, because of their beauty, spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim. In practice, however, ringed seal skins are used more often in the making of clothing because the harvest of this species is more abundant. Seal skins are used for handicrafts and other articles, are bartered, or are sold (USDOI, BLM, 2004a).

Ringed (natchiq), spotted (qasigiaq), and bearded (ugruk) seals are important subsistence resources for Nuiqsut hunters. In April and May, hunters ride out to Harrison Bay on snow machines and look for breathing holes, cracks in the ice and open water where seals might surface to breathe. By the second week in June, open waters on the Colville River and much of Harrison Bay allow hunters to take boats out on a route locally called "around the world," following the Nigliq Channel to Harrison Bay, west to Atigaru Point, then along the ice edge out as far as 28 miles, then to Thetis Island (Amauliqtuq), east to Oliktok Point, then back south through the main channel of the Colville River.

Polar Bears

The harvest of polar bears (nanuq) by Nuiqsut hunters begins in mid-September and extends into late winter. Polar bear meat is sometimes eaten, although only limited harvest data are available. The NE NPR-A Final Amended IAP/EIS (USDOI, BLM, 2004b) notes: "Nuiqsut residents have indicated that polar bears are not an important subsistence resource for the community and if taken would be an incidental harvest."

Beluga Whales

Nuiqsut residents indicate that beluga whales are not important to the subsistence cycle of the community, although some sources have mentioned beluga whales being taken incidentally during the bowhead harvest (USDOI, BLM, 1998).

Walrus: ADF&G subsistence survey data indicate that two walrus were harvested in the 1985/1986 harvest season, but no new walrus data for the community have been gathered since then (ADF&G, 2001). Walrus are probably taken incidentally during seal hunting (NSB, 1998). During the 2004 whaling season, walrus were seen (and heard) on Cross Island for the first time in anyone's memory.

Moose and Moose Use Areas

Moose (tuttuvak) are normally harvested by boat in August upriver from Nuiqsut on the Colville, Chandler and Itkillik rivers, but the timing of harvest varies depending on hunting seasonal regulations. Local residents have indicated that the weather is not suited for moose hunting in September due to winds and fall whaling occupies much of the community during the month of September.

Harvest data for moose are indicated in Table 2.15-4. In 1985, hunters reported a harvest of 13 moose (ADF&G, 2001). In 1993, nine moose were reported harvested by surveyed subsistence households (ADF&G, 2001, Brower and Hepa, 1998). A subsistence-harvest survey conducted by the NSB DWM for the period from July 1994 to June 1995 reported five moose harvested or 5% of the total edible pounds harvested that season (Brower and Hepa, 1998).

Moose are hunted from the Colville River Delta area upstream to Ninuluk Creek, up the drainages of the Itkillik River and Fish and Judy creeks, and up some side streams off the Colville River. One hunter mentioned going almost to the Killik River confluence looking for moose, while several others reported Fish and Judy creeks, the Chandler and Anaktuvuk river confluences, several side streams and channels of the Colville River and the Itkillik River area as prime moose hunting areas (USDOI, BLM, 2004a). Although relatively small numbers of moose are harvested, they are a valued component of the subsistence harvest in Nuiqsut, and hunters spend considerable effort in their pursuit. Moose offer a large amount of meat per animal harvested because of their relatively large size compared to other terrestrial mammal subsistence resources. Moose, when harvested, are very commonly shared with the rest of the community at large.

Waterfowl and Waterfowl Use Areas

The most important species of waterfowl for Nuiqsut hunters are the Canada and white-fronted goose and brant; eiders are also harvested.

The only upland bird hunted extensively is the ptarmigan (ADF&G, 2001; Brower and Hepa, 1998). Recent data indicate the subsistence bird harvest provided 5% of the total subsistence harvest (Brower and Hepa, 1998) (Table 2.15-3). Waterfowl hunting occurs mostly in the spring, beginning in May, and continues throughout the summer. In the summer and early fall, such hunting usually occurs as an adjunct to other subsistence activities, such as checking fish nets.

Waterfowl harvested by the Iñupiat of Nuiqsut occupy two habitats in the greater Nuiqsut area. Ducks, geese, and brant molt and nest in the wet tundra to the north of Nuiqsut. Eiders nest on the sandy areas of the Colville River Delta and the barrier islands, molting after their arrival. Both groups of waterfowl raise their young in the area until fall, when they migrate south. Nuiqsut hunters harvest waterfowl in May and June during the migration using snow machines and boats. The hunters harvest the migrating birds from snow blinds built to the south, near Sentinel Hill and Ocean Point or at Fish Creek. Once the river breaks up, hunters look for birds by boat, and start to look for eiders in the delta and in Harrison Bay at the ice edge as summer approaches. Hunters end the waterfowl harvest when the birds are on their nests (USDOI, BLM, 2004a).

The NSB collected waterfowl harvest data for 1994-1995, 2000 and 2001 (Brower and Hepa 1998; USDOI, BLM, 2004a). Goose hunting areas include the Fish and Judy creeks area, the Colville River Delta, the area around Nuiqsut extending to the Fish and Judy creeks area, along the Colville River up to Sentinel Hill, the area around Ocean Point, and along the Itkillik River. As shown in the ASDP EIS (USDOI, BLM, 2004a), more than three-quarters of geese, including white fronted and Canada, were harvested in the Fish and Judy creeks area and the Colville River Delta. Most of the remaining geese were harvested up the Colville River from Ocean Point to Umiraq. Interviewed subsistence users in Nuiqsut related that the harvest sequence for migratory waterfowl proceeds from the south, and that those harvested upriver are the first birds of the season (USDOI, BLM, 2004a).

Furbearers

As discussed in the ASDP EIS, Nuiqsut fur hunters described three species of terrestrial furbearers as being especially important: wolf (amġuq), wolverine (qavvik), and fox (USDOI, BLM, 2004a). Once there is adequate snow in the winter for snowmachine travel, generally by November, hunters begin the pursuit of wolf and wolverine in earnest. The harvest area for furbearers extends from the eastern edge of the Colville River Delta along the coast almost to Admiralty Bay and then south along the Ikpikpuk River to the Colville River and eastward to the Toolik River, north and crossing the Dalton Highway to Franklin Bluffs, and west and north back to the Colville River Delta.

Berries and Plants

Berries (akpik) of numerous varieties are harvested in the Fish and Judy creeks area, and along the Colville, Chandler, Anaktuvuk, and Itkillik rivers. Plants such as masu (Eskimo potato), medicinal plants, and greens are harvested when families are out at camp hunting and fishing in the late summer. Berry picking is still considered a job primarily for women and children, but men pick berries on occasion. Berry varieties include salmonberries (aqpik) and blueberries (asiaq). Berries are primarily harvested in August, when many families are out moose hunting up the creeks and rivers of the area, and often they will pick buckets or large freezer bags full of berries. These are taken home and stored in ice cellars or freezers for later use in agutuq, or Eskimo ice cream, made from whipped seal or other fat, sugar, plants, and berries.

2.15.4 Land Ownership

The majority of land and waters in the project area are owned by either the State (mainland, islands, and within the 3-mi offshore zone) or Federal Government (OCS outside the 3-mi zone). There is private land including three Native allotments and Cross Island, which is owned by the NSB (Figure 2.15-8).

2.15.5 Environmental Justice

Environmental Justice Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 *FR* 7629), requires each Federal Agency to make the consideration of environmental justice part of its mission. Section 1-101 states:

> To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions…

Other portions of this order require agencies to develop strategies to address environmental justice (1-103), research, data collection, and analysis (Section 3-3), and, of particular relevance to this analysis, requirements to collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence (4-401). EIS's drafted after the effective date of this order contain sections on environmental justice.

In particular, Alaska Iñupiat Natives, a recognized minority, are the predominant residents of the North Slope Borough. Therefore, it is important to address whether or not the environmental impacts of the proposed Liberty (SDI) Project will have disproportionately high and adverse impacts on NSB residents.

Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments," requires Federal agencies to consult with tribal governments on Federal matters that significantly or uniquely affect their communities. In January 2001, a USDOI Alaska Regional Government-to-Government policy was signed by all the USDOI Alaska Regional Directors, including the MMS.

The MMS public process for Environmental Justice outreach and for gathering and addressing Environmental Justice concerns and issues is described in detail in the Beaufort Sea multiple-sale FEIS (USDOI, MMS, 2003). Since 1999, all MMS public meetings have been conducted under the auspices of Environmental Justice. Environmental Justice-related concerns are taken back to MMS management and incorporated into environmental studies planning and design, environmental impact evaluation, and the development of mitigating measures.

Outreach meetings for the Liberty (SDI) Project were conducted by BPXA on February 28, 2006, in Barrow with the NSB Planning and Wildlife Management Departments; on June 7, 2006, in Barrow with ICAS; on June 8, 2006, in Barrow with NSB Mayor Edward Itta; and on March 8, 2007, in Barrow with NSB personnel. The MMS attended both the February 28, 2006, and the June 7, 2006, meetings in Barrow. On April 18, 2006, MMS conducted government-to-government consultation with the Native Village of Kaktovik. Attendees at all meetings were generally positive about the onshore approach to the project and in Barrow, concerns were raised about Native allotments and oil spills in the project's vicinity. Issues raised at these meetings include:

- the oil industry's continuing inability to clean up an oil spill in broken ice;
- the need to stage cleanup equipment in local communities to make spill response more timely and to give more local people response training;
- bowhead whale migration may be deflected from noise caused by small vessels;
- the need to expand conflict avoidance agreements to other resources not considered by the Alaska Eskimo Whaling Commission (AEWC), such as fish, bearded seals, walrus, and beluga whales;
- that multiple industrial operations may have a cumulative adverse impact on bowhead whale migration;
- include a cumulative effects analysis that addresses the recommendations of the 2003 NRC Report Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope;
- the effects of toxins and contaminants in the Arctic environment on subsistence foods;

On May 11, 2007 (pursuant to Executive Order 13175) MMS invited Federally Recognized Tribes to hold formal Government-to-Government consultations regarding the current Liberty (SDI) Project. Refer to Appendix G for Government-to-Government consultations.

Section 3

Environmental Consequences

3. ENVIRONMENTAL CONSEQUENCES

This section discusses the environmental consequences of the proposed Liberty (SDI) Project and alternatives. The MMS updated the information and expanded on the information provided in the EIA, as needed. Consequences of the proposed project are discussed in terms of expansion of the Endicott Satellite Drilling Island (SDI), onshore construction, and drilling and oil production. Separate sections are provided on the impacts of oil spills, the effects of alternatives, and the cumulative effects of the project. Effects conclusions are summarized for the proposed action and alternatives in Tables 3.5-1 through 3.5-9.

3.1 SDI EXPANSION

3.1.1 Air Quality

The ambient air pollutant impacts due to construction of the SDI expansion are expected to be within the limits of the National and Alaska Ambient Air Quality Standards (AAQS). Pollutants will be emitted from temporary operations and/or mobile equipment such as diesel-fired construction equipment, and temporary electrical generators. Pollutant emissions from marine vessels are expected to be negligible because marine traffic, in general, will not be used to support construction of the SDI expansion. Fugitive particulate-matter emissions will result from gravel mining operations and gravel placement operations, but will be minimized through fugitive-dust abatement techniques such as road watering. As part of the air permitting process, the Alaska Department of Environmental Conservation (ADEC) will review the construction equipment inventory and the construction plans to ensure compliance with the National and Alaska AAQS. A dispersion modeling analysis of project emissions will be included in the air permit application and will demonstrate National and Alaska AAQS compliance. An ambient-air-quality monitoring station has been in operation on the SDI since February 2007 to provide data to support air quality permitting.

The following information was provided by BPXA to MMS on July 26, 2007, outlining the air permitting process:

- Liberty Prevention of Significant Deterioration (PSD) permit application submittal: April 25, 2007
- Ambient Air Monitoring (required before ADEC can determine application complete): (February 2007 to January 2008)

The following lists the estimated times from the date of ambient air monitoring completion:

- Compile ambient air data and submit to ADEC - 30 days (February 2008)
- Preliminary Permit and TAR - 30 days (March 2008)
- Public Notice - 30 days (April 2008)
- Final Permit and TAR Issued - 30 to 60 days (depending on comments received) (May to June 2008)
- Current estimate of Air Permit issuance: late June/early July 2008

3.1.2 Sediment Suspension and Transport

Expansion of the SDI requires the placement of approximately 860,000 cubic yards (yd^3) of gravel fill. The material will be placed progressively outward from the existing pad perimeter. The pad expansion footprint is approximately 704 by 1,394 ft**.** The gravel fill and slope protection will be placed through the ice during the winter, commencing after ice road construction and concluding prior to breakup.

It is anticipated that the placement of gravel fill will increase suspended sediment concentrations in the marine waters in the immediate vicinity of the construction site and create a turbidity plume that extends to nearby areas. The total suspended solids (TSS) concentrations and the nature of the plume depend on the properties of the gravel fill, water depth at the site, current speed, and current direction (BPXA, 1998).

Measurements of TSS concentrations attributable to gravel island construction are limited. During construction of Endeavor Island in the summer of 1980, suspended sediment concentrations were found to increase by about 70 mg/l above ambient levels within 30 m of the island and to increase by about 10 mg/l at a distance 1,830 m from the site (NORTEC, 1981; as reported in BPXA, 1998). Results from turbidity monitoring performed in summer 2003 during replenishment of the Northstar Island gravel berm indicate that turbidity increased approximately 20% on average relative to the baseline condition in the near field (Coastal Frontiers, 2003b). The associated plume rarely was detectable beyond 500 m from the site and typically dissipated within 2 hours.

During the winter construction of BF-37, a gravel island located about 3 km north of the Endicott Main Production Island (MPI), the concentration of suspended sediments near the island did not increase significantly (Toimil and England, 1982; Toimil and Dunton, 1983 and 1984; as reported in BPXA, 1998). Suspended sediment concentrations were measured during the first 7 days after fill placement commenced at radial distances of 140 and 170 m from the island. The maximum TSS concentration increase relative to ambient conditions was 3 mg/l. It was speculated that the sediment plume was limited by low under-ice current speeds, ice bonding of fine-grained material, and formation of silt/ice agglomerates.

Suspended sediment concentrations and turbidity plume characteristics were estimated previously for the original Liberty offshore island concept (Ban et al., 1999). The methods and assumptions used for this analysis are employed here to assess the worst-case impact of gravel-fill placement operations for expansion of the SDI pad. The key assumptions are given below:

- Gravel placement rate: 15,500 m^3/day
- Fines content in gravel fill: 10%
- % resuspension of fines: 12%
- Particle size of fines fraction: 5-100 microns (µ)
- Density of gravel fill:2600 kg/m^3
- Density of fine particles: 1,784 kg/m^3
- Under-ice current speed: 2 cm/sec

Applying the above assumptions for the worst-case scenario yields a release of fine-grained material to the marine environment of 186 m^3/day. This equates to a mass flux (M) of 5.6 kg/sec. The resulting concentration of suspended sediments in the immediate vicinity of the site is estimated by the following relationship:

$$C_o = M/Q \quad (1)$$

where:

C_o = concentration of suspended sediments

M = mass flux of suspended fines (5.6 kg/sec, derived above)

Q = flow rate (Eq. 2)

The flow rate is defined by the following relationship:

$$Q = vDH \qquad (2)$$

where:

v = under-ice current speed (2 cm/sec)

D = width of pad expansion (215 m)

H = water depth (≈3 m, as discussed in Section 2.3.2)

Using the variables given above and applying Equations 1 and 2, yields TSS concentrations at the immediate project site of about 430 mg/l for the worst-case scenario. These values are higher than those estimated for the Liberty offshore island concept due to the shallower water depths at the SDI site. Although the estimated turbidity is high by winter standards, the concentrations are only slightly higher than the range previously reported for Foggy Island Bay during the summer (Section 2.5.3). The increased turbidity is anticipated to be a short-lived impact, with most of the suspended material settling out within or adjacent to the footprint of the pad expansion.

The extent of the turbidity plume can be estimated by applying Stokes' Law (Equation 3 below) to calculate the fall velocity of the suspended particles and then determining the travel distance required for those particles to reach the seafloor as a function of the water column below the ice canopy and the current speed (Equation 4). Stokes' Law is given below:

$$w = g\, d^2\, (\rho_p - \rho_{sw})/18\mu \qquad (3)$$

where:

w = particle fall velocity

g = acceleration due to gravity (9.8 m/sec^2)

d = particle diameter (5 to 100 microns)

ρ_p = density of particle (1,784 kg m^3)

ρ_{sw} = density of seawater (1,026 kg/m^3)

μ = dynamic viscosity of seawater (0.0014 kg/m^3)

Applying Stokes' Law for particle sizes between 5 and 100 microns yields fall velocities ranging from 0.00074 cm/sec to 0.29508 cm/sec.

The suspended particles will be transported under the ice canopy by currents until they settle to the seafloor. Assuming gravel placement operations commence on January 1 when the average ice thickness is 0.9 m (Section 2.4.7), the height of the water column below the ice would be approximately 2.1 m. The travel distance for a given particle size is given by the following relationship:

$$D = v\, H_{under\text{-}ice} / w \qquad (4)$$

where:

D = travel distance

v = under-ice current speed (2.0 cm/sec)

H = height of the water column below the ice (2.1 m)

w = particle fall velocity (given by Stokes' Law)

The predicted travel distance for various particle sizes is shown in Table 3.1-1. Fine sands (>75 µm) will settle out of suspension almost immediately, migrating only about 20 m before reaching the seafloor. Silts (75 to 5 µm) are predicted to settle between 25 and 5,700 m from the project site. Finer particles (clays and colloids) would travel greater distances; however, these fractions are not anticipated in substantial quantities.

A large portion of the suspended material will settle to the seafloor within or adjacent to the footprint of the SDI pad expansion. The finer fractions (<50 µm) are expected to be transported as a plume to either the northwest or southwest by the prevailing currents. The predominant under-ice current direction is westerly/northwesterly (occurring 60 to 70% of the time on average). Under these conditions, the turbidity plume is predicted to migrate along the Endicott Causeway between the SDI and the MPI. Particles greater than 5 µm likely will be deposited on the seafloor within 6 km of the project site in a narrow band near the junction of the seafloor and the landfast ice (1- to 2-m water depth). During the more infrequent periods of easterly flow, the plume is anticipated to migrate southeasterly along the bathymetric contours.

The plume migration estimates are believed to be conservative in that:

- Gravel placement operations are anticipated to be conducted when the ice thickness is >0.9 m and the corresponding water column height under the ice canopy is less than the assumed 2.1 m;
- The turbidity plume will be migrating toward shallower waters under the predominate northwest currents;
- The speed of easterly directed currents may be less than the estimated 2 cm/sec due to sheltering effects of the Endicott Causeway; and
- The sheet pile wall will be installed simultaneously with gravel placement in winter, thus reducing plume migration.

Minor reshaping of the south and west pad sideslopes is anticipated shortly after breakup or during the open-water season. This activity may result in a slight increase in TSS concentrations for a short period of time. The naturally occurring turbidity levels are generally high during this time of the year due to river discharge and wave-induced suspension of fine material. Under the predominantly easterly winds, the turbidity plume associated with this activity is anticipated to migrate northwest along the Endicott Causeway. The shelter provided by the causeway would limit the ability for the plume to migrate towards the Boulder Patch during westerly wind events. During periods of high river discharge, the turbidity plume will be entrained with the river plume and dispersed into Foggy Island Bay.

3.1.3 Oceanography

The proposed SDI pad expansion is not expected to have any major impact on regional oceanography during the construction period. Minimal localized and short-term impacts can be anticipated, such as potential changes in water movement and sediment deposition around Duck Island 1 & 2, leading to alteration of the oceanographic processes that have shaped these abandoned exploration pads. The exploration islands might be reshaped by an erosion channel between the SDI and the islands.

The primary impacts are expected to occur at the time of river breakup, when the overflood may be partially diverted by the ice road. The expanded SDI pad footprint is anticipated to have a limited and localized influence on the river overflood. There also may be an increased propensity for strudel scouring at the project site due to removal of the ice sheet around the pad perimeter during construction. Currents in the immediate vicinity of the pad expansion will be affected during the breakup and open-water periods, but the current patterns and velocities are not expected to be substantially different from those at the existing SDI facility.

3.1.4 Marine Water Quality

As discussed in Section 3.1.2, TSS concentrations in the immediate vicinity of the project site may increase by up to 430 mg/l during gravel placement operations. While the estimated turbidity is high by winter standards, the concentrations are only slightly greater than the range previously reported for Foggy Island Bay during the summer. A large portion of the suspended material is predicted to settle within or adjacent to the footprint of the SDI pad expansion. The finer fractions will create a turbidity plume along the Endicott Causeway, likely dissipating within 6 km of the project site. These conditions will exist temporarily when gravel is placed in the water. Because the amount of material placed below water is less than half of the projected gravel fill volume required for the expansion, the increased turbidity should not persist through the entire winter construction period. In addition, the sheet pile wall will be installed in the winter, further reducing plume migration. These conditions are not anticipated to exceed previously documented TSS concentrations in Foggy Island Bay.

A potential for small equipment spills (oil, diesel fuel, and hydraulic fluid) exists during the construction period. Any spills on the gravel pad or ice surface will be cleaned up immediately. A release to marine waters is unlikely. During the winter, such a spill would be confined within the perimeter of the excavated ice sheet and cleaned up immediately.

3.1.5 Benthic and Boulder Patch Kelp Communities

The SDI expansion will cover a bottom area of approximately 20 acres. Although this represents permanently lost habitat to benthic invertebrates, the area is miniscule compared to the total habitat available in coastal waters. The habitat loss would have no measurable effect on lower trophic organisms. The SDI extension is sited entirely outside of the Boulder Patch kelp habitat, and no kelp habitat will be lost directly.

The SDI expansion is located near the perimeter of the Boulder Patch kelp community (Figure 2.7-1a), which begins a short distance offshore and east of the Endicott Causeway. The community is defined as the area with more than 10% coverage of boulders, but that area is surrounded by a limited area with <10% coverage of boulders. Kelp grows under the ice in dim light during spring. If there is a springtime turbidity plume during the SDI expansion, the plume is likely to drift alongshore (Sections 3.1.2 and 3.1.5.3), temporarily affecting only a small portion of the kelp in the Boulder Patch and adjacent area (see Figure 2.5-1).

A large segment of the Liberty oil reserves lay beneath the Boulder Patch. Movement of the original Liberty offshore island development, located directly in the Boulder Patch, to the SDI is facilitated by the use of uERD technology. The technology enables subterranean access to oil and gas reserves within several lateral miles of the wellhead. Moving the primary well site outside the Boulder Patch greatly reduces the risk of impact to this unique community.

3.1.5.1 Marine Access

Substantial marine access is not expected to be required to support Liberty(SDI) construction and operation. A sealift by barge is planned to transport the ***LoSal™*** EOR process and power generation modules to the existing MPI dock. A dock will be provided at the SDI as a contingency for providing limited marine access in support of rig mobilization and demobilization.

The two predominant ways in which barge traffic could adversely affect biological communities of the Boulder Patch are through physical disturbance associated with propeller wash, and from barge and tug discharges (see below). Water depths in the Boulder Patch range from 3 to 9 m. Most of the Boulder Patch consists of rocks and gravel <20 mm in size. Large rocks are scarce but may reach diameters of 1 m. At these depths, excessive propeller downwash could disturb epilithic fauna and cause the braking or detachment of kelp. Barge traffic will be routed around Boulder Patch to mitigate the potential for physical damage.

3.1.5.2 Refined-Oil Spills

Small refined-oil spills (diesel fuel, engine lube, fuel oil, gasoline, and grease) can occur whenever machinery is in use. Small refined-oil discharges from boat traffic or operations on the SDI would not mix deep enough in the water column to affect the Boulder Patch and other deep-water benthos. Discharges in shallow docking areas or in the immediate vicinity of the SDI could contaminate nearby benthos, but the effect would be highly localized and temporary. Overall, small oil discharges from boat traffic and construction activities are not expected to have measurable effects on benthic biota or the biota of the Boulder Patch.

3.1.5.3 Water Quality (Suspended Sediments)

A detailed discussion of the potential effects of turbidity and sediment settlement on the Boulder Patch community can be found in the Liberty FEIS (USDOI, MMS, 2002). Expansion of the SDI will increase suspended sediment concentrations in the marine waters in the immediate vicinity of the construction site and create a turbidity plume that extends to nearby areas. The turbidity is expected to be high by winter standards but well within the range reported for Foggy Island Bay during summer. The increased turbidity during construction is expected to be a short-lived impact, with most of the suspended material settling out immediately adjacent to the SDI expansion area (see Section 3.1.2). It is projected that large grain ($\geq$15μ) suspended sediments will settle to the seafloor within 300 m of the SDI and will not reach the Boulder Patch. Finer particles 5μ in size will deposited on the seafloor within 3 km of the site. Any settlement within the Boulder Patch would be temporary. Settlement occurs on the seafloor and kelp beds naturally during late summer and early fall, but late fall storms regularly resuspend the sediments and transport it away from the Boulder Patch (Dunton and Schonberg, 2000). Because water currents are so slow during winter, sediments from the SDI expansion could settle on kelp or could freeze into the ice cover, thereby reducing light penetration for kelp growth under the ice during spring. The effect would again be temporary, being limited to the initial winter of construction.

Overall, increased turbidity and sediment from construction is not expected to have a measurable effect on the Boulder Patch community. The general benthos could be impacted in the immediate vicinity of the SDI, but the area affected would be minor relative to the size of the overall nearshore benthic community. Any effect during construction would be temporary. The effect of turbidity and suspended sediments during long-term abandonment of the facility is discussed later in Section 3.3.2.

3.1.5.4 Oceanography

The proposed SDI expansion is not expected to have any impact on regional oceanography. Currents in the immediate vicinity of the pad expansion will be affected during the open-water period but will not differ much from patterns associated with the present SDI pad. No effect on either the Boulder Patch or the overall benthic community is expected.

3.1.6 Fish and Essential Fish Habitat

3.1.6.1 Noise/Activity Disturbance

The expansion of the SDI will occur during winter when most of the surrounding waters will be frozen to the bottom. Fish presence in the immediate vicinity will be nominal and restricted to marine species in waters deeper than 6 ft beginning seaward of the SDI. Because marine fishes are widely distributed in their range and largely unrestricted in their movements, noise and activity associated with the SDI expansion would not have a measurable effect on marine populations. Adult and sub-adult anadromous and amphidromous fishes range far up and down the coast, and any noise disturbance would be localized and unlikely to interfere with coastal distributions. If noise and activity from the SDI expansion were stressful, fish would merely avoid them. Juvenile broad whitefish, least cisco, and arctic cisco are more restricted to the Sagavanirktok Delta in summer, but there is sufficient habitat for them to avoid noise in the immediate area of the SDI. Overall, noise and activities associated with the SDI expansion are likely to have only minimal, short term impacts on local fish populations. Essential Fish Habitat (EFH) will not be adversely impacted.

3.1.6.2 Habitat Loss

The SDI extension will cover a bottom area of approximately 20 acres. This represents permanently lost habitat to fish, but the area is a small fraction of the total habitat available in coastal waters. The habitat loss should have no meaningful effect on local fish populations. Infrastructure support such as causeways, bridges, permanent roadways, and culverts are already in place in support of the Endicott facilities. Except for the upgrade to the existing West Sagavanirktok River Bridge, no additions are planned. No additional fish habitat in the project area will be affected, and there will be no adverse effects to EFH.

3.1.6.3 Ice Road Construction

The ice road that will support winter expansion of the Liberty (SDI) Project will run from the proposed mine site to the SDI, and will parallel the existing Endicott Road. The ice road will cross under one of the Endicott bridges and run across grounded sea ice to the south side of the SDI. There are presently no indications that deepwater fish overwintering habitat exists anywhere along the proposed route. Although tundra ponds are a dominant feature of the Arctic Coastal Plain, water depths in most cases are insufficient for overwintering, and most are not accessible to fish (Hemming, 1995). The possible exception would be where the roadway crosses under the middle breach. Both the inner and outer breaches contain centerline channels of up to 4,000 m^2 in area where depth exceeds 2 m and which have maximum depths of about 5 m (Dewey, Morehead, and Wilson, 1993). At these depths they more than likely provide some overwintering habitat for fish. It is further likely that the middle breach also contains some overwintering area the extent of which is unknown.

A second 3-mi-long ice road may be built on the lagoon side of the Endicott Causeway between the MPI and SDI. In addition to running along the length of the causeway, the ice road will parallel a scour channel that also runs along the lagoon side of the causeway. In places, channel depth can reach 2.5 m and be approximately 100 m wide (Davis, Petrillo, and Parker, 1992). Although not excessively deep, the channel may be up to 3,000 m in length. Assuming maximum winter ice thickness of 2 m, under-ice free water only 0.5 m in depth would still translate into 150,000 m^3 of potential fish overwintering habitat. A mild winter with a maximum ice thickness of 1.5 m could provide 300,000 m^3 of potential fish overwintering habitat. Such a volume of overwintering area is considerable. Of 22 fish overwintering sites surveyed in the lower Sagavanirktok River and Delta, under-ice free-water habitat ranged in volume from 4,000 to 57,000 m^3 (Adams and Cannon, 1987; Schmidt, Griffiths, and Martin, 1989).

The construction of an ice road over shallow overwintering habitat can cause additional freezing. Overwintering habitat could be lost, oxygen levels could decrease, and overwintering fish could be adversely affected. However, the extent to which fish use the Endicott Causeway channel as overwintering habitat is unknown, as are the actual winter dimensions of the channel. Even if this potential habitat were lost for a winter, the long-term effects on fish stocks would be minimal. North Slope fishes regularly endure population fluctuations associated with especially harsh winters. If the ice roads are limited to the grounded-ice area along their route, damage to any potential fish overwintering habitat would be minimized. BPXA confirmed via email to MMS on October 23, 2007, that hydrology field work was performed in the summer of 2007 for potential fish over-wintering areas. The areas included the potential ice road routing locations. EFH will not be adversely affected by ice road construction.

It is projected that ice roads will require 22 million gallons of freshwater per year during the peak construction season. The primary source of freshwater for ice roads will be the Duck Island Mine Site, which is believed to hold on the order of 600 million gallons of water. The mine site has never been breached (Hemming, 1988) and is therefore assumed not to contain fish.

Following completion of the SDI expansion, should BPXA continue to use similarly designed and located ice roads in support of Liberty-related activities, effects are anticipated to be similar for each phase of the project.

3.1.6.4 Gravel/Mine Site Development

The proposed mine site will be located in the eastern operating area of the Prudhoe Bay Unit, approximately 7.5 mi northeast of the Deadhorse Airport in the Sagavanirktok River delta. The proposed mine site is adjacent to the existing Duck Island Mine Site at South ½ Section 6, North ½ Section 7, Township 10 North, Range 16 East, Umiat Meridian. The extension of the SDI will require 860,000 yd^3 of gravel to be mined from the proposed site.

In January 2009, gravel will be removed from an area of approximately 21 acres, with the primary excavation area developed as a single cell, and the entire development mine site, including a stockpile area for overburden, will be approximately 50 acres in size. The Liberty Mine Site Mining and Rehabilitation Plan has been revised since submittal of the DPP in April 2007, and incorporates post-application comments from various regulatory agencies (e.g., ADNR, Office of Habitat Management and Permitting (OHMP) and the Division of Mining, Land and Water; U.S. Army Corps of Engineers, and the State Pipeline Coordinator's Office. The following gravel/mine site volumes/design were submitted by BPXA to MMS on October 15, 2007 as a component of the DPP modification:

- Shorelines with slopes of 3H:1V (or shallower) on three of the four sides of the site and 5H:1V (or shallower) on the other side resulting in:
  - Excavation Area increase from 18 to 21 acres (+3 acres)
  - Organic overburden stockpile volume increased from 60,000 yd^3 to 65,000 yd^3 (+5,000 yd^3)
  - Inorganic overburden stockpile volume increased from 215,000 yd^3 to 240,000 yd^3 (+25,000 yd^3)
  - Water diversion berm (April 2007 DPP refers to this as a Safety Berm) volume increased from 15,000 yd^3 to 20,000 yd^3 (+5,000 yd^3)
  - Access road footprint decreased from 2 to 1.4 acres
  - Access road volume decreased from 15,000 to 12,000 yd^3
- Incorporation of an approximate 300-ft long rip-rap breach in the western portion of the water diversion berm into the rehabilitation plan. The purpose of the breach is to enhance filling the mine while mitigating scour during periods of flood events.

Refer to Appendix I, Gravel Site Mining and Rehabilitation Plan, of this EA for complete details.

Although located within the floodplain, the proposed mine site does not appear to occur in a deep-water area where large-scale fish overwintering might take place. The excavation would eliminate some shallow water areas that are likely used by freshwater fish during summer, but the amount of loss would be small relative to the summer freshwater habitat available within the Sagavanirktok River delta.

When properly rehabilitated, abandoned and flooded gravel mine sites in or near river beds and floodplains can serve as suitable habitat for fish year-round. A detailed discussion of mine site reclamation and fish enhancement studies on the North Slope is provided in USDOI, MMS (2002). The utility to fish and wildlife of reclaimed, flooded mine sites depends on the mine's permanent access to surrounding stream or river channels, the contour and profile of the rehabilitated shoreline, depth, sufficient oxygen concentration, and sufficient primary and invertebrate production to sustain summer populations. A permanent connection to surrounding streams and rivers allows fish to move in and out of a site throughout the open-water season. In the absence of a direct connection, sites can be seasonally or sporadically connected to the surrounding drainages. Seasonally connected waterbodies are flooded during breakup, while sporadically connected waterbodies are flooded only during high-water years (U.S. Army Corps of Engineers, 1997; USDOI, MMS and BLM, 1998). To serve as viable overwintering habitat, mine-site water must be deep enough to provide sufficient under-ice-free water during winter, and be of a volume sufficient enough to prevent oxygen depletion during the long period of winter ice cover.

No EFH will be adversely affected by development of the gravel mine site.

3.1.6.5 Refined-Oil Spills

Nonpoint source pollution can have deleterious effects on salmonids, particularly growth in juveniles. Petroleum hydrocarbons damage developing salmon eggs, larvae, and fry at extremely low concentrations. Sculpin eggs and larvae and juvenile Pacific cod, which may occur in nearshore areas, likely would experience similar effects. Refined-oil spills associated with machinery operations tend to be quite small and could be cleaned up before reaching surrounding waterbodies. Mandatory safety measures and protocols designed to limit the occurrence and frequency of refined-oil spills are an integral part of industry operations on the North Slope.

During winter operations, ice cover would prevent spills from reaching fish habitat. If small spills associated with summer construction work on the SDI were able to leach into surrounding waterbodies, the affected area would be highly localized and would not affect feeding grounds and migratory corridors within the lower Sagavanirktok River delta.

Because they tend to be small in volume, any discharge reaching surrounding waters would affect only a small portion of fish habitat. Small refined-oil spills associated with the SDI expansion are not expected to have any measurable effect on arctic fish populations in the project area, and EFH will not be adversely affected. Small refined-oil spills that might occur during the on-shore construction and development phases of the Liberty (SDI) Project are expected to have similarly negligible effects on fish and EFH.

3.1.6.6 Water Quality (Suspended Sediments)

Expansion of the SDI will increase suspended sediment concentrations in the marine waters in the immediate vicinity of the construction site and create a turbidity plume that extends to nearby areas. The turbidity is expected to be high by winter standards but well within the range reported for Foggy Island Bay during summer. The increased turbidity is expected to be a short-lived impact and would affect only a tiny portion of the habitat used by marine fish.

3.1.6.7 Oceanography

The proposed SDI expansion is not expected to have any impact on regional oceanography. Currents in the immediate vicinity of the pad expansion will be affected during the open-water period but will not differ much from patterns associated with the present SDI pad. These minor changes in oceanography will have no measurable effects on marine or anadromous fish, and EFH will not be adversely affected.

3.1.7 Marine Mammals

Marine mammals are a large component of the Beaufort Sea ecosystem in the vicinity of the SDI. Three species of seals are native to the region: ringed seal (*Phoca hispida*), spotted seal (*Phoca largha*), and bearded seal (*Erignathus barbatus*). The Pacific walrus (*Odobenus rosmarus divergens*) may occasionally occur in the development area. Beluga whales (*Delphinapterus leucas*) are common offshore during the open-water season. Polar bears (*Ursus maritimus*) inhabit marine environments throughout the year and may use habitats near the project area for denning. Because polar bears have recently been nominated for listing as a threatened species under the Endangered Species Act, discussions of this species are included in the Threatened and Endangered Species sections of this EA. The bowhead whale (*Balaena mysticetus*) is also listed as endangered under the Endangered Species Act and is addressed in the Threatened and Endangered Species section.

3.1.7.1 Noise/Activity Disturbance

Noise and activity associated with the SDI expansion will not cause disturbance to beluga whales because the expansion will occur during winter when beluga whales are absent from the area. Activities related to facility installation that occur during the summer are not likely to affect beluga whales because they migrate well offshore from the barrier islands and are not common in the SDI area.

Noise and activities during the SDI expansion could affect seal behavior and distribution in the area, but the extent of disturbance is likely to be minimal. Underwater noise is unlikely to travel more than 2 km because of the rapid attenuation of industrial sounds in shallow waters (Blackwell and Greene, 2001). Blackwell, Greene, and Richardson (2004) reported underwater broadband sound levels from Northstar Island activities during winter reached background levels at distances of 3 to 4 km from the island. In addition, some seals may become habituated to industrial sounds, thus minimizing potential disturbance. Blackwell, Lawson, and Williams (2004) reported that 23 ringed seals showed little to no reaction to industrial noises during 55 hours of observation, and some seals were as close as 46 m to the island. Two of the 23 ringed seals looked at the island, 10 seals looked at a helicopter, and 1 seal returned to the water from the ice as a helicopter approached. Helicopters would be used during emergency situations only and would not be likely to disturb seals near the SDI. Moulton et al. (2002, 2003, and 2005) reported that limited winter industrial activity at Northstar Island did not appear to significantly affect ringed-seal density in the spring. Williams et al. (2006b) reported no relationship between ringed seal use of subnivean structures and the distance of those structures from Northstar Island. It is unlikely that large numbers of seals would be impacted by noise and activity disturbances during the SDI expansion and facility installation.

3.1.7.2 Small Spills or Leaks

It is unlikely that small spills (<200 bbl of crude oil) or leaks of oil, chemicals, or wastewater arising from the Liberty (SDI) Project will impact marine mammals. Such discharges would likely be contained and cleaned up immediately and are unlikely to enter the marine environment. Spill-prevention measures are required to be implemented during expansion of the SDI to keep small releases of pollutants from entering the marine environment.

3.1.7.3 Marine Access

The sealift required to transport Liberty (SDI) Project facilities has the potential to temporarily displace marine mammals adjacent to the route. Disturbances are most likely to arise when a barge passes near swimming beluga whales, walruses, or seals, or near seals, and walruses hauled out on ice. Underwater noise from vessel traffic was detected up to 27 km from the source by Blackwell and Greene (2006) during monitoring work near Northstar Island, but the radii in which marine mammals would be displaced is likely to be much smaller. Any disturbance to marine mammals from a sealift would be temporary (USDOI, MMS, 2002). There is the potential for a vessel to strike a marine mammal causing injury or death, but a strike would be very unlikely with currently only one sealift proposed for the project.

3.1.7.4 Loss of Habitat

Expansion of the SDI will increase the current footprint on the seafloor by 20 acres, which will be lost as seafloor habitat for marine mammals. Small numbers of seals might use this area to feed. Frost et al. (2004) reported that ringed-seal densities on landfast ice in the Alaska Beaufort Sea from 1996 to 1999 ranged from 0.57 to 1.14 seals/km^2 and were highest in water depths from 5 to 35 m. Moulton et al. (2002) reported that ringed-seal densities on landfast ice in the Alaskan Beaufort Sea from 1997 to 1999 were 0.39, 0.35, and 0.56 seals/km^2, respectively, with the highest densities occurring in 5 to 15 m of water. Seal densities were significantly lower in shallow water <3 to 5 m (Moulton et al., 2002; Frost et al., 2004). Water depths surrounding the SDI are generally 3 m or less, and it is unlikely that large numbers of seals use this habitat. Based on the larger seal density of 1.14 seals/km^2 in deeper water reported by Frost et al. (2004), habitat that might support approximately 0.10 seals could be lost due to gravel placement for the SDI expansion. Habitat loss for seals and other marine mammals from the SDI expansion is likely to be negligible.

3.1.7.5 Water Quality (Suspended Sediments)

The SDI working surface and seafloor footprint will be expanded from 11 to 31 acres through gravel placement. Suspended sediments resulting from construction activities during gravel placement will increase water turbidity in the area immediately around the expansion.

3.1.7.6 Summer Erosion

The SDI is located in the Sagavanirktok River delta. Large river deltas naturally experience pulses of erosion and turbidity from rain and runoff events. Increased turbidity from SDI expansion is anticipated to be short-lived, and most suspended material is expected to settle to the seafloor within or adjacent to the footprint of the pad expansion (see Section 3.1.2 for greater detail). Erosion from the expansion of the SDI should not be substantial enough to create changes in the water quality that will be likely to affect marine mammals. The after-abandonment effects on turbidity of the SDI addition and whole causeway are discussed further in Section 3.3.2.

3.1.8 Marine and Coastal Birds

Among the marine and coastal birds within the Liberty (SDI) Project area, the species most likely to be affected by the expansion of the SDI are species that are abundant in the vicinity of the project (snow geese), species with small total population sizes (red-throated loon, jaegers, tundra swan, brant, buff-breasted sandpiper), and species with declining population trends (long-tailed ducks, dunlin, phalaropes, and sandpipers).

3.1.8.1 Noise/Activity Disturbance

Gravel excavation and hauling from the newly developed mine site will occur during winter when most birds do not remain on the Arctic Coastal Plain. Noise from installation of sheetpile slope protection during January to March would not affect migratory birds.

Noise from grading and compaction activities during July to December could disturb and displace small flocks of molting long-tailed ducks and a few foraging red-throated loons and Pacific loons in the vicinity of the SDI. Disturbance could decrease foraging efficiency of long-tailed duck, common eider, and loons, negatively affecting their energetics. Disturbance due to gravel pad grading and compactions would be short-term, limited to one summer.

Nesting common eiders (~16 nests) and glaucous gulls (~4 nests) on the exploration pad for Duck Island 1 & 2, located west of the expanded SDI pad, could also be disturbed by expansion-related activities at SDI. Disturbance could interrupt nesting behaviors. Disturbance during nesting could lead to nest abandonment with subsequent death of eggs or young (Johnson, 2000b).

3.1.8.2 Water Quality (Suspended Sediments)

Erosion of the expanded SDI during the summer would increase turbidity in the vicinity of the expansion. Increased turbidity would hinder capture of prey by marine birds such as long-tailed ducks, common eiders, red-throated loons and Pacific loons, which dive for fish and invertebrate prey. Reduced water quality would be considered a temporary source of displacement if coastal and marine birds were forced to forage elsewhere.

3.1.8.3 Oceanography

The SDI expansion would potentially change water movements and sediment deposition around Duck Island 1 & 2, leading to alteration of the oceanographic processes that have shaped this abandoned exploration pad that is presently used by nesting common eiders and glaucous gulls. The exploration island could either become attached to the expanded SDI, or could be reshaped by an erosion channel between the SDI and the island. In either case, it is possible that access by arctic fox and bear may be enhanced by its proximity to the expanded SDI, thereby making this habitat unsuitable for nesting, as has been observed at the Endicott Causeway (Johnson, 2000b). Should loss of this nesting habitat occur, approximately 16 common eider and 4 glaucous gull nests would be displaced. If eider nesting habitats are limited, the nesting capacity of the eider population would be reduced. It may be possible to monitor the situation and either retain an effective separation between the expanded SDI and Duck Island 1 & 2 or create/replace similar nesting opportunities elsewhere.

3.1.8.4 Bird Strikes

Increased traffic on the access road during expansion of the SDI could limit the ability of some tundra-nesting birds and their broods to access coastal habitats. Some of these broods (particularly snow geese and brant) could be struck by vehicles when attempting to cross the roadway or could avoid crossing the road and experience increased predation. The present level of mortality from roadkill is unknown. BPXA informed FWS that speed limits on the Endicott road system are reduced from 45 miles per hour (mph) to 35 mph between July 1 and August 15 to protect snow geese. The reduced speed limit for vehicles during the nesting and/or broodrearing period could help reduce the negative effects of increased construction traffic. These negative effects are difficult to estimate, but the reporting of roadkill birds could help evaluate whether this is a substantial form of mortality to some coastal and marine bird species.

Increases to existing bird strike mortality is assumed to be low (<20 birds/year), however mortality could be larger due to episodic events such as a flock of birds colliding with structures (especially during periods of darkness or inclement weather) or entire broods could be struck by one vehicle. The removal of a hen would guarantee the death of an entire brood. Overall, expansion of the SDI will increase the potential for bird mortality, but this increase is not anticipated to be major. Per the FWS Final Biological Opinion (BO), BPXA must report all avian mortalities and collisions (including vehicle collisions) and their circumstances. The transmission of these data will help verify the assumption that collision mortality is low and negative effects are small.

3.1.8.5 Marine Access

Late-summer barge traffic to the MPI and/or SDI could cause short-term displacement of molting and foraging long-tailed ducks, common eiders, red-throated loons and Pacific loons. As the barges are generally slow-moving, these birds have an opportunity to move away from the approaching vessel before any direct harm occurs. The infrequent disturbance to these birds is not expected to result in a major impact.

3.1.8.6 Small Spills or Leaks

Minor spills (<200 bbl of crude oil)and leaks of oil, chemicals, or wastewater could affect the quality and abundance of prey species for diving seabirds. However, chronic discharges of small amounts of petroleum compounds could reduce water repellency of bird feathers, compromising their insulative capacity, resulting in hypothermia and death/drowning. The most abundant species (long-tailed ducks, common eiders, red-throated loons and Pacific loons) would experience the largest collective mortality, but smaller populations would be impacted to a disproportionately greater degree. Preventive measures are required to be implemented during construction to keep small releases of pollutants from entering the marine environment where they could impact a large number of birds prior to an active spill response.

3.1.8.7 Increased Bird-Predator Populations

Wildlife access to human-use foods during expansion of the SDI could increase the abundance and distribution of predatory birds (ravens, gulls) and mammals (foxes, bears) in the area. Per the FWS Final BO (see Appendix C of this EA), BPXA intends to implement techniques to prevent wildlife accessing anthropogenic food and waste. These techniques include installation of predator-proof dumpsters, new refuse-handling techniques; and educating their workforce on problems associated with feeding wildlife. If these techniques are effective, increased bird mortality from enhanced predator populations should not affect coastal and marine birds.

3.1.8.8 Habitat Effects

Some tundra-nesting and foraging habitats (~39 acres) temporarily would be unavailable during the spring following ice road construction. The ice road and associated snowdrifts likely would not melt before shorebirds and other migrants establish breeding territories and nesting sites.

Snow geese use wet meadows along the north side of the Endicott Road to grub for rhizomes during early spring, prior to nesting on Howe Island. The proposed ice road, north of the Endicott Road, crosses through early-spring foraging habitats and summer broodrearing habitats used by snow geese, tundra swans, and brant. Late melting of the ice road would delay the development of sedges and other forage species. The delay in forage maturation decreases the fiber content and increases the nutritional value as forage for brood-rearing geese in July and August (Gadallah and Jefferies, 1995; Piedboeuf and Gauthier, 1999). Ice road construction would alter local nesting distributions and habitat usage during spring and summer. These changes would be short-term (1 to 2 years), and localized, and minimal habitat impacts are anticipated.

3.1.9 Terrestrial Mammals

Among the terrestrial mammals that occur in the Liberty (SDI) Project area are, caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrels, and lemmings. These are the species potentially affected by development.

3.1.9.1 Noise/Activity Disturbance

Noise in the outer delta may displace caribou from coastal insect-relief habitats such as mud flats, nearshore islands such as Howe Island, and coastal spits. Prolonged displacement of caribou from these insect-relief habitats is not likely from the intensity and duration of activity proposed, and no population-level impacts are anticipated. Muskoxen are seldom observed in the project area; therefore, very few individuals would be affected, and no population-level impacts are anticipated.

3.1.9.2 Oceanography

Alteration of longshore currents, sediment deposition patterns, or Sagavanirktok Delta circulation patterns could lead to increased sediment deposition around Howe Island or Duck Island, perhaps connecting the islands to the SDI and causeway, thereby facilitating predator access to these islands and their colonial-nesting snow geese, brant, and glaucous gulls. Easy access across shallow water or ice to these areas with high concentrations of readily accessible forage, eggs, goslings, and adults would have a positive effect on local bears and foxes.

3.1.9.3 Increased Road Traffic

Construction traffic along the Endicott Road would be heaviest during installation of well pad facilities, the drilling rig, and the ***LoSal™*** enhanced oil recovery (EOR) process plant and drilling operations during summer and fall. Traffic levels of more than 15 vehicles/hour would hinder crossing of the Endicott Road by large groups of caribou, which may exclude them from some coastal insect-relief habitats (Murphy and Lawhead, 2000). Caribou do not usually calve in the Sagavanirktok River delta; therefore, changes in calving-caribou habitat use or distribution due to project construction are not anticipated. Oil field policies give caribou the right-of-way when crossing roads. Large groups of caribou crossing the road may cause traffic delays of up to several hours.

Many caribou in the vicinity of the North Slope oil fields are habituated to typical construction traffic levels. Collision mortality would likely increase with the increasing traffic levels and the increasing size of the Central Arctic Caribou Herd. However, mortality would likely remain low, with no population-level effects anticipated.

Increased traffic would lead to increased collision mortality for arctic ground squirrels and arctic foxes. Grizzly bears and muskoxen rarely occur in the project area and are not likely to be hit by trucks. A few collisions may occur over the life of the project resulting in injury or death of a few individuals. Speed limits and driver safety programs are designed to reduce collisions of vehicles with large mammals, and population effects are not anticipated.

3.1.10 Wetlands and Vegetation

Expansion of the SDI will greatly reduce the impact to wetlands and vegetation associated with the Liberty development compared to the other alternatives. The major impacts to wetlands and vegetation will occur during development of the gravel mine site (discussed in Section 3.2.7) and transportation of materials and personnel to and from development areas.

3.1.10.1 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil, chemicals, or wastewater arising from activities at the SDI will impact wetlands and vegetation. The SDI is composed of gravel fill deposited to support Endicott development and is largely barren of vegetation. Such minor discharges would likely be contained and cleaned up immediately.

3.1.10.2 Increased Road Traffic to Site

Traffic along the Endicott Road would increase to accommodate Liberty development and construction activities. Fallout from dust plumes associated with vehicle traffic has the potential to alter wetland characteristics and vegetation communities. The highest levels of traffic would likely occur during facility installation and infrastructure construction. Xeric, prostrate shrub-dominated communities and nonvascular species of moss and lichen are the most susceptible to impacts. Potential thinning of the vegetative canopy and altering of species composition would be the most common result of increased traffic and associated dust fallout (Auerbach, Walker, and Walker, 1997; Everett, 1980; Walker and Everett, 1987).

3.1.11 Threatened and Endangered Species

Three species listed as threatened or endangered under the Endangered Species Act occur in the Liberty (SDI) Project area: the bowhead whale (endangered), spectacled eider (threatened), and Steller's eider (threatened). The Kittlitz's murrelet (a candidate species) likely occurs in the Beaufort Sea and could be found in the Liberty (SDI) Project area.

Two other species—the polar bear (proposed for listing as threatened) and the yellow-billed loon (a draft 90-Day Finding has been released for public review)—are included in this section, as they may receive protection under the ESA during the life of the Liberty (SDI) Project.

The MMS completed consultation with FWS and NMFS as required by Section 7 of the ESA. The FWS completed a BO on October 3, 2007, that concluded the current Liberty (SDI) Project would not jeopardize populations of Steller's eiders, spectacled eiders, or Kittlitz's murrelets. The NMFS completed informal consultation on October 19, 2007, resulting in concurrence with MMS and the U.S. Army Corps of Engineers determination that the Liberty (SDI) Project is not likely to adversely affect the bowhead whale.

3.1.11.1 Noise/Activity Disturbance

Bowhead Whale

The noise and disturbance related to gravel deposition for the SDI expansion that will take place during the winter months of January through March will have no impact on bowhead whales that are wintering in the Bering Sea during these months. Following breakup, the newly deposited gravel will be machine-graded and vibra-compacted, a technique that uses a vibratory roller to condense gravel substrate. Noise from the compaction that may occur during the bowhead migration will not be likely to affect bowhead whales that are migrating offshore.

Any potential impacts will be mitigated by (1) the distance of migrating bowheads from the sound source, (2) the timing of the bowhead migration in the offshore waters of the project area, and (3) the rapid attenuation of sound likely to occur in the shallow waters of the project area. During the westward autumn migration bowhead whales are generally seaward of the barrier islands with annual variability in the mean distance offshore (Treacy, 2002a). The mean distance of migrating bowheads from shore in the Beaufort Sea west of Prudhoe Bay in 2000 (17.7 km) was less than for any single year (1982-2000) and much less than the cumulative mean (35.4 km; Treacy, 2002a). Blackwell et al. (2004) also reported interannual variability in the proximity of migrating bowheads to shore in the southern portion of the bowhead migration corridor near Prudhoe Bay. The migration corridor tended to be closer to shore in 2003 than the previous 2 years.

Underwater acoustic measurements at nearby Northstar Island during the open-water period indicated that construction noise was inaudible beyond 1.85 km (Blackwell and Greene, 2001). This attenuation distance for construction noise is dramatically less than the distance (approximately 15 km) between the SDI and the bowhead whale fall migration corridor. The peak of the bowhead migration in the offshore waters of the project area occurs during August and September, thus, migrating bowheads will not be affected by activities associated with the SDI expansion proposed for June and July. Consequently, noise and activity disturbances related to SDI expansion would not be likely to affect bowhead whales. However, unforeseen events resulting in a delayed sealift during the bowhead whale migration could result in unanticipated disturbances to bowhead whales. Furthermore, seasonal variations in bowhead whale distribution could result in feeding aggregations of whales closer to shore than is typically noted. This scenario could also result in unforeseen disturbances to bowhead whales.

McDonald et al. (2006) noted subtle offshore displacement of the southern edge of the bowhead whale migration corridor ranging from 0.66 to 2.24 km during times of industrial activity on Northstar Island during the 2001-2004 migrations. However, Northstar Island is located about 5 km farther offshore than the SDI. Blackwell and Greene (2006) reported underwater industrial sounds from Northstar Island during the summer reached background levels at distances of 2 to 4 km from the island. The SDI lies landward of the barrier islands approximately 15 km from the bowhead whale fall migration corridor. Water depth near the SDI is shallower than near Northstar Island, and underwater noise would likely attenuate more rapidly in the SDI area. Additionally, the barrier islands act as another impediment to industrial sounds originating in nearshore areas (USDOI, MMS, 2002). Per the informal consultation dated October 19, 2007 (refer to Appendix D of this EA), NMFS stated "…while the Liberty project may affect these whales, our assessment…finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur)."

Polar Bear

Ice road construction that is scheduled to begin in January could disturb polar bears in nearby maternal den sites, because denning is typically initiated during November and December. Bears leaving den sites with cubs during March and April also could be disturbed by noise and activity. Newborn polar bears are among the most undeveloped of placental mammals; therefore, undisturbed maternal dens are critical in protecting them from the rigors of the arctic winter for the first 2 months of life (Amstrup, 2000). Denning females are particularly sensitive to disturbance, and any cubs driven from their dens at this time likely would die. Substantial changes in cub survival and physical stature would have population-level effects (Regehr et al., 2006). For example, in other regions, declines in cub survival and physical stature were documented before statistically substantial declines in population size were confirmed. Therefore, protecting core maternity denning areas per the existing FWS Letter of Authorization (LOA) mitigation measures is important to the long-term conservation of polar bears.

Food and associated odors could attract polar bears during the SDI expansion. This could result in hazing to drive bears from the area, or in destruction of problem bears. Current North

Slope practices are designed to minimize or eliminate the potential for polar bear attraction to developed areas.

ESA-protected Birds

Much of the SDI expansion work is scheduled to take place during the winter when eiders, murrelets, and loons are absent from the project area. Noise and activity disturbances continuing into the spring nesting season at the SDI site likely will have minimal effects on eiders nesting on inland tundra habitats. Noise and human activity may displace male eiders, female eiders with broods, murrelets, and yellow-billed loons from marine habitats in the immediate area of the SDI during the postbreeding period. However, these temporary impacts should be minimal due to the large amount of similar habitat in the surrounding area and the low density of these species in the project area.

3.1.11.2 Water Quality (Suspended Sediments)

The SDI working surface and seafloor footprint will be expanded from 11 to 31 acres through gravel placement. Suspended sediments resulting from construction activities during gravel placement will have the potential to increase water turbidity.

ESA-protected Birds

As with noise and human activity, the alteration of water quality may render habitats in the immediate area of the SDI useless to birds. However, these temporary impacts to eiders, murrelets, and loons should be minimal due to the large amount of similar habitat in the surrounding area and the low density of these species in the project area.

3.1.11.3 Summer Erosion

Erosion of fine sediment and increased turbidity in waters surrounding the SDI is very unlikely to impact bowhead whales. The main migratory corridor used by bowhead whales during their annual migration is outside the barrier islands nearly 15 km offshore from the SDI. This corridor makes bowhead occurrence near the SDI very unlikely. Furthermore, summer erosion and increased turbidity occur naturally and are properties inherent to large river deltas like the Sagavanirktok River.

ESA-protected Birds

As with noise and human activity, the alteration of water quality may render habitats the immediate area of the SDI useless to birds. However, these temporary impacts to eiders, murrelets, and loons should be minimal due to the large amount of similar habitat in the surrounding area and the low density of these species in the project area.

3.1.11.4 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil, chemicals, or wastewater during SDI expansion will impact bowhead whales and polar bears. Such minor discharges would likely be contained and cleaned up immediately and are unlikely to enter the marine or terrestrial environments used by them.

ESA-protected Birds

Minor spills and leaks of oil could affect the quality and abundance of prey species for diving seabirds. Chronic discharges of small amounts of petroleum compounds during SDI expansion ultimately could reduce water repellency of bird feathers, compromising their insulative capacity, resulting in hypothermia and death/drowning when these materials melt out of ice and snow. The greatest potential for impacts are to migrating flocks of spectacled eiders (during the spring and fall), but the loss of fewer yellow-billed loons could result in a disproportionately greater impact. Spill prevention measures are required to be implemented during expansion of the SDI to keep small releases of pollutants from entering the marine environment where they could impact a large number of birds.

3.1.11.5 Increased Road Traffic to Site

Increased road traffic during SDI expansion is not expected to have any effects on bowhead whales in the offshore, marine environment.

Much of the SDI expansion is scheduled to take place during the winter when eiders, murrelets, and loons are absent from the project area.

3.1.11.6 Bird Strikes

There is the potential for spectacled and Steller's eider mortality to result from collisions with infrastructure at the SDI and MPI because eiders fly at relatively low altitudes over the water. Day, Prichard, and Rose (2005) reported the mortality of 36 common and king eiders as a result of collisions with facilities at Northstar Island and Endicott over a 4-year period. Collisions can occur with the sheetpile bulkhead and slope barrier protection.

Spectacled eider density is typically greater in the Liberty (SDI) Project area than Northstar Island (at the eastern extent of its range) and Steller's eiders are rare in the area. Nevertheless, spectacled eiders, in particular, are most susceptible to collisions with Liberty (SDI) Project facilities. The low numbers of these two listed eider species in the area should result in a lower potential for collisions with Liberty facilities at the SDI. Conservation measures are required to decrease the potential for spectacled eiders being killed via collisions with infrastructure on the SDI and the MPI. Per the FWS Final BO, BPXA must work with the FWS to design, install, and operate strobe warning lights for the Liberty (SDI) Project.

3.1.11.7 Increased Bird-Predator Populations

Access to human-use foods during facility construction could help increase the abundance and distribution of ravens, bears, or arctic foxes in the area. Efforts to eliminate wildlife access to human-use foods/garbage will be implemented at the beginning of facility construction. Per the FWS Final BO, BPXA intends to implement techniques to prevent wildlife accessing anthropogenic food and waste. These techniques include installation of predator-proof dumpsters, new refuse-handling techniques, and educating their workforce on problems associated with feeding wildlife. If these techniques are effective, increased predation from enhanced bird-predator populations should not affect ESA-listed birds.

3.1.11.8 Habitat Effects

Gravel for the SDI expansion would be mined from the Duck Island Mine Site. While this activity would occur during the winter, the gravel pit is in spectacled eider nesting habitat, and at least 65 acres of this habitat would be affected. As presently described, all of this nesting habitat would be permanently lost. The Mining and Rehabilitation Plan (Appendix I of this EA) implements suggestions made by the ADNR regarding slope configuration and breaching of the water-diversion berm to enhance flooding of the abandoned mine site. The mine site rehabilitation could restore eider nesting habitats, and/or once the mine site completely fills and is connected to the ephemeral Duck Island Creek, it may potentially support nesting yellow-billed loons with fish from the creek.

Gravel mining would have the potential to result in a loss of habitat for spectacled eiders. Spectacled eiders have been observed in this area along the Sagavanirktok River delta during aerial surveys (TERA, 1996). Density estimates for spectacled eiders in this area have ranged between 0.04 and 0.32 eiders/km^2 (TERA, 1996) and 0.01 to 0.61 eiders/km^2 (Larned et al., 2006). Spectacled eider density at the mine site could be up to 0.61 individuals/km^2; however, the surrounding areas have lower estimated densities of spectacled eiders. Due to the low density of spectacled eiders in the general area of the proposed mine site, few spectacled eiders would likely be displaced by mine site development. Based on the greater density of 0.61 eiders/km^2 reported by Larned et al. (2006), the 35 acres of disturbed land at the mine site might represent habitat loss for approximately 0.09 spectacled eiders.

Ice from ice roads has the potential to linger over tundra after the surrounding snow has melted in spring. Lingering ice on the ice-road footprint could prevent this strip of tundra habitat from temporarily being used as nesting habitat for spectacled eiders. Tundra compaction beneath ice roads can result in structural changes to the plant community following melting of the ice (Walker, 1996), which could temporarily affect eider use within the ice road footprint. The compacted tundra may not recover for many years, making it unsuitable as eider habitat. This potential impact could be minimized by selecting an ice road route which avoids tundra near known eider-nesting locations and favors habitat not preferred by eiders, but it is unclear if BPXA would complete this work or whether it would prove successful in retaining eider nesting habitat. This is partially due to the likelihood that eiders would not nest near (within 200 m) the roadway due to traffic noise and other activity. Because road activity likely precludes nesting by eiders near the road, alterations of these habitats are not considered to have more than minimal effects.

Ice-road construction involves withdrawing water from deep lakes in areas adjacent to the Endicott Road. Bergman et al. (1977) reported that spectacled eiders at Point Storkersen used deep *Arctophila* lakes during prenesting, nesting, and postnesting periods. Deep *Arctophila* lakes also have been used by brood-rearing spectacled eiders in NPR-A (Derksen, Rothe, and Eldridge, 1981). In addition, spectacled eiders often select nest sites near the edge of lakes, often within 1m of the shore. Withdrawal for ice roads that lowers the water level of lakes could affect spectacled eider nesting habitat. Most lakes would likely return to pre-withdrawal levels during spring flooding (Rovansek, Hinzman, and Kane, 1996), but care should still be taken when selecting lakes for water sources for ice roads. Water taken from deep open and deep *Arctophila* lakes should be minimized or avoided as these lakes may be used by spectacled or Steller's eiders. However, these are the lake types most suitable as water sources for ice road construction from an industry perspective and BPXA has not committed to avoiding the use of lakes important to spectacled eiders.

Similarly, water drawn from deepwater lakes to create the ice roads could alter nesting habitats used by yellow-billed loons. While BPXA has stated they would survey these lakes for their use by loons prior to ice road construction, it remains unclear if BPXA would actually avoid withdrawing water from lakes used by loons. The temporary loss of nesting habitat for up to three pairs of yellow-billed loons for up to 2 seasons would not be considered a major impact, but it is an impact that could be avoided.

3.1.12 Cultural Resources

In accordance with NHPA provisions of the November 24, 2006, Memorandum of Understanding among MMS, the U.S. Army Corps of Engineers, ADNR, and BPXA:

> The MMS, after consultation with the COE and other cooperating agencies, will notify BPXA if it determines that it is necessary to assess whether the Liberty (SDI) Project may affect archaeological resources within the project area. The MMS will request that BPXA provide archaeological and, if required, traditional cultural properties reports in accordance with the National Historic Preservation Act of 1966 (16 USC § 470 et seq.). The MMS will consult with the State Historic Preservation Officer and applicable Tribal Historic Preservation Officers, if necessary. This consultation will also cover the cooperating agency permit review requiring consultations.

The SHPO, in letters to BPXA on January 26, 2007, and the U.S. Army Corps of Engineers on June 8, 2007, requested that archaeological surveys be conducted in the Liberty (SDI) Project areas that previously had not been surveyed. These project areas would include locations where project activities such as ice road construction, gravel extraction, SDI expansion, West Sagavanirktok River Bridge upgrade, pipeline construction, facilities installation, and new drill rig construction could occur. BPXA notified MMS on July 2, 2007, that a cultural resources survey contract has been awarded to Reanier & Associates, with a final report expected in late 2007.

The MMS, after consulting the State of Alaska AHRS database, has identified no cultural and archaeological sites offshore, nearshore, or onshore within the area of potential effect of the Liberty Development Project. The SHPO concurred with the MMS determination of no effect to offshore historic or prehistoric resources. The U.S. Army Corps of Engineers agreed to the responsibility to conduct a separate consultation in accordance with NHPA for onshore resources. Refer to Appendix F for SHPO consultation correspondence.

3.1.13 Socioeconomics and Related Impacts

This section discusses the possible socioeconomic and related impacts (including subsistence-harvest resources, sociocultural, and environmental justice) associated with the SDI expansion. As noted in the above paragraphs, possible impacts of SDI expansion could arise from noise/activity disturbance, small operational spills of refined products (no large crude spills from drilling or production), and the temporary presence of construction workers in the area.

3.1.13.1 Economy and Sociocultural Systems

The Liberty FEIS (USDOI, MMS, 2002) estimated that the entire project would generate 870 full-time equivalent (FTE) construction jobs and an additional 1,248 indirect FTE jobs in Alaska during 14 to 18 months of construction. The new alternatives are likely to have smaller labor requirements, and only some of these jobs would be associated with SDI expansion. For example, the maximum annual number of workers required during SDI expansion (and associated onshore construction) is estimated to be 116. In principle, adverse sociocultural impacts could arise from either adverse impacts on subsistence-harvest resources or an influx of substantial numbers of workers. However, neither impact is anticipated, and no major sociocultural impacts associated with the SDI expansion are expected.

3.1.13.2 Subsistence and Area Use Patterns

Subsistence-harvest data are presented in the affected environment section. These data indicate that (in terms of total subsistence harvest for the potentially affected communities) the major subsistence foods include caribou, bowhead whales, and various types of fish (e.g., cisco and broad whitefish). Conclusions on possible impacts of SDI expansion on important subsistence resources are addressed in this EA and is *summarized* as follows:

- Section 3.1.6, Fish and Essential Fish Habitat: Noise/activity disturbance; ice road construction; gravel/mine site development; refined oil spills; water quality; and oceanography are not expected to have any measurable effect on arctic fish populations in the project area, and EFH will not be adversely affected.
- Section 3.1.9, Terrestrial Mammals: Noise/activity disturbance; oceanography; increased road traffic will affect very few individuals, and no population-level impacts are anticipated.
- Section 3.1.11, Threatened and Endangered Species (bowhead whale, spectacled eider, Steller's eider, and polar bear [proposed]): No major impacts on any of these species are anticipated as a result of noise/activity disturbance. Food and associated odors could attract polar bears during the SDI expansion, which could result in hazing to drive bears from the area or in the destruction of problem bears. Polar bears are unlikely to be seriously impacted by noise and activity disturbances from the SDI expansion. Small spills or leaks of oil, chemicals, or wastewater from the Liberty (SDI) Project are unlikely to impact bowhead whales, polar bears, or spectacled eiders.

In addition to the above, potentially major impacts might occur on the subsistence bowhead harvest if the sealift occurred during critical migration and hunting periods. However, if the sealift were delayed into September for any reason, BPXA would coordinate the sealift activity with the AEWC and Barrow and Nuiqsut Whaling Captains Associations through a Conflict Avoidance Agreement (CAA) or other communication mechanisms. Consistent with safe navigation and ice conditions, the sealift may be routed inshore to avoid migrating bowhead whales and subsistence whaling.

There are not expected to be any major effects on possible subsistence-harvest resources resulting from noise/activity disturbance or small operational spills of refined products during SDI expansion. And, if the sealift were delayed, measures would be taken to mitigate any major effect.

3.1.13.3 Environmental Justice

Adverse sociocultural or subsistence resource impacts would raise environmental justice issues, because (as noted elsewhere in this EA) the majority of the population is a recognized minority. However, major impacts to subsistence resources and harvests, and sociocultural systems are not anticipated; therefore, disproportionate high adverse environmental justice impacts are not anticipated as a result of SDI expansion.

3.1.14 Waste Management

All waste from the Liberty (SDI) Project would be handled in accordance with State, Federal, and local regulations. Use of permitted disposal wells and other approved disposal methods will result in zero surface discharge of drilling wastes and, in conjunction with BPXA's waste minimization policy, will result in little or no impact from waste disposal. See Section 10 of the Liberty DPP for more information on waste handling.

3.2 ONSHORE CONSTRUCTION

To take advantage of the infrastructure at Endicott, BPXA proposes to drill the uERD wells from the SDI by expanding the island by approximately 20 acres to support Liberty (SDI) Project drilling. Water for waterflooding to maintain reservoir pressure will be provided via the existing produced-water injection system available at the SDI, augmented by the ***LoSal™*** EOR process supplied by a ***LoSal™*** facility constructed on the MPI.

Associated onshore facilities to support this project will include upgrade of the existing West Sagavanirktok River Bridge, ice road construction, and development of a new permitted mine site adjacent to the Endicott Road to provide gravel for expanding the SDI. Existing North Slope infrastructure will also be used to support the project. The proposal to construct a new bridge across the west channel of the Sagavanirktok River as discussed in the April 2007 DPP has been removed from the Project Description. Per the BPXA Design Basis and Preliminary Construction Plan, dated September 2007, the existing Sagavanirktok River Bridge will be upgraded by replacing the superstructure. The bridge capacity will match the capacity of the existing Endicott bridges at 175 tons.

This approach will require the existing bridge superstructure to be dismantled. New pile caps will be installed on the existing steel pipe pile supports, which are embedded into the river bed to approximately 60+ ft. The single lane (approximately 18± ft between the guard rails) box girder bridge will have prestressed concrete deck panels will be installed on the refurbished bridge supports. This work will not entail driving new piles, icebreaking piers, or bridge revetments. Instead, gravel fill inside the existing piers will be removed to the mud line. A reinforcing steel cage will be lowered into the hollow steel pier. The pier will then be filled with concrete, this will strengthen the bridge piers against ice loads.

The state-of-the-art of uERD wells for this project will be outside current reach of industry technology performance. As a result, BPXA first plans to drill a single well to assure that such drilling is feasible. If that well is successful and the technology is proven, then BPXA will proceed with drilling additional wells and installing new facilities to complete the project as described in the 2007 Liberty DPP.

3.2.1 Air Quality

The ambient air pollutant impacts due to onshore construction of the permanent Liberty facilities are expected to be within the limits of the National and Alaska AAQS. Pollutants will be emitted from temporary operations and/or mobile equipment such as diesel-fired construction equipment, and temporary electrical generators. Pollutant emissions from marine vessels are expected to be negligible because, with the exception of a single sealift, marine vessels will not be used to support construction of the SDI expansion. Pollutant emissions from aircraft are expected to be negligible for the same reason. Fugitive particulate-matter emissions may result from local traffic, but will be minimized through fugitive-dust abatement techniques such as road watering. As part of the air permitting process, ADEC will review the construction equipment inventory and the construction plans to ensure compliance with the National and Alaska AAQS. A dispersion modeling analysis of project emissions will be included in the air permit application and will demonstrate National and Alaska AAQS compliance. An ambient-air-quality monitoring station has been in operation on the SDI since February 2007 to provide data to support air quality permitting.

3.2.2 Hydrology

The SDI is accessed by the existing Endicott Road. Increased use of this road for the Liberty (SDI) Project would require upgrading of the bridge at the Sagavanirktok West Channel to provide higher capacity. Environmental consequences of this action on the local hydrology would be negligible, because the new superstructure will be identical in length to the existing bridge. Flow patterns through the bridge will not change. Construction-related consequences will be minimized by installation of the new superstructure during the winter, when the river and ground are frozen.

3.2.3 Fish and Essential Fish Habitat

3.2.3.1 Pipeline Construction

The only pipeline construction associated with the project will be from the two Liberty (SDI) Project pipelines that will run approximately 3 mi from the SDI to Endicott MPI. The new pipelines will be located entirely on the existing gravel causeway and will not physically affect fish habitat. Construction noise is not likely to affect fish, and if it does the impact will be localized and avoidable. These are the only pipelines planned for construction. If construction noises do disturb fish, the effect would be localized and avoidable.

3.2.3.2 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil, chemicals, or wastewater arising from the Liberty (SDI) Project pipeline construction will impact fish or EFH. Such minor discharges likely would be contained and cleaned up immediately, and it is unlikely that any would enter the marine environment.

3.2.3.3 West Sagavanirktok River Bridge and Causeway Culverts

BPXA proposes to upgrade the existing Sagavanirktok River Bridge superstructure. Permitting for the bridge superstructure upgrade will be overseen by the U.S. Army Corps of Engineers and the ADNR OHMP. All work related to the bridge project will occur in the winter.

The current Sagavanirktok River vehicle bridge and the associated causeway and culverts across the floodplain have a history of adversely affecting anadromous fish habitat. The Sagavanirktok River has been specified as being important for the migration, spawning, or rearing of anadromous fishes in accordance with Alaska Statute 41.14.870(a). At least two deep-water overwintering holes are located near the existing bridge and pipeline crossing (Morris, 2000). One is located directly adjacent to the roadway bridge (Bjerklie, 1991a, 1991b, 1993). The hole has maximum depth of about 3 m, with an average depth of about 2.5 m and a cross-river width of 70 m (Bjerklie, 1991a, 1991b, 1993). The upstream and downstream extent of the hole is unknown, but the site provides major overwintering habitat for several species of freshwater and anadromous fish. In the Sagavanirktok watershed, freshwater species such as grayling, round whitefish, and burbot often overwinter collectively in the few deep-water sanctuaries that are available (Bendock, 1981). The sites near the bridge also appear to be a major overwintering and possibly a spawning area for broad whitefish (Morris, 2000).

The risk to fish during winter operations would be possible disturbance of overwintering areas near the bridge. Streambed disturbance in areas where there is under-ice free water could increase turbidity, and if oxygen-demanding materials are discharged, decreased oxygen levels could be stressful or even lethal to fish. Morris (2000) found that under natural conditions, water quality at overwintering sites in the Sagavanirktok River degrades considerably over the course of the winter. Space becomes more cramped as ice cover thickens and oxygen levels decline. All of the sites that he surveyed were considered either marginal or failed. Such conditions indicate that any fluctuation in environmental conditions potentially can have major effects on fish overwintering survival.

Construction noise generated from the superstructure upgrade could stress or injure overwintering fish. Disturbance during construction or permanent loss of habitat in the vicinity of the construction site is unlikely to result in irreparable damage to fish populations. Stock estimates for broad whitefish 120 to 250 mm in length indicate that the Sagavanirktok population expands and collapses on a regular basis (Gallaway et al., 1997). Population estimates for the period 1982-1984 and 1988-1992 ranged from a low of 25,800 in 1984 to 432,341 in 1990. It is doubtful that a population of this size would rely on a single overwintering site to sustain stock integrity. Craig (1989) postulated that North Slope fish populations reduce their chances of extinction by spreading their members over many overwintering sites, and a significant impact at any one site would not eliminate all members of the population.

The ADF&G's Fish Distribution Database indicates that adult pink and chum salmon have been infrequently documented in the Sagavanirktok River. However, spawning activity or juvenile life stages have not been documented. Essential Fish Habitat will not be adversely affected by bridge construction activity.

3.2.4 Marine Mammals

3.2.4.1 Ice Road Construction (Winter Only)

The Liberty (SDI) Project will involve construction of an ice road approximately 11 km long from a mine site adjacent to the Endicott Road to the SDI. The proposed route will be located adjacent to the Endicott Road and will transit approximately 6.4 km of tundra habitat and 4.8 km of marine environment. Noise and activities from ice road construction could impact marine mammals in the area.

Beluga whales and Pacific walruses are absent from the Liberty (SDI) Project area in winter. Ice road construction and use will occur in winter and will have no effect on beluga whales or walruses.

Adult seals and their pups could be displaced during ice road construction, but seal density near the coast along the ice road route is low (Moulton et al., 2002). Moulton et al. (2002, 2003, and 2005) reported that limited winter industrial activity at Northstar Island, including ice roads, did not appear to significantly affect ringed-seal density in the spring. Williams et al. (2006b) reported no relationship between ringed-seal use of subnivean structures and the distance of those structures from ice roads associated with Northstar Island. Additionally, water along much of the proposed ice road route could be shallow enough to freeze to the bottom during winter and be unsuitable for use by seals. Ice-road construction for the SDI expansion would have little effect on seal abundance or distribution.

3.2.4.2 Pipeline Construction (SDI to MPI)

The Liberty (SDI) Project will involve construction of two new pipelines between the MPI and SDI along the Endicott Causeway during the winter. No marine mammals are expected to be close enough to be impacted by this activity.

3.2.4.3 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil, chemicals, or wastewater arising from the Liberty (SDI) Project pipeline construction will impact marine mammals. Such minor discharges would likely be contained and cleaned up immediately, and it is unlikely that any would enter the marine environment. Spill-prevention measures are required to be implemented during pipeline construction to keep small releases of pollutants from entering the marine environment.

3.2.5 Marine and Coastal Birds

3.2.5.1 Noise/Activity Disturbance

Noise and activities associated with upgrading the bridge would primarily occur during the winter and would not affect migratory birds. Similarly, the pipelines between the SDI and MPI are scheduled to be constructed in winter when most birds are absent from the project area and noise/activity impacts from pipeline construction are expected to be minimal.

Increased summer traffic would disturb birds along the Endicott Road, especially if traffic volumes are constant throughout the 24-hour day and occur during the months of July and August. Disturbance to birds from vehicle traffic on the North Slope has been noted for brant and for Canada and white-fronted geese, and the extent of disturbance was shown to be directly correlated with the birds' distance from the road (Murphy et al., 1988; Murphy and Anderson, 1993). Disturbance to birds (e.g., "heads up" behavior) was most apparent within 50 m of roads, but some disturbance was reported as far as 150 to 210 m from the road (Murphy and Anderson, 1993). These disturbances occurred most often prior to nesting and during brood-rearing and fall staging when geese gathered to feed in open areas near roads. Susceptibility to this potential disturbance on eiders could depend on the stage of reproduction. Birds responding unfavorably to this noise and activity may be displaced to other, less suitable areas.

Noise and activity associated with facility construction at SDI and MPI could disturb and displace small flocks of molting long-tailed ducks and individual red-throated and Pacific loons. Disturbance could decrease foraging efficiency of long-tailed duck, common eider, and loons, negatively affecting their energetics. Disturbance due to these construction activities would be limited to less than 2 summers and these birds are anticipated to move short distances away from the disturbance to other habitats. These alternative habitats may be less suitable.

Nesting common eiders (~16 nests) and glaucous gulls (~4 nests) on nearby Duck Island 1 & 2 could also be disturbed by facility construction-related activities at SDI. Disturbance could interrupt nesting behaviors. Disturbance during nesting could lead to nest abandonment with subsequent death of eggs or young (Johnson, 2000b). Disturbance due to facility construction activities would be limited to <2 summers. Due to specialized nesting requirements of common eiders, it is unknown if these birds could locate alternative, suitable nesting sites.

3.2.5.2 Small spills or leaks

Minor spills (<200 bbl of crude oil) and leaks of oil or chemicals could affect the quality and abundance of prey species for diving seabirds around the SDI. Chronic discharges of small amounts of petroleum compounds could reduce water repellency of bird feathers, compromising their insulative capacity, resulting in hypothermia and death/drowning. The most abundant species (long-tailed ducks, common eiders, red-throated loons and Pacific loons) would experience the largest collective mortality, but smaller populations would be impacted to a disproportionately greater degree. Preventive measures will be implemented during onshore construction to minimize small releases of pollutants from entering the marine environment where they could impact a large number of coastal and marine birds prior to an active spill response.

3.2.5.3 Increased Road Traffic to Site

Increased vehicle traffic on the Endicott Road during facility construction could limit the ability of some tundra-nesting birds and their broods to access coastal habitats. Birds responding unfavorably to high levels of vehicular traffic could avoid crossing the road remain in areas where they could experience increased predation or be may be displaced to other, less suitable areas. These potential effects could be experienced for up to two years, until facility construction is completed. BPXA informed FWS that speed limits on the Endicott road system are reduced from 45 mph to 35 mph between July 1 and August 15 to protect snow geese. The reduced speed limit for vehicles during the nesting and/or broodrearing period could help reduce the negative effects of increased construction traffic. Per the FWS Final BO, BPXA must report all avian mortalities and collisions (including vehicle collisions) and their circumstances.

3.2.5.4 Marine Access

The sealift could temporarily displaced eiders, murrelets, and loons from preferred marine feeding habitats, but impacts would likely be minimal and displaced birds could use adjacent habitats or return to preferred habitats after sealift passage. Per the FWS Final BO, BPXA has committed to ensuring that vessels do not enter the Ledyard Bay Critical Habitat Unit located in the Chukchi Sea, where large numbers of flightless spectacled eiders molt.

3.2.5.5 Bird Strikes

Additional facilities constructed on both the MPI and SDI would lead to an incremental increase in bird strike mortality especially for migrating sea ducks, many of which fly low and fast along coastal areas during spring and fall migrations. The drilling rig, which will be approximately 250 ft tall, will be on the SDI for at least 3 years and could contribute to an increase in bird strikes when present. The present level of bird strike mortality associated with MPI facilities is unknown. The other buildings/facilities could contribute to additional collision mortality for the life of the project.

BPXA design engineers have committed to consult with the FWS on identifying and implementing ways to reduce how facility lighting attracts/disorients birds in the project vicinity. Effectively reducing escaped lighting is believed to reduce the potential for birds to strike facilities on the MPI and SDI. Per the FWS Final BO, BPXA has committed to the placement of warning strobes outside the eastern sheet-pile wall in an effort to help migrating eiders avoid the Endicott SDI. Also per the FWS Final BO, BPXA must report all avian mortalities and collisions and their circumstances. The transmission of these data will help determine if these design features are effective.

Increased vehicle traffic on the access road during facility construction could limit the ability of some tundra-nesting birds and their broods to access coastal habitats. Some of these broods (particularly snow geese and brant) could be struck by vehicles when attempting to cross the roadway or could avoid crossing the road and experience increased predation. The present level of mortality from roadkill is unknown. A reduced speed limit for vehicles during the nesting and/or broodrearing period could help reduce the negative effects of increased construction traffic. These negative effects are difficult to estimate, but the reporting of roadkill birds could help evaluate whether this is a substantial form of mortality to some species.

Increases to existing bird strike mortality is assumed to be low (<20 birds/year), however mortality could be larger due to episodic events such as a flock of birds colliding with structures (especially during periods of darkness or inclement weather) or entire broods could be struck by one vehicle. The removal of a hen would likely result in the loss of an entire brood. Overall, onshore construction activities will increase the potential for bird mortality, but this increase is not anticipated to be major. The aforementioned reporting of all avian mortalities and collisions and their circumstances will help verify the assumption that collision mortality is low and any adverse effects are small.

3.2.5.6 Increased Bird-Predator Populations

Creation of artificial nesting habitats for ravens and other predatory birds have influenced their distribution across the North Slope. Newly constructed facilities for the Liberty (SDI) Project may create nesting habitats for ravens and other predatory birds which could lead to increased predation on tundra-nesting birds in the project vicinity (USDOI, FWS, 2003). Bridge spans and new pipelines may create nesting habitats for ravens and other predatory birds.

Per the FWS Final BO, BPXA has committed search Liberty (SDI) Project structures for raven-nesting activities from March 1 through June 30 each year. Monitoring would take place every 4 days and, if nesting materials are found, they will be removed and disposed of to prevent their reuse by ravens. An annual report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year. If effective measures are implemented, increased predation from increased nesting of bird-predators on project structures should avoid impacts to coastal and marine birds.

Other components of the Liberty (SDI) Project may afford foxes new denning sites. For example, the currently proposed mine rehabilitation plan includes retention of portions of an elevated earthen berm and the stockpiles of organic overburden, which could become a site of future new fox dens. Per the FWS Final BO, BPXA intends to monitor the berm and stockpiles weekly from April 15 through June 15. If denning activities are observed, the ADF&G and FWS will be contacted to develop a plan to prevent further activity. An annul report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year.

3.2.5.7 Habitat Effects

BPXA has indicated that ice roads, north of the Endicott Road, may be used during winter construction of onshore facilities, similar to that used for expansion of the SDI. If ice roads were used, some tundra-nesting and foraging habitats (~39 acres) would be unavailable during the spring following ice road construction. The ice road and associated snowdrifts will not likely melt before shorebirds and other migrants establish breeding territories and nesting sites.

Snow geese use wet meadows along the north side of the Endicott Road to grub for rhizomes during early spring, prior to nesting on Howe Island. The proposed ice roads cross through early-spring foraging habitats and summer brood-rearing habitats used by snow geese, tundra swans, and brant. Late melting of the ice road will delay the development of sedges and other forage species. The delay in forage maturation decreases the fiber content and increases the nutritional value as forage for brood-rearing geese in July and August (Gadallah and Jefferies, 1995; Piedboeuf and Gauthier, 1999). Ice road construction could alter local nesting distributions and habitat usage during spring and summer. These changes would be short-term (3-4 years), are localized, and minimal habitat impacts are anticipated.

3.2.6 Terrestrial Mammals

3.2.6.1 Ice Road Construction

Ice road construction and use would cause disturbance to caribou that may remain on the Arctic Coastal Plain during winter. Ice roads provide a hard surface, which as compared to deep snowdrifts, caribou may prefer for travel. Visibility for drivers may be limited due to darkness and snowstorms during winter months; these factors increase the likelihood of vehicle-collision mortalities for caribou and muskoxen. However, there are strict rules in the oil fields about vehicle travel during periods of poor visibility to ensure personnel safety. Because most caribou and muskoxen move south into the foothills and mountains of the Brooks Range during winter, very few collision mortalities have occurred during these months. If the growth of the Central Arctic Herd results in more caribou remaining on the Arctic Coastal Plain during winter, the likelihood of collisions with vehicles and equipment will increase.

Areas of suitable grizzly-bear denning habitat occur throughout the Sagavanirktok River delta along river channel and flood terrace banks, and on stabilized-sand-dune ridges. Construction of the ice road over or very close to a grizzly bear den would cause death, injury, or disturbance for individual bears or female bears with newborn cubs. About 60 to 70 grizzly bears frequent the oil field area (Shideler and Hechtel, 2000). BPXA will work with the ADF&G to identify known bear dens in the vicinity of the planned ice roads. The ice road would avoid known dens. Identification of arctic-fox den structures would also prevent injury and destruction of fox den sites. Fox den structures may be used repeatedly for centuries. Older dens are large, easily recognizable structures located on mounds, low hills, or ridges with thin snow accumulations, many entrances, and altered vegetation types (Burgess, 2000). Some resident arctic foxes that remain at den sites throughout the winter (Burgess, 2000) would be displaced by den site destruction or disturbance, and would likely to seek shelter under modules and open crawl spaces beneath buildings at nearby oil field facilities.

Ice roads built on top of lemming burrows and runways may lead to onsite death and habitat abandonment by lemmings; arctic ground squirrel burrows that exist under the snow would lead to death of hibernating ground squirrels and destruction of these sites. Ground squirrel burrows are located on mounds, river bluffs, stabilized sand dune ridges, and other well-drained locations throughout the project area. Ice road construction and disturbance would affect a few individuals, and no population-level effects on grizzly bears, arctic foxes, arctic ground squirrels, or lemmings are anticipated.

Minor fuel or antifreeze spills may leach into nearby underground burrows causing death of arctic ground squirrels, foxes, and lemmings. Antifreeze spills on the ice road may attract arctic foxes, squirrels, and lemmings, and would cause injury or death if ingested in sufficient quantity. A few individuals would be affected, and no population-level effects are anticipated from these spills and leaks.

3.2.6.2 Mine Site Development

A few individuals or small groups of caribou may remain in the project area during winter, but most will move south into the foothills and the Brooks Range and would not be exposed to disturbance from mine site excavation. Some tundra habitats used by caribou and muskoxen for foraging would be lost or altered due to mine site excavation, but the areas would be minimal compared to available habitats, and no population-level effects are anticipated.

Grizzly denning and foraging habitats would be potentially lost or altered in the excavation area. Excavation of the mine site in areas containing arctic ground squirrel burrows or arctic fox dens would cause death of a few hibernating ground squirrels and destruction of burrows and fox dens. As with ice road construction, identification and avoidance of active grizzly bear dens and arctic fox den structures would prevent injury to these animals and destruction of their dens.

As described for ice road construction, minor spills or leaks of such materials as fuel or antifreeze from vehicles and equipment used during mine site construction may occur and contaminate den sites. Antifreeze spills may attract arctic foxes and would cause injury or death of a few individuals if ingested in sufficient quantity. Population effects are not anticipated from these spills and leaks.

3.2.6.3 West Sagavanirktok River Bridge

A few individuals or small groups of caribou may remain in the project area during winter, but most will move south into the foothills and the Brooks Range and would not be exposed to noise and activities associated with the bridge upgrade. Bridge design would presumably allow passage of caribou, muskoxen, and grizzly bears beneath the bridge and would not block movements of these animals along riparian corridors. Small areas of river-bluff habitats used by bears for denning and foraging would be lost. Grizzly bears that den at or very near the bridge site would be killed, injured, or disturbed by winter construction. At bridge approaches, alteration of tundra habitats supporting arctic ground squirrel burrows or arctic fox dens would cause death of a few hibernating ground squirrels and destruction of the burrows and fox dens. Identification and avoidance of active grizzly bear dens and arctic fox den structures would prevent injury to grizzly bears and destruction of fox den sites.

The bridge project and pipelines crossing the river downstream from the bridge, may make this area less attractive to caribou and muskoxen for movement along the riparian corridor. The additional shade created by these multiple overpasses, however, would provide shade habitats that caribou may use to avoid parasitic bot and warble flies which are negatively phototaxic.

Minor spills or leaks of such materials as fuel or antifreeze at the construction site may attract arctic foxes, and ingestion of the antifreeze in sufficient quantities would cause injury or death. Overall, population-level impacts from bridge project activities are not expected.

3.2.7 Wetlands and Vegetation

The most noteworthy disturbance to wetlands and vegetation will potentially occur during the onshore construction phase of the Liberty (SDI) Project. Development of the gravel mine site, transporting materials during construction activities, and improvements to transportation corridors will have varying levels of impact to wetlands and vegetation.

3.2.7.1 Ice Road Construction

Onshore ice-road construction will primarily be used during the SDI expansion to transport gravel fill from the mine site to the SDI. Additional ice roads may be used to bypass the West Sagavanirktok River Bridge or during upgrade of the bridge superstructure. The impact from ice roads varies with topography and soil moisture conditions. Moist or wet meadow communities typically show little to no sign of disturbance after the ice road has melted (Payne, Guyer, and Keating, 2003; Yokel et al., 2003). Drier sites, elevated microsites, and tussock-type tundra are at a relatively greater risk for disturbance (Jorgenson, 1999; Pullman et al., 2003). Ice-road construction has the potential to compact the subnivean layer, damage or kill off some plants, and remove standing dead material from the aerial canopy (Walker et al., 1987).

It is unlikely that minor spills or leaks of oil or chemicals arising from ice road activities will impact wetlands and vegetation. Such minor discharges would likely be contained and cleaned up immediately.

3.2.7.2 Mine Site Development

The primary mine cell will cover an area of approximately 21 acres. Vegetation, mineral surface soils, and unusable gravels removed from the mine will be stockpiled adjacent to the excavated areas. Including the stockpiled material, a total area of approximately 50 acres will be used for the mining operation. Excavation, mining, and stockpiling of materials will destroy vegetation in that area. Development will follow an approved mining and rehabilitation plan.

3.2.7.3 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil or chemicals arising from mine site activities will impact wetlands and vegetation. Such minor discharges would likely be contained and cleaned up immediately.

3.2.7.4 West Sagavanirktok River Bridge

Upgrade of the West Sagavanirktok River Bridge will rely on ice roads to support construction activities. The impact associated with ice roads is discussed in Section 3.2.7.1 above.

Bridge upgrade activities would result in increased traffic to and from the construction site. A portion of the construction would be conducted during winter months which would reduce the level of dust fallout to some degree. Fallout from dust plumes associated with vehicle traffic has the potential to alter wetland characteristics and vegetation communities. Xeric, prostrate shrub-dominated communities and non-vascular species of moss and lichen are the most susceptible to impacts. Potential thinning of the vegetative canopy and altering of species composition would be the most common result of increased traffic and associated dust fallout (Auerbach, Walker, and Walker, 1997; Everett, 1980; Walker and Everett, 1987).

3.2.7.5 Rig and Facilities Installation

Traffic along the Endicott Road would increase to accommodate drill rig construction and fabrication and installation of module and infrastructure components. Fallout from dust plumes associated with vehicle traffic has the potential to alter wetland characteristics and vegetation communities, as discussed in Section 3.2.7.4 above.

3.2.7.6 Pipeline Construction (SDI to MPI)

It is unlikely that minor spills or leaks of oil or chemicals arising from new pipeline construction will impact wetlands and vegetation. The causeway along which the pipelines will be constructed is gravel fill placed during the Endicott development and largely barren of vegetation. Such minor discharges would likely be contained and cleaned up immediately.

Construction activities along the SDI to MPI road are not adjacent to any tundra that would be affected by dust fallout. However, in support of construction activities it would be expected that traffic along the main Endicott Road would increase. Fallout from dust plumes associated with vehicle traffic has the potential to alter wetland characteristics and vegetation communities, as discussed in Section 3.2.7.4 above.

3.2.8 Threatened and Endangered Species

3.2.8.1 Noise/Activity Disturbance

Bowhead Whale

Noise and activity disturbances as a result of construction of Liberty (SDI) Project pipelines between the MPI and SDI would be unlikely to impact bowhead whales. Pipeline construction would take place during the winter and would not influence bowhead whales wintering in the Bering Sea. Bowhead whales will not be in the project area during bridge upgrading. There will be no impacts on bowhead whales from noise and activity originating from the bridge upgrade. Per the informal consultation dated October 19, 2007 (refer to Appendix D of this EA), NMFS stated "…while the Liberty project may affect these whales, our assessment…finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur)."

Polar Bear

Polar bear denning habitat occurs in the project area (Durner, Amstrup, and Ambrosius, 2001), and noise and activity during ice road construction could disturb polar bears at maternal den sites (Blix and Lentfer, 1991). Although polar bears may tolerate and habituate to industrial activity, maternal females with newborn young are more sensitive to disturbance and can be displaced from their den sites due to human activities. It is recommended that BPXA consult with FWS polar bear specialists before building ice roads to obtain the current information regarding polar bears in the project area. Should a polar bear den be discovered, appropriate mitigation measures will be employed, as specified in FWS Letters of Authorization (LOAs) for BPXA-operated North Slope oil fields. The current FWS LOA was issued January 1, 2007, and expires December 31, 2007. BPXA, in an email to MMS on October 18, 2007, acknowledged the expiration date of the current LOA and anticipates the annual renewal.

Impacts of industrial noise and activity from construction at the SDI on polar bears are described in detail in Section 3.1.11.1 and would be similar to the effects of winter ice road construction.

ESA-protected Birds

Some facility construction (especially pipelines and bridge work) would be completed during the winter, when ESA-listed birds are not in the project area. Noise and activity disturbances continuing into the spring nesting season at the SDI site likely will have minimal effects on eiders nesting on inland tundra habitats, but could displace murrelets and nonbreeding eiders and loons from marine areas around the SDI. Similarly, post-breeding eiders and yellow-billed loons could experience the same impacts later in the summer and fall. These temporary impacts should be minimal due to the large amount of assumed similar habitat in the surrounding area and the low density of ESA-listed birds in the project area.

3.2.8.2 Small Spills or Leaks

Bowhead Whale

Bowhead whales are unlikely to be impacted by minor spills (<200 bbl of crude oil) or leaks of oil or chemicals originating from construction of pipeline between the MPI and SDI. Such minor discharges would be held with in containment or would be cleaned up immediately. Bowhead whales migrate 15 km or more offshore from the coastline, and any discharge from the Endicott Causeway would be unlikely to enter their offshore environment.

Polar Bear

Polar bears are unlikely to be impacted by minor spills (<200 bbl of crude oil) or leaks of oil or chemicals originating from construction of pipeline between the MPI and SDI. Such minor discharges would be held with in containment or would be cleaned up immediately.

ESA-protected Birds

Minor spills and leaks of oil could affect the quality and abundance of prey species for ESA-listed birds. Chronic discharges of small amounts of petroleum compounds during SDI expansion ultimately could reduce water repellency of bird feathers, compromising their insulative capacity, resulting in hypothermia and death/drowning when these materials melt out of ice and snow. The greatest potential for impacts is to migrating flocks of spectacled eiders (during the spring and fall), however, the loss of fewer numbers of yellow-billed loons could result in a relatively greater impact. Spill-prevention measures are required to be implemented during facility construction to keep small releases of pollutants from entering the marine environment, where they could impact a large number of birds prior to an active spill response.

3.2.8.3 Increased Road Traffic to Site

There is also the possibility for increased road traffic to obstruct the movement of spectacled eiders, especially during brood-rearing and molting periods when birds are flightless. TERA (1996) reported that spectacled eider broods traveled an average of 0.53 km each day during the first week following hatching, and broods were known to cross roads repeatedly. Reduced speed limits have been implemented on the Endicott Road in past years as a mitigation tool for minimizing impacts on snow geese broods. Continuing reduced speed limits will also help minimize the impacts on spectacled eiders from increased road traffic resulting from development of the Liberty (SDI) Project. Additionally, the nesting density of spectacled eiders in the Liberty (SDI) Project area is low, and it is likely that few birds would be disturbed by increased road traffic.

3.2.8.4 Marine Access

Any sealifts could temporarily displaced eiders, murrelets, and loons from preferred marine feeding habitats, but impacts would likely be minimal and displaced birds could use adjacent habitats or return to preferred habitats after sealift passage. The sealift could disturb tens of thousands of spectacled eiders molting in the Ledyard Bay Critical Habitat Area (Chukchi Sea). BPXA has committed to completely avoid sealift transit through the Ledyard Bay Critical Habitat Area.

3.2.8.5 Bird Strikes

Migrating eiders tend to fly low and fast along coastal areas during spring and fall migrations and they sometimes are killed when they collide with structures in their path, especially during periods of darkness or inclement weather. Day, Prichard, and Rose (2005) reported the mortality of 36 common and king eiders as a result of collisions with facilities at Northstar Island and Endicott over a 4-year period. The present level of bird strike mortality associated with MPI facilities is unknown.

New facilities constructed on both the MPI and SDI are expected to result in an incremental increase in ESA-listed bird strike mortality, especially for spectacled and Steller's eiders. The drilling rig, which will be approximately 250 ft tall, will be on the SDI for at least 3 years and could contribute to an increase in bird strikes when present. The other buildings/facilities could contribute to additional collision mortality for the life of the project.

Spectacled eider density typically is greater in the Liberty (SDI) Project area than at Northstar Island (at the eastern extent of its range), and Steller's eiders are rare in the area. The low numbers of these two listed eider species in the area should result in a low potential for collisions with Liberty (SDI) Project facilities. Conservation measures are required per the FWS Final BO to decrease the potential for spectacled eiders being killed from collisions with Liberty (SDI) Project facilities and the MPI.

BPXA design engineers have committed to consult with the FWS on identifying and implementing ways to reduce how facility lighting attracts/disorients birds in the project vicinity. Effectively reducing escaped lighting is believed to reduce the potential for birds to strike facilities on the MPI and SDI. Increased vehicle traffic on the access road during facility construction could limit the ability of some spectacled eiders and their broods to access coastal habitats. Some of these eider broods could be struck by vehicles when attempting to cross the roadway or could avoid crossing the road and experience increased predation. The present level of mortality from roadkill is unknown. A reduced speed limit for vehicles during the nesting and/or broodrearing period could help reduce the negative effects of increased construction traffic. These negative effects are difficult to estimate, but the reporting of roadkill birds will help evaluate whether this is a substantial form of mortality to some species.

Increases to existing bird strike mortality is assumed to be low (<1 bird/year), however mortality could be larger due to episodic events such as a flock of eiders colliding with structures or entire broods being struck by one vehicle. The removal of an eider hen would likely result in the loss of an entire brood. Overall, onshore construction activities will increase the potential for ESA-listed bird mortality, but this increase is not anticipated to be major. Per the FWS Final BO, BPXA must report all avian mortalities and collisions (including vehicle collisions) and their circumstances. The transmission of these data will help verify the assumption that collision mortality is low, and negative effects are small.

3.2.8.6 Increased Bird-Predator Populations

Wildlife access to human-use foods during construction of new facilities could increase the abundance and distribution of bears or arctic foxes in the area. Per the FWS Final BO, BPXA intends to implement techniques to prevent wildlife accessing anthropogenic food and waste. These techniques include installation of predator-proof dumpsters, new refuse-handling techniques, and educating their workforce on problems associated with feeding wildlife.

Creation of artificial nesting habitats for ravens and other predatory birds have influenced their distribution across the North Slope. Newly constructed facilities for the Liberty (SDI) Project may create nesting habitats for ravens and other predatory birds which could lead to increased predation on threatened eiders and yellow-billed loons in the project vicinity (USDOI, FWS, 2003). Bridge spans and new pipelines would potentially increase the amount of artificial nesting habitat for ravens and other predatory birds.

Per the FWS Final BO, BPXA has committed to search Liberty (SDI) Project structures for raven-nesting activities from March 1 through June 30 each year. Monitoring would take place every 4 days and if nesting materials are found, they will be removed and disposed of to prevent their reuse by ravens. An annual report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year. If effective measures are implemented, increased predation from increased nesting of bird-predators on project structures should avoid impacts to coastal and marine birds.

Other components of the Liberty (SDI) Project may afford foxes new denning sites. For example, the currently proposed mine rehabilitation plan includes retention of portions of an elevated earthen berm and the stockpiles of organic overburden, which could become a site of future new fox dens. Per the FWS Final BO, BPXA intends to monitor the berm and stockpiles weekly from April 15 through June 15. If denning activities are observed, the ADF&G and FWS will be contacted to develop a plan to prevent further activity. An annul report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year.

The Final BO measures are expected to be implemented; therefore, increased predation from enhanced bird-predator populations should not affect ESA-listed birds.

3.2.8.7 Habitat Effects

There would be no loss of habitat for bowhead whales from the bridge upgrade, and there will be no major habitat loss for spectacled and Steller's eiders. There is currently a bridge at this location, and the bridge upgrade would not result in loss of eider habitat.

There would be no loss of habitat for polar bears due to the bridge upgrade.

ESA-listed Birds

Ice from ice roads has the potential to linger over tundra after the surrounding snow has melted in spring. Lingering ice on the ice-road footprint could prevent this strip of tundra habitat from temporarily being used as nesting habitat for spectacled eiders. Tundra compaction beneath ice roads can result in structural changes to the plant community following melting of the ice (Walker, 1996), which could temporarily affect eider use within the ice road footprint. The compacted tundra may not recover for many years, making it unsuitable as eider habitat. This potential impact could be minimized by selecting an ice road route that avoids tundra near known eider-nesting locations and favors habitat not preferred by eiders, but it is unclear if BPXA would complete this work or whether it would prove successful in retaining eider nesting habitat. This is partially due to the likelihood that eiders would not nest near (within 200 m) the roadway due to traffic noise and other activity. Because road activity (including ice roads) likely precludes nesting by eiders near the road, alterations of these habitats (e.g. creation of an ice road) will have minimal effects.

Ice road construction involves withdrawing water from deep lakes in areas adjacent to the Endicott Road. Bergman et al. (1977) reported that spectacled eiders at Point Storkersen used deep *Arctophila* lakes during pre-nesting, nesting, and post-nesting periods. Deep *Arctophila* lakes also have been used by broodrearing spectacled eiders in NPR-A (Derksen, Rothe, and Eldridge, 1981). In addition, spectacled eiders often select nest sites near the edge of lakes, often within 1m of the shore. Withdrawal for ice roads that lowers the water level of lakes could affect spectacled eider nesting habitat. Most lakes would likely return to pre-withdrawal levels during spring flooding (Rovansek, Hinzman, and Kane, 1996), but care should still be taken when selecting lakes for water sources for ice roads. Water taken from deep open and deep *Arctophila* lakes should be minimized or avoided as these lakes may be used by spectacled or Steller's eiders. However, these are the lake types most suitable as water sources for ice-road construction from an industry perspective and BPXA has not committed to avoiding the use of lakes important to spectacled eiders.

Similarly, water drawn from deepwater lakes to create the ice roads could alter nesting habitats used by yellow-billed loons. While BPXA has stated they would survey these lakes for their use by loons prior to ice road construction, it remains unclear if BPXA would actually avoid withdrawing water from lakes used by loons.

3.2.9 Cultural Resources

In accordance with NHPA provisions of the November 24, 2006, Memorandum of Understanding among MMS, the U.S. Corps of Engineers, ADNR, and BPXA:

> The MMS, after consultation with the COE and other cooperating agencies, will notify BPXA if it determines that it is necessary to assess whether the Liberty (SDI) Project may affect archaeological resources within the project area. The MMS will request that BPXA provide archaeological and, if required, traditional cultural properties reports in accordance with the National Historic Preservation Act of 1966 (16 USC § 470 et seq.). The MMS will consult with the State Historic Preservation Officer and applicable Tribal Historic Preservation Officers, if necessary. This consultation will also cover the cooperating agency permit review requiring consultations.

The SHPO, in letters to BPXA on January 26, 2007, and the U.S. Corps of Engineers on June 8, 2007, requested that archaeological surveys be conducted in Liberty (SDI) Project area that previously had not been surveyed. These project areas would include locations where project activities such as ice road construction, gravel extraction, SDI expansion, West Sagavanirktok River Bridge upgrade, pipeline construction, facilities installation, and new drill rig construction could occur. BPXA notified MMS on July 2, 2007, that a cultural resources survey contract has been awarded to Reanier & Associates, with a final report expected in late 2007.

The MMS, after consulting the State of Alaska AHRS database, has identified no cultural and archaeological sites offshore, nearshore, or onshore within the area of potential effect of the Liberty (SDI) Project. The SHPO concurred with the MMS determination of no effect to offshore historic or prehistoric resources. The U.S. Army Corps of Engineers agreed to the responsibility to conduct a separate consultation in accordance with NHPA for onshore resources. Refer to Appendix F for SHPO consultation correspondence.

3.2.10 Socioeconomics and Related Impacts

This section discusses the possible socioeconomic and related impacts (including subsistence-harvest resources, sociocultural, and environmental justice) associated with onshore construction. Possible impacts could arise from various construction activities (e.g., ice road construction, mine site development, pipeline construction, and West Sagavanirktok River Bridge upgrade), small operational spills of refined products, and the temporary presence of construction workers in the area.

3.2.10.1 Economy and Sociocultural Systems

The Liberty FEIS (USDOI, MMS, 2002) estimated that the entire project would generate 870 full-time equivalent (FTE) construction jobs and an additional 1,248 indirect FTE jobs in Alaska during 14 to 18 months of construction. The current proposal is likely to have smaller labor needs, and only some of these would be associated with onshore construction. For example, the maximum annual number of workers required during onshore construction and associated SDI expansion is estimated to be 116. In principle, adverse sociocultural impacts could arise from either major adverse impacts on subsistence-harvest resources or an influx of substantial numbers of workers. However, neither impact is anticipated. Therefore, there would be no major sociocultural impacts associated with onshore construction.

3.2.10.2 Subsistence and Area Use Patterns

Subsistence-harvest data presented in Section 2 indicate that in terms of total subsistence harvest for the potentially affected communities, the major subsistence foods include caribou, bowhead whales, and various types of fish such as cisco and broad whitefish. Conclusions on possible impacts of onshore construction on important subsistence resources are addressed in this EA and summarized as follows:

- **Section 3.2.3 Fish and Essential Fish Habitat:** Pipeline construction noise is not likely to affect fish and, if it does, the impact will be localized and avoidable. Small spills or leaks likely would be contained and cleaned up immediately, and it is unlikely that any would enter the marine environment. West Sagavanirktok River bridge upgrade will not adversely affect Essential Fish Habitat.

- **Section 3.2.6 Terrestrial Mammals:** Ice road construction and disturbance would affect a few individuals, and no population-level effects on grizzly bears, arctic foxes, arctic ground squirrels, or lemmings are anticipated. Minor fuel or antifreeze spills would affect a few individuals, and no population-level effects are anticipated from these spills and leaks. Mine Site Development would affect some habitat, but the areas would be minimal compared to available habitats, and no population-level effects are anticipated. West Sagavanirktok River bridge upgrade is not expected to have overall, population-level impacts.
- **Section 3.2.8 Threatened and Endangered Species (bowhead whale, and polar bear [proposed]):**Noise and construction activity will not impact the bowhead whale. Protecting core maternity denning areas per the existing FWS LOA mitigation measures is important to the long-term conservation of polar bears.

Thus, there are not expected to be any major effects on subsistence-harvest resources resulting from onshore construction activities.

3.2.10.3 Environmental Justice

Major adverse sociocultural or subsistence-resource impacts would raise environmental justice issues because, as noted elsewhere in the EA, the majority of the population is a recognized minority. However, major impacts to subsistence resources and harvests, and sociocultural systems are not anticipated; therefore, disproportionate high adverse environmental justice impacts are not anticipated as a result of onshore construction.

3.2.11 Waste Management

All waste from the Liberty (SDI) Project would be handled in accordance with State, Federal, and local regulations. Use of permitted disposal wells and other approved disposal methods will result in zero surface discharge of drilling wastes and, in conjunction with BPXA's waste minimization policy, will result in little or no impact from waste disposal. See Section 10 of the Liberty DPP for more information on waste handling.

3.3 DRILLING, OIL PRODUCTION, AND ABANDONMENT

During the drilling and oil-production phases, discharges and accidental spills might affect the environment. Later, during the eventual Project Termination of the Liberty field, the owners of the Endicott Causeway would have to make decisions about the fate of the causeway (DPP Section 13). The causeway is located in State water; the State might decided to maintain and use it or to let it be abandoned. The effects of causeway abandonment is likely to be reviewed by the U.S. Army Corps of Engineers, because the causeway is in navigable waters. As required by 30 CFR 250.700(b), MMS also would review the effects of abandonment of the Liberty "facility," which would include the 860,000 yd^3 enlargement of the SDI. An additional, detailed plan about abandonment of the wells and facilities would be required by MMS at the time of abandonment. The specific requirements can be found at 30 CFR 250 Subpart Q - Permanently Plugging Wells (250.1710 through 1717); Removing Platforms and Other Facilities (250.1725 through 1780); and Site Clearance for Wells, Platforms, and Other Facilities (250.1740 through1743).

The U.S. Army Corps of Engineers has the authority to place the following special condition on the Department of Army, Clean Water Act 404 authorization (if issued):

- Upon abandonment, all on or above ground fills shall be removed unless otherwise identified as part of the final abandonment plan.

The rationale for the special condition refers to a General Condition on the permit form that states that upon abandonment, the site must meet the approval of the District Engineer/Commander.

3.3.1 Air Quality

The ambient air pollutant impacts due to drilling and oil production activities at the Liberty (SDI) Project are expected to be within the limits of the National and Alaska AAQS and the applicable PSD Class II increments. Pollutants will be emitted from drilling operations on the SDI and a new gas-fired combustion turbine on the MPI. As part of the air permitting process, ADEC will review the Liberty emission unit inventory to ensure compliance with all applicable New Source Performance Standards (NSPSs) and National Emission Standards for Hazardous Air Pollutants (NESHAPs). The ADEC will also determine best available control technology (BACT) for the PSD-affected pollutants. A dispersion modeling analysis of project emissions will included in the air permit application and will demonstrate National and Alaska AAQS and PSD Class II increment compliance. An ambient-air quality monitoring station has been in operation on the SDI since February 2007 to gather data to support air quality permitting.

3.3.2 Sediment Suspension and Transport

Erosion of the gravel fill material is expected to be minimal following installation. Similarly, the suspension of fine materials also will be minimal. The majority of the fine fractions near the waterline will be winnowed from the fill material by wave action during the first open-water season. While these particles will contribute to TSS concentrations, the impact is anticipated to be very small. The release of fine material from the pad following the initial open-water season is expected to be negligible. Turbidity might increase temporarily if the causeway is removed at abandonment, and the effects of that phase would be similar to the description in Section 3.1.2.

Barging operations are expected to be limited to a sealift for the ***LoSal*™** EOR plant modules. Marine access is a secondary option for rig mobilization and demobilization. Extensive dredging is not anticipated. As a result, increased turbidity associated with marine operations is expected to be minimal, temporary, or nonexistent, partly because barge traffic will be routed around the Boulder Patch (Section 3.1.5.1).

3.3.3 Oceanography

The proposed SDI pad expansion is not expected to have any noteworthy impact on regional oceanography. Minimal localized impacts can be anticipated.

During winter, rapid changes in temperature may produce thermally induced shrinkage cracks propagating from the perimeter of the SDI pad expansion (a source of stress concentration). These cracks may provide strudel drainage pathways at the time of river overflood. These conditions are expected to be similar to those that occur at the existing SDI facility.

If ice roads are used to support drilling operations, the thickened ice may act as a partial barrier to river overflood and divert a portion of the flow. The expanded SDI pad footprint is not anticipated to impede the river overflood or affect the extent of overflood on the sea ice. The aforementioned cracks propagating from the perimeter of the SDI pad expansion are expected to be similar to those that occur at the existing SDI facility. The resulting strudel drainage pathways will be displaced slightly relative to the current pad configuration, but the propensity for strudel scouring is not expected to be substantially different from the existing condition.

Currents in the immediate vicinity of the pad expansion will be affected during the breakup and open-water periods. However, the current patterns and velocities are not expected to be substantially different from those at the existing SDI facility. Local wave patterns also will be altered but are anticipated to be similar to existing conditions.

3.3.4 Marine Water Quality

The release of fine material from the pad following the initial open-water season is expected to be negligible.

The SDI pad expansion will be integrated with the existing SDI drainage system. A perimeter road will confine surface water drainage onto the work surface. This containment also will reduce the risk of any incidental equipment spills (oil, diesel fuel, and hydraulic fluid) from reaching marine waters.

The Liberty (SDI) Project will have zero surface discharges of drilling wastes. Operational discharges will include reject water from the ***LoSal™*** EOR process plant, reverse-osmosis reject water, seawater treatment filter backwash, and sanitary/domestic wastewater.

Per BPXA letter to the EPA, Alaska Operations Office dated July 24, 2007, regarding domestic/sanitary wastewater streams:

> It should be noted, that although the Liberty Project will generate additional sanitary and domestic wastewater streams, these wastes will be transported to and disposed of in NPDES permitted wastewater treatment facilities designed and permitted to accommodate these waste streams. As such, there are not anticipated changes (e.g. piping, treatment or additives) to the selected wastewater treatment facility. There are no current plans to utilize NPDES General Permit No. AKG-33-0000 for the disposal of sanitary and domestic waste streams generated from this project. The options for disposal of sanitary and domestic wastewater generated from the Liberty Project are as follows:
>
> 1. Utilization of the permanent living quarters (PLQ) at the Endicott production facility to house construction and drilling personnel. This option would utilize the existing Endicott wastewater treatment infrastructure. This is preferred Liberty Project option for wastewater disposal (see DPP Section 10.3 WASTE MANAGEMENT).
> 2. Utilization of a temporary construction/drilling camp at or near the project location. Wastewater would be stored in holding containers and trucked to the existing Endicott production facility for disposal (see DPP Section 10.3 WASTE MANAGEMENT).
> 3. Utilization of a temporary construction/drilling camp at or near the project location. Wastewater would be stored in holding containers and trucked to existing Prudhoe Bay Unit infrastructure for disposal.
>
> At this time, it is not known which sanitary and domestic wastewater disposal option will be used. This will depend on several factors – primarily bed space availability at the Endicott production facility during the time of construction and drilling activities.

An amendment has been submitted to the NPDES permit renewal request to cover the discharge from the ***LoSal™*** EOR process plant. Per the aforementioned BPXA letter to EPA dated July 24, 2007, the ***LoSal™*** pilot project scheduled for fall 2007 will use freshwater sources. Therefore, there will be no wastewater discharge produced, as LoSal**™** water will be injected for enhanced oil recovery purposes. Stormwater and firewater test discharges will be permitted under the existing NPDES General Permit for Facilities Related to Oil and Gas Extraction.

Issues associated with a crude oil spill are discussed in Section 3.4.

3.3.5 Benthic and Boulder Patch Communities

Regarding cumulative effects on the benthos and Boulder Patch kelp community, the effects of construction and abandonment of just the proposed addition to the SDI are expected to be short lived (Section 3.1.5.3). The Liberty FEIS concluded similarly that the abandonment of the original Liberty offshore island would be minor (USDOI, MMS, 2002:Sections III.C.e(2)(a) and III.D.6.e (1). However, the abandonment of the SDI addition probably would occur at the same time as abandonment of the whole Endicott causeway. The level of cumulative effect of sediment eroding from the whole causeway for decades if the causeway and SDI are abandoned in place would be much greater and longer lasting than if the causeway and SDI were to be removed. In a sense, the causeway addition and initial construction involve the movement of millions of cubic yards of gravel from an onshore quarry to an offshore location within a few miles of the Boulder Patch. Any fine sediment material extend the berm that is offshore of the causeway (Section 2.7.3.5). Furthermore, the natural erosion rate of the causeway might be increased due to the retreating summer ice cover and increasing fetch for storm waves, and such erosion would be increased greatly if the Arctic becomes ice free, as projected by climate models for the late-summer within the lifetime of this project (by 2040). A definitive conclusion about the level of effects on the kelp cannot be formed at this stage, partly because it is not clear that the whole causeway would be abandoned, and partly because future rates of erosion have not been projected. Regardless, if the SDI addition to the causeway were to be abandoned, MMS and the U.S. Army Corps of Engineers would require a detailed abandonment plan, per 30 CFR Part 250 subpart Q, at the time of abandonment. The U.S. Army Corps of Engineers has the authority to place the following special condition on the Department of Army, Clean Water Act 404 authorization (if issued):

- Upon abandonment, all on or above ground fills shall be removed unless otherwise identified as part of the final abandonment plan.

The rationale for the special condition refers to a General Condition on the permit form that states that upon abandonment, the site must meet the approval of the District Engineer/Commander.

The measurement of kelp growth rates at DS-11 for the past 4 decades have helped to determine the “natural” effects of erosion and suspended sediments around the existing causeway. Continued annual measurement of the rates would help with the eventual distinction during abandonment of sedimentation effects due to: (1) the existing causeway with increased erosion rates due to the retreating summer ice cover, and (2) the causeway with an enlarged SDI.

3.3.5.1 Large Oil Spills

A detailed discussion of the potential effects of large oil spills (equal to or greater than [≥]200 bbl of crude oil) on the Boulder Patch kelp community and other lower trophic organisms can be found in USDOI, MMS (1996a, 2002) and USDOI, BLM and MMS (1998).

Boulder Patch

A detailed discussion of the potential effects of large oil spills on the Boulder Patch community can be found in USDOI, MMS (2002). Studies indicate that Liberty crude would be particularly resistant to natural dispersion in the water column. It probably would disperse very little and very slowly down into the Stefansson Sound water column. Based on mixing models, the amount and toxicity of Liberty crude oil reaching subtidal marine plants are expected to be so low that the oil would have no measurable effect on these plants, regardless of when the spill occurred.

Oil-spill-trajectory analysis (Section 3.4.3) indicates that the dispersal plume under east winds would largely bypass the Boulder Patch and would be confined to nearshore waters west of the SDI. Plume deflection under west winds would carry surface oil eastward into Foggy Island Bay and likewise would bypass most of the Boulder Patch.

Other Coastal and Benthic Invertebrates

As discussed above, the inability of Liberty crude oil to substantially penetrate the water column would shield benthic invertebrates from contamination. Oil reaching the nearshore shallows likely would be toxic and probably would have lethal or sublethal effects on some invertebrates that inhabit these areas during summer, including mollusks, annelid worms, echinoderms, crustaceans, and amphipods. Based on estimates made for the initial offshore alternative of the Liberty project, an assumed large oil spill would be estimated to have lethal or sublethal effects on about one-third of the nearshore benthic invertebrate community (USDOI, MMS, 2002) in the Stefansson Sound area. Recovery for nearshore benthic invertebrates likely would occur in a single season after water quality returns to prespill conditions. Because of ice cover, nearshore shallows are devoid of benthic invertebrates during winter. After breakup, most invertebrates move onshore to repopulate the area for the duration of the open-water season.

Studies have shown that large oil spills commonly have no major effect on planktonic organisms. Even if spills contact large numbers of plankton, the short regeneration time of these organisms and rapid replacement from nearby waters likely keep any effect to a minimum. Because of their wide distribution, large numbers, rapid regeneration rate, and high fecundity, plankton communities exposed to large oil spills appear to recover quickly (NRC, 1985). Any oil spill associated with the Liberty (SDI) Project operations likely would have only a localized and short-lived effect on plankton communities. Further, nearshore invertebrates that reside in the water column (copepods, mysid shrimp, and euphausiids) have the potential for being affected by surface concentrations of saline brine by discharge from the ***LoSal*™** EOR process plant. The discharge would be regulated by the EPA; regardless, the effect on plankton would be almost immeasurable because of their widespread distribution, large numbers, and high reproduction rates.

3.3.6 Fish and Essential Fish Habitat

3.3.6.1 Water Usage

The Liberty (SDI) Project development will also require water for:

- Construction of the ice road: 22 million gallons per year (gal/yr) during the peak construction season
- Drilling rig use: 15 million gal/yr during drilling

- Temporary camp: 2.7 million gal/yr during drilling

Plans currently call for the ice road to be built almost entirely from water in the existing Duck Island Mine site, which is believed to hold on the order of 600 million gallons of water. The Endicott seawater treatment plant (STP) can provide an additional 20,000 barrels per day (bpd). Water also is available from several existing sources in the eastern Prudhoe Bay Unit. Should the existing water sources prove insufficient to support the Liberty (SDI) Project, it may be necessary to remove water from deepwater tundra lakes or rivers. In this event, different sites will be assessed to determine if water withdrawal can proceed within State and Federal agency guidelines.

3.3.6.2 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil or chemicals arising from drilling and oil production at the Liberty (SDI) Project will impact fish. Such minor discharges would likely be contained and cleaned up immediately. It is unlikely that any discharges would enter the marine environment.

3.3.6.3 Large Oil Spills

The lethal and sublethal effects of oil spills on fish have been discussed extensively in USDOI, MMS (1996a, 2002) and USDOI, BLM and MMS (1998). The greatest potential for a large oil spill (≥200 bbl of crude oil) adversely affecting fish and fish habitat is during the open-water summer season that lasts from May through September. The nearshore shallows in and around the proposed Liberty (SDI) Project area and Endicott Causeway are the obligatory nursery grounds for a genetically distinct stock of broad whitefish that spawn in the Sagavanirktok River. This nearshore area also serves as prime summer feeding grounds for juvenile arctic and least cisco. The Sagavanirktok Delta is a critical migratory pathway for Dolly Varden that annually move between upriver overwintering and spawning sites and offshore feeding grounds. The Liberty (SDI) Project also lies within the nearshore, brackish-water coastal corridor used by most anadromous and amphidromous species to disperse and forage along the coast. Large number of marine fish, including fourhorn sculpin and arctic flounder, also forage in nearshore waters.

Extensive oil contamination in nearshore areas would likely have lethal and sublethal effects on the anadromous, amphidromous, and marine fish that reside there. Large foraging areas could be lost. It is possible that the nearshore corridor used for migration and feeding dispersals by anadromous and amphidromous species could be broken. Contamination and blocking of the nearshore corridor in late summer could prevent these fish from returning to their obligatory freshwater overwintering grounds in the Colville and Sagavanirktok rivers. Recovery would be more rapid for some species than others. Arctic cisco spawn exclusively in the Mackenzie River in Canada and the least cisco in the Colville River. Large segments of their respective populations would be unaffected by an oil spill in the Liberty (SDI) Project area, allowing for a more rapid recovery. Broad whitefish and Dolly Varden stocks that spawn and overwinter exclusively in the Sagavanirktok River could be more seriously impacted, and population recoveries would likely be slower.

Freshwater fish would probably not be affected to any great extent by a large Liberty oil spill emanating from the SDI or Endicott Causeway. River discharge would prevent contaminated water from moving upriver into freshwater habitats. Although limited numbers of freshwater fish are found in the Sagavanirktok Delta during summer, their numbers are small and likely represent only a tiny fraction of the population.

Fourhorn sculpin, arctic flounder, arctic cod, and saffron cod are the two predominant marine species that occupy nearshore shallow waters during summer. Extensive oil contamination in these areas could have lethal and sublethal effects on any fish that came in contact with the spill, depending on intensity and duration. However, the impact to overall populations would be minimal. Marine fish populations are widespread throughout the Beaufort Sea, and the Liberty (SDI) Project area represents only a small portion of their summer habitat. Because of their wide, vast distribution and high reproductive rates, the impact of a large Liberty oil spill to marine fish species would be minor.

A large oil spill from the proposed Liberty (SDI) Project may adversely affect EFH; however, MMS believes that with the project being based from an existing SDI and not requiring a new subsea pipeline to transport oil to shore, those effects have been reduced to the maximum extent practicable and are consistent with the NOAA document entitled Non-Fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures (USDOC, NOAA, 2003).

3.3.7 Marine Mammals

3.3.7.1 Noise/Activity Disturbance

Noise and other disturbances from the proposed drilling activities for the Liberty (SDI) Project could impact marine mammals in the area. Beluga whales are not likely to be affected because of the distance between drilling activities and their migratory corridor well offshore from the barrier islands. Greene and Moore (1995) reported that underwater noise originating from artificial islands is generally inaudible beyond a few kilometers. It was predicted that drilling noise during periods of normal ambient conditions would attenuate to below-audible ranges approximately 2 km from the source. Underwater drilling noise could be audible up to 10 km from the source during unusually calm periods (Greene and Moore, 1995), but most beluga whales would likely be beyond 10 km from the SDI drilling source, and disturbance to beluga whales from SDI drilling activities would be unlikely.

Pacific walruses are absent during winter and rare visitors during summer in the Liberty (SDI) Project area. It is unlikely that noise from drilling and oil production would impact walruses.

Seals in the area could potentially be disturbed by drilling and oil production activities from the Liberty (SDI) Project. Numerous acoustical studies have reported underwater distances at which drilling sounds reach background levels. Blackwell, Greene, and Richardson (2004) reported that drilling noise during winter at Northstar Island reached background levels at approximately 9.4 km. Blackwell and Greene (2006) reported underwater broadband sounds associated with oil production at Northstar Island during the open-water season reached background levels at distances of 2 to 4 km. Ringed seals may be able to detect underwater industrial sounds out to 1.5 km in the water and approximately 5 km in the air (Blackwell, Greene, and Richardson, 2004). Moulton et al. (2002, 2003, and 2005) reported that limited winter industrial activity at Northstar Island did not appear to significantly affect ringed-seal density or behavior in the spring. Williams et al. (2006b) reported no relationship between ringed seal use of subnivean structures and the distance of those structures from Northstar Island. In addition, seals may become habituated to industrial sounds near artificial islands (Blackwell, Lawson, and Williams, 2004a). Noise and activity disturbances from drilling and oil production activities at the Liberty (SDI) Project are unlikely to displace or disturb large numbers of seals.

3.3.7.2 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil or chemicals arising from drilling and oil production at the Liberty (SDI) Project will impact marine mammals. Such minor discharges would likely be contained and cleaned up immediately. It is unlikely that any discharges would enter the marine environment.

3.3.7.3 Large Oil Spills

A large oil spill (≥200 bbl of crude oil) originating from the Liberty (SDI) Project poses the greatest potential to impact marine mammals when measured against all other development-related consequences. The impact on marine mammals from an oil spill would depend on numerous factors, including the species, its age and health status, and the size/behavior of the spill. Seals, beluga whales, and possibly a few Pacific walruses could experience many impacts from direct exposure to oil, including skin and eye irritation, risk of infection, and stress. These effects could contribute to the death of a few individuals (Geraci and Smith, 1976; Geraci and St. Aubin, 1980; St. Aubin, 1990). Furthermore, ingestion through consuming oiled prey or inhalation could lead to an accumulation of hydrocarbons in the bloodstream and cause death through kidney failure (Oritsland et al., 1981).

3.3.8 Marine and Coastal Birds

3.3.8.1 Noise/Activity Disturbance

Drilling noise would be limited, because all drilling rig facilities will be enclosed. Associated noise and activities would continue from 2010 through 2013, potentially disturbing and displacing birds from the vicinity of the SDI. It is possible that some birds could habituate to drilling noise and activity, but our analysis assumes that all birds would be displaced to other nearby areas. Human/industrial activity on the expanded SDI during drilling and production could lead to long-term abandonment of Duck Island 1 & 2, located west of the SDI, by common eiders (~16 nests) and glaucous gulls (~4 nests).

Operational traffic along the Endicott Road would decrease from levels associated with SDI expansion and facility construction phases of this project. The existing operational levels of traffic on the Endicott Road have not led to distributional changes for broodrearing snow geese (Johnson, 1998; Johnson, 2000a) and no substantial changes in marine and coastal bird distribution or abundance is anticipated.

Overall, noise and disturbance associated with drilling and production operations would continue to be localized, and no long-term adverse effects on marine and coastal bird populations are anticipated.

3.3.8.2 Small Spills or Leaks

A small spill is defined as <200 bbl, but BPXA estimates 42 bbl of product would be spilled over the life of the Liberty (SDI) Project. The 95% confidence interval on the total volume of small product spills range from 10 to 125 bbl. An estimated 2 bbl/yr would be spilled. Over a 12-hour period, 15% of a small diesel fuel oil spill into the Beaufort Sea would persist, because 45% would evaporate and 40% would disperse. Over 19 hours, 11% of a 2-bbl spill of light diesel fuel oil in the Beaufort Sea would remain, with 22% evaporating and 67% dispersing. This spill would cover approximately 0.37 acres of the waters surface after 19 hours.

Minor spills and leaks of oil, chemicals, or wastewater could affect the quality and abundance of prey species for diving seabirds if they were to enter the marine environment. Discharges of small amounts of petroleum compounds also could reduce water repellency of bird feathers, compromising their insulative capacity, resulting in hypothermia and death/drowning. The most abundant species (long-tailed ducks, common eiders, and red-throated and Pacific loons) would experience the largest collective mortality, but smaller populations would be impacted to a disproportionately greater degree. Chronic discharges could collectively affect a large number of birds over time. Preventive measures such as daily visual inspections are required to be ongoing during drilling and production operations to keep small releases of pollutants from entering the marine environment where they could impact a large number of birds prior to an active spill response.

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil or chemicals arising from drilling and oil production at the Liberty (SDI) Project will impact marine and coastal birds. Such minor discharges would likely be contained and cleaned up immediately. It is unlikely that any discharges would enter the marine environment.

3.3.8.3 Large Oil Spills

A large spill is defined as ≥200 bbl. BPXA estimates an 8% chance of one or more large spills occurring over the production life of the project. At the 95% confidence interval BPXA estimates a 4 to 15% chance of one or more large spills occurring over the production life of the Liberty (SDI) Project. BPXA estimates a 92% chance of no large spills occurring over the life of the Liberty (SDI) Project.

For purposes of spill-trajectory modeling and analyses, a spill size of 1,000 bbl was used (in the Liberty FEIS [USDOI, MMS 2002]). This modeling did not account for any cleanup or containment but indicated that a spill could happen at any time of the year. In certain situations, containment could be enhanced if the spill were held against the Endicott Causeway, slowing the potential for the spill to spread into marine areas.

A large oil spill from the SDI during drilling and production would have a variety of impacts to marine and coastal birds if they were to enter the marine environment, depending on the size of the spill, time of year, and trajectory of the spill. Spilled oil can cause direct mortality by contact resulting in hypothermia, shock, and drowning, or indirect mortality through ingestion during preening or contamination of prey species. Details for the mechanisms for oil-spill impacts to birds are discussed in Section III of the Liberty FEIS (USDOI, MMS, 2002).

A large spill originating from SDI drilling activities directed offshore of the Endicott Causeway during May to early November would contact flocks of migrating king and common eiders and molting long-tailed ducks, broodrearing common eiders and glaucous gulls in the Stefansson Sound region. A large spill during either spring or fall migration periods, when hundreds to thousands of birds move along the Beaufort Sea coast daily, would substantially increase the number of birds exposed to floating oil. For example, a large spill reaching the nearshore coastal areas between Prudhoe Bay and Tigvariak Island during the summer likely would contact more than 1,000 long-tailed ducks; hundreds of glaucous gulls; and dozens of common eiders, king eiders, scoters, and loons. These individuals represent 1 to 3% of their populations on the Arctic Coastal Plain. Spill losses are expected to be minor for regional populations of birds with stable or increasing numbers, but losses of birds with declining populations, such as long-tailed ducks, may be more serious.

A large spill reaching the Sagavanirktok River delta during July through September could expose all of the Howe Island nesting snow geese as they leave Howe Island with their goslings and most (62%, 2,367 of 3,816 total geese, 982 adults) of broodrearing snow geese, based on their July 19, 2006, distribution. The Howe Island snow goose colony represents a large proportion of the snow geese nesting in Arctic Alaska. More than 4,000 broodrearing and staging waterfowl (1,494 snow geese, 1,098 white-fronted geese, 1,038 Canada geese, 251 brant, 103 tundra swans, 220 northern pintails) could be exposed to a large spill reaching the Sagavanirktok River delta, representing 1 to 10% of the Arctic Coastal Plain populations for these species. Loss of foraging habitats in the Sagavanirktok River delta for these waterfowl, including coastal salt marshes, mudflats and river channel habitats in the Sagavanirktok River delta, potentially would be more problematic (Noel, Johnson, and Butcher, 2004; Sedinger and Stickney, 2000). Spill losses for these species are expected to be minor for most regional populations, with the exception of snow geese. These waterfowl species have exhibited stable or increasing numbers across the Arctic Coastal Plain.

A large spill contacting the Sagavanirktok River delta during late summer and fall shorebird staging in August and September could directly affect thousands of shorebirds and likely would result in the long-term contamination of coastal tundra and mudflat habitats (Troy, 2000). Degradation of foraging habitats and contaminated prey species would reduce survival of migrant shorebirds, with thousands to tens of thousands of migrant shorebirds potentially affected (Andres, 1994; Powell, Taylor, and Lanctot, 2005). A major spill into the Sagavanirktok River would have regional effects on bird productivity and abundance.

Overall, the risk of a large spill is considered low. The risk of spilled oil entering the marine environment is low; the risk of substantial harm to coastal and marine birds is further reduced, because marine and coastal birds are not present throughout the year. The risk of a spill and potential for contacting birds is affected by spill response and containment, which could be effective in preventing a spill reaching the Sagavanirktok River/delta area. While the effects from a large spill entering the marine environment have the potential to affect a large proportion of regional bird populations, this is not considered a likely event, and no major impacts are anticipated.

3.3.8.4 Discharges

Some hypersaline and process waters would be discharged from the MPI, which is authorized under a National Pollutant Discharge Elimination System (NPDES) permit. These discharges, regulated by the Environmental Protection Agency (USEPA) to avoid adverse environmental effects, may result in minor changes to forage availability for long-tailed ducks, eiders, loons, and glaucous gulls in the vicinity of the MPI. Seawater intake would entrain some forage species, reducing the quantity of available forage by a very small amount.

Warm effluent discharges would create a thaw area in the ice of the receiving water that is attractive to early arriving sea ducks such as king eiders, common eiders, and loons. If the discharge is nutrient enriched, local marine productivity could be enhanced, attracting long-tailed ducks, common eiders, loons, and glaucous gulls to the area throughout the summer. Attraction to these discharge streams could expose birds to contaminants, but compliance with EPA permit stipulations should reduce this potential risk to low levels.

3.3.8.5 Bird Strikes

The effects of bird strikes have been described for the SDI expansion (Section 3.1) and facility construction (Section 3.3). Effects from the 250-ft tall drill rig would exist for about 3 years, while it is working on site (2010 through 2013). The effects from these facilities would continue during the life of the project. The effects from some facilities may occur even after production ceases.

BPXA design engineers have committed to consult with the FWS on identifying and implementing ways to reduce how facility lighting attracts/disorients birds in the project vicinity. Effectively reducing escaped lighting is believed to reduce the potential for birds to strike facilities on the MPI and SDI. Systematic monitoring for dead or injured birds on the SDI and MPI could help determine if these design features are effective.

There would be an anticipated increase in vehicle traffic on the Endicott Road to operate the facility, but this is much reduced from the construction phase; no substantial changes in the ability of some tundra-nesting birds and their broods to access coastal habitats is anticipated. The present level of mortality from roadkill is unknown. A reduced speed limit for vehicles during the nesting and/or broodrearing period could help reduce any negative effects of traffic on the Endicott Road. These negative effects are difficult to estimate, but the reporting of roadkill birds could help evaluate whether this is a substantial form of mortality to some species.

Increases to existing bird strike mortality is assumed to be low (<20 birds/year); however, mortality could be larger due to episodic events such as a flock of birds colliding with structures (especially during periods of darkness or inclement weather). Overall, long-term operation of the production facility will increase the potential for bird mortality, but this increase is not anticipated to be major. Per the FWS Final BO, BPXA must report all avian mortalities and collisions (including vehicle collisions) and their circumstances. The transmission of these data will help verify the assumption that collision mortality is low, and negative effects are small.

It remains unclear what would happen to Liberty (SDI) Project facilities at project termination/abandonment. The Liberty DPP states BPXA will make no decision regarding abandonment at this time and did not detail any abandonment procedures. As the expansion of the SDI was essential to obtain resources from Federal lease lands, the long-term effects of these federally permitted facilities, especially in terms of perpetual bird strike hazard, need to be factored into when these facilities (sheet pile, buildings, gravel pad, etc.) would be removed. Information collected during a monitoring/reporting program for bird strikes will contribute toward a careful assessment of the environmental effects of various abandonment scenarios. At the present time, the MMS environmental effects analysis is based on BPXA's expectation that, ultimately, the entire facility would be removed.

The U.S. Army Corps of Engineers has the authority to place the following special condition on the Department of Army, Clean Water Act 404 authorization (if issued):

- Upon abandonment, all on or above ground fills shall be removed unless otherwise identified as part of the final abandonment plan.

The rationale for the special condition refers to a General Condition on the permit form that states that upon abandonment, the site must meet the approval of the District Engineer/Commander.

3.3.8.6 Increased Bird-Predator Populations

Wildlife access to human-use foods during drilling or production operations could increase the abundance and distribution of predatory birds (ravens, gulls) and mammals (foxes, bears) in the area. Efforts to eliminate wildlife access to human-use foods/garbage will be incorporated into the day-to-day operation of the Liberty (SDI) Project in compliance with policies developed by the NSB. BPXA also commits to preventing the creation of new fox denning sites and will remove any new den sites construction in new facilities for the Liberty (SDI) Project.

This analysis assumes that effective mitigation measures will be implemented, and no increased mortality to ESA-listed birds from enhanced predator populations would occur.

3.3.9 Terrestrial Mammals

Drilling and production operations at the expanded SDI site would be similar to activity levels generated during development of the original Endicott facility. These activities have not appeared to substantially alter the use of the Sagavanirktok River delta area by caribou (Pollard et al., 1996), although reduced crossings of the Endicott Road/pipeline corridor have been noted, especially during periods when traffic levels are greater than 15 vehicles/hour (Lawhead, Byrne, and Johnson, 1993). Before installation of animal-proof dumpsters, numerous grizzly bears and arctic foxes often frequented the Endicott facility and habitats along the Endicott Road. These animals then subsequently caused unusually high levels of depredation of snow geese and other nesting birds at the Howe Island and Duck Island nesting colonies (Johnson and Noel, 2005). After installation of animal-proof dumpsters and the killing in defense of life and property of several food-conditioned bears known to frequent Howe Island, depredation of Howe Island snow geese has diminished (Rodrigues, McKendrick, and Reiser, 2006).

3.3.9.1 Large Oil Spills

Large oil spills (≥200 bbl of crude oil) during drilling and production would have a variety of impacts on mammal habitats depending on the size, time of year, and trajectory of the spill. Details for the mechanisms for oil spill impacts to terrestrial mammals are discussed in Section III of the Liberty FEIS (USDOI, MMS, 2002).

A pipeline rupture along the Endicott Causeway and Road would impact coastal tundra habitats. The severity of the impacts would depend on the size and timing of the spill. A small spill during winter would most likely be contained and removed with little or no damage to terrestrial mammal habitats, while a large spill occurring during the summer would cause more extensive habitat damage. Additional habitat damage and disturbance would occur from the cleanup of a large spill and subsequent site restoration. Spill cleanup in coastal areas would disturb caribou, muskoxen, grizzly bears, and arctic foxes. The number of people anticipated for a large spill (300 workers over 6 months) and the duration of cleanup activities (complete cleanup may take 4 years) would displace large caribou groups from foraging and insect-relief habitats in the Sagavanirktok River delta.

Caribou and muskoxen using coastal and delta habitats during summer for insect relief may become oiled or ingest contaminated vegetation. Oiled caribou calves would likely perish due to loss of thermoinsulation, leading to hypothermia; oiled adults would likely perish due to inhalation, adsorption through the skin, or ingestion of oil. Based on survey data collected between 1998 and 2003 (Figure 2.11-3), 20 caribou groups with an average of 75 and a maximum of 2,250 individuals would potentially be exposed to oil and disturbance from a large oil spill and subsequent cleanup activities in the East and West Channels of the Sagavanirktok River delta. The maximum number of caribou potentially exposed represents 7% of the Central Arctic Caribou Herd based on the 2002 census result of 31,857 caribou. Based on survey data collected between 1997 and 2003 (Figure 2.11-3), 1 muskoxen group with an average of 12 and a maximum of 18 individuals would be potentially exposed to oil and disturbance from a large oil spill and cleanup activities in the East and West Channels of the Sagavanirktok River delta. The maximum number of muskoxen exposed represents 9% of the Alaskan North Slope muskoxen based on the 2005 census result of 195 muskoxen. It is unlikely that the maximum number of animals exposed would actually perish due to oil toxicity. No population-level effects to either caribou or muskoxen would be expected due to contact with oil, short-term habitat losses, and/or disturbance from spill cleanup.

Large spills originating from SDI drilling activities reaching coastal habitats in the Sagavanirktok River delta and coastlines from Prudhoe Bay to Tigvariak Island would contaminate beaches and tidal flats. Grizzly bears and arctic foxes would likely ingest oiled birds, seals, or other carrion, which would result in the loss of a few bears and foxes. Bears and foxes would be hazed from the spill area, but may still become oiled or ingest contaminated prey. A few individuals would perish, but no population-level effects are anticipated.

3.3.10 Wetlands and Vegetation

3.3.10.1 Small Spills or Leaks

It is unlikely that minor spills (<200 bbl of crude oil) or leaks of oil or chemicals arising from drilling and oil production will impact wetlands and vegetation. Such minor discharges would likely be contained and cleaned up immediately.

3.3.10.2 Large Oil Spills

Because Liberty (SDI) facilities will be located offshore, impact to wetlands, coastal saltmarshes, and vegetation from a large oil spill (≥200 bbl of crude oil) are not likely. Impacts to coastal saltmarshes would be the primary concern. Saltmarshes and other intertidal community types are considered high-value habitat for some species of birds (Sedinger and Stickney, 2000; Johnson, 2000). The degree of impact would vary depending on the concentration of the spill, time of year, and the affected area with regards to vegetation type, soil structure, and moisture regime. Impacts may range from complete die-off to little or no impact to wetland and other vegetative communities, but such impacts are not expected to occur.

3.3.11 Threatened and Endangered Species

3.3.11.1 Noise/Activity Disturbance

Bowhead Whales

Noise and other disturbances from the proposed drilling and oil production activities for the Liberty (SDI) Project are unlikely to impact bowhead whales. Much of the drilling would take place during the winter months when bowhead whales are in the Bering Sea. Drilling which takes place during their annual fall migration would also be unlikely to disturb bowhead whales due to the distance between the source of drilling at the SDI and the bowhead whale migratory corridor 15 km or more offshore. Greene and Moore (1995) concluded that underwater noise originating from drilling on artificial islands is generally inaudible beyond a few kilometers. It was predicted that drilling noise during periods of normal ambient conditions would attenuate to below-audible ranges approximately 2 km from the source. Miles, Malme, and Richardson

(1987) predicted the radii of potential bowhead-whale response to drilling on an artificial island to be 0.05 to 1.8 km.

Underwater sound propagation is dependent on numerous factors including not only the sound pressure level at the source, but also ambient and environmental conditions such as sea state, water depth, bathymetry, and substrate type (Richardson et al., 1995). Underwater drilling noise could be audible up to 10 km from the source during unusually calm periods (Greene and Moore 1995). Blackwell, Greene, and Richardson (2004) reported that underwater broadband-sound levels from drilling on Northstar Island reached background levels about 9.4 km from the island. McDonald et al. (2006) reported subtle offshore displacement of the southern edge of the bowhead whale migratory corridor offshore from Northstar Island, but the bowhead migration corridor is closer to Northstar Island (approximately 8 km) than it is to the SDI (approximately 15 km). The SDI has had a drilling operation for years with no apparent documented impacts to bowhead whales. The Liberty (SDI) Project is also inshore of the barrier islands, which likely act as an additional sound barrier to the bowhead-whale migratory corridor. Eskimo whalers have infrequently observed individuals and groups comprised of a few whales in the bay mouths between and inside the barrier islands. These observations have ranged between 8.8 and 10 km from the SDI. It is unlikely that noise from drilling and oil production activities at the Liberty (SDI) Project will impact migrating bowhead whales offshore. Impacts to individual whales or to the bowhead population are considered negligible. Per the informal consultation dated October 19, 2007 (refer to Appendix D of this EA), NMFS stated "…while the Liberty project may affect these whales, our assessment…finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur)."

Polar Bears

Small numbers of polar bears using maternal dens or polar bears passing through the area during fall could be affected by drilling and oil production noise. Polar bears would likely habituate to industrial noise if it is not associated with other stimuli (Perham, 2005), and effects on polar bear abundance and distribution would be minimal.

ESA-Listed Birds

Noise and activity disturbances at the drilling and production site during the spring nesting season will not affect nesting spectacled and Steller's eiders, because they select nest sites in tundra habitats that are not located near the SDI.

Noise and activity in the immediate area of the SDI could displace eiders and their broods, Kittlitz's murrelets, or yellow-billed loons to adjacent habitats. If these habitats are similar, then adverse effects to ESA-listed birds would likely be very small (refer to Appendix C of this EA).

Operational traffic along the Endicott Road would decrease from levels associated with SDI expansion and facility construction phases of this project. The return of basic operational levels of traffic on the Endicott Road should allow the preproject distribution and abundance of ESA-listed birds along the Endicott Road to be restored.

3.3.11.2 Small Spills or Leaks

A small spill is defined as <200 bbl, but BPXA estimates 42 bbl of product would be spilled over the life of the Liberty (SDI) Project. The 95% confidence interval on the total volume of small product spills range from 10 to 125 bbl. An estimated 2 bbl/yr would be spilled. Over a 12-hour period, 15% of a small diesel fuel oil spill into the Beaufort Sea would persist, because 45% would evaporate and 40% would disperse. Over 19 hours, 11% of a 2-bbl spill of light diesel fuel oil in the Beaufort Sea would remain, with 22% evaporating and 67% dispersing. This spill would cover approximately 0.37 acres of the waters surface after 19 hours. Minor discharges would likely be contained and cleaned up immediately and would be unlikely to affect these species.

Bowhead Whales

It is unlikely that minor spills (<200 bbl of crude oil) or leaks or oil, chemicals, or wastewater from the Liberty (SDI) Project will impact bowhead whales.

Polar Bears

It is unlikely that minor spills (<200 bbl of crude oil) or leaks or oil, chemicals, or wastewater from the Liberty (SDI) Project will impact polar bears.

ESA-listed Birds

Preventive measures such as daily visual inspections are required during drilling and production operations to keep small releases of pollutants from entering the marine environment, where they have the potential to impact ESA-listed birds prior to an active spill response.

If minor spills and leaks of oil, chemicals, or wastewater were to enter the marine environment, they could affect the quality and abundance of prey species for eiders, murrelets, and loons in the project area. Discharges of small amounts of petroleum compounds also could reduce water repellency of bird feathers, compromising their insulative capacity, resulting in hypothermia and death/drowning.

3.3.11.3 Large Oil Spills

Refer to Section 3.4.1.1 (page 3-67 of this EA), which explains the assumptions regarding large oil spills.

Bowhead Whales

A large oil spill (≥200 bbl of crude oil) from the Liberty (SDI) Project or a large fuel spill from sea lift operations likely poses the greatest threat to bowhead whales of any development-related consequences associated with the project. Geraci (1990) hypothesized that whales could experience any of the following adverse effects from an oil spill: oiling of the skin, inhalation of harmful vapors, ingestion of contaminated prey/food, fouling of their baleen, decreased food availability, displacement from preferred feeding habitats, death, and other effects. All of these factors have the potential to decrease bowhead whale survival following direct exposure to a large oil spill. There is no empirical evidence supporting bowhead whale mortality as a direct result of contact with spilled oil, but whales could experience death from prolonged exposure to oil (USDOI, MMS, 2002).

Oil-spill response activities could also affect bowhead whales if an oil spill occurred. The extent of consequences to whales from oil spill response efforts would depend on the location, timing, amount, and behavior of spilled oil in marine habitat. Effects would be greatest if a spill took place in the bowhead-whale migratory corridor during fall migration and decrease with distance from the corridor. An oil spill scenario, using the deterministic GNOME model, during the open-water season in August does not approach the migratory corridor (see Section 3.4.3). The Oil-Spill Risk Analysis (OSRA) stochastic model analysis described in detail in Appendix A, Liberty FEIS (USDOI, MMS, 2002), indicates contact areas outside the barrier islands could occur for a ≥1,000-bbl crude oil spill originating at the original offshore Liberty site. Refer to section 3.4.1.1 of this EA (page 3-67), which explains that, for the purposes of analysis, the large spill size in this EA is 1,000 bbl.

Probabilities of contacting Sea/Ice Segments 10 and 11 and Environmental Resource Areas (ERAs) 24, 29, 30, and 39 that are important from August through October to migrating bowhead whales adjacent to Liberty (SDI) Project are as follows:

One day postspill probability of contact to all ERAs and Sea/Ice Segments+<0.05

ERA	days postspill	winter probability(%)	summer probability(%)
10	3	<0.05	1.0
11	3	<0.05	1.0
24	3	<0.05	1.0
29	3	<0.05	3.0
30	3	1.0	7.0
39	3	1.0	6.0
10	10	1.0	3.0
11	10	1.0	5.0
24	10	<0.05	4.0
29	10	<0.05	7.0
30	10	1.0	11.0
39	10	1.0	13.0
10	30	2.0	4.0
11	30	1.0	8.0
24	30	<0.05	7.0
29	30	1.0	10.0
30	30	2.0	13.0
39	30	3.0	15.0
10	360	5.0	5.0
11	360	5.0	8.0
24	360	8.0	8.0
29	360	11.0	11.0
30	360	11.0	14.0
39	360	15.0	16.0

The OSRA model estimates there is a <0.05% chance that an oil spill would contact the spring lead system over a 360-day period in winter or summer. The probabilities estimated by the model would be modified further by a number of factors including, but not limited to, the probability of a specific spill being contained or partially contained onshore, the proportion of an Sea/Ice Segment or ERA that is contacted by oil, and the specifics of whale location, numbers, sex/age classes, and movement related to spilled oil and cleanup operations. An oil spill during the open-water season in August does not approach the migratory corridor (see Section 3.4.3). Disturbances likely would be related to displacement from noise and activity of spill response vessels. Oil-spill-response activities could have a positive impact on bowhead whales by displacing individuals to areas away from the spill, thereby reducing the risk of exposure to spilled oil; however, oil-spill-response activities could be of consequence to subsistence hunting success by deflecting migrating whales farther offshore. The ERA 39 would have the highest probability (range of <0.05 to 16% from 1 day to 360 days postspill, respectively) of contact by spilled crude oil from the Liberty (SDI) Project. The potential for bowhead whales to be affected by an oil spill from the Liberty (SDI) Project is relatively small based on the estimated spill size and relative probability of spilled oil contact, ranging from 0.05% for 1 day postspill in all ERAs and Sea/Ice Segments to a maximum of 16% in one of the six ERAs and Sea/Ice Segments used by fall migrating bowhead whales, and <0.05% of contacting the spring lead system, where bowheads migrate in spring. Both deterministic and stochastic models support a conclusion that impacts to bowhead whales from a Liberty (SDI) Project crude oil spill would be negligible.

Polar Bears

A large oil spill could have major effects on polar bears and their main prey – seals (St. Aubin, 1990a,b). In polar bears, oiling can cause acute inflammation of the nasal passages, marked epidermal responses, anemia, anorexia, stress, renal impairment, and death. These effects may not become apparent until several weeks after exposure to oil. Oiling of the pelt causes serious thermoregulatory problems for marine mammals by reducing its insulation value. Skin damage and hair loss also can occur (Oritsland et al., 1981). Bears also are known to be attracted to petroleum products and can be expected to actively investigate oil spills and to consume foods fouled with petroleum products (Derocher and Stirling, 1991). Because bears frequently groom their fur when it is fouled, a spill could result in contaminated bears ingesting oil and, thus, becoming susceptible to lethal and chronic/sublethal effects of hydrocarbon exposure.

Although a small number of bears may be affected by an oil spill initially, effects can be substantial over the long term through interactions between natural environmental stressors and compromised health of exposed animals, and through chronic, toxic exposure as a result of bioaccumulation (Peterson et al., 2003).

Due to the seasonal distribution of polar bears, the times of greatest impact from an oil spill are summer and autumn (Amstrup, Durner, and McDonald, 2000).

Spilled oil can concentrate and accumulate in leads and openings that occur during spring breakup and autumn freezeup periods. The mechanical concentration of spilled oil in leads and openings in the ice would increase the chance that polar bears and their principal prey would be oiled (Amstrup, Durner, and McDonald, 2000). This also holds true during winter, because polar bears prefer the lead system at the shear zone between the shorefast ice and the active offshore ice (USDOI, FWS, 1999a). This narrow zone of moving ice parallels the coastline and creates openings that are used by seals, and polar bears use leads and openings in the ice where prey are most abundant and accessible (Durner et al., 2004). Consequently, they are more vulnerable to winter oil spills. The impact of a large spill entering the marine environment, particularly during the broken-ice period, could have substantial adverse effects to the polar bear population. The number of polar bears affected by an oil spill could be substantially higher, if the spill spread to areas of seasonal polar bear concentrations, such as Cross Island. Coastal areas provide important denning habitat for polar bears, particularly along the coast of ANWR. Oiling of such habitats could have a negative impact on polar bears.

The proportion of maternal dens located in terrestrial versus pack-ice habitats appears to be increasing in recent years. Durner, Amstrup, and Ambrosius (2001) identified large areas along the coast and adjacent areas along the Sagavanirktok River near the SDI that are suitable for terrestrial maternal den sites. Continued changes in ice quantity and quality related to climate change could result in increased numbers of terrestrial maternal den sites near the Liberty (SDI) Project in future years (Fischbach, Amstrup, and Douglas, 2007). Higher numbers of denning polar bears and cubs in coastal areas could expose more bears to an oil spill from the Liberty (SDI) development.

Overall, the risk of a large oil spill from the Liberty (SDI) Project is considered low. The risk of a spill and the potential for it contacting polar bears is affected by spill response and containment, which is expected to be effective in preventing a spill from reaching areas frequented by polar bears. The MMS is requiring that BPXA specifically address polar bears and polar bear aggregations in their oil-spill-response planning (see Section 4). While the effects from a large spill potentially could be major, this is not considered a likely event, and no major impacts are anticipated from the proposed action.

ESA-Listed Birds

A large oil spill likely would pose the greatest threat to spectacled eiders and, to a lesser extent, Steller's eiders in the Liberty (SDI) Project area. Oiling of bird feathers can lead to shock, hypothermia, and drowning (USDOI, MMS, 2002). Eiders surviving the initial phases of exposure to an oil spill could be susceptible to related impacts, including reduced functioning of the endocrine system (impeding detoxification of other body systems), liver damage, loss of weight and, ultimately, decreased production of young (USDOI, MMS, 1996a). The MMS assumes that any spectacled or Steller's eider, Kittlitz's murrelet, or yellow-billed loon coming in direct contact with oil would die.

Spectacled eiders occur in low densities in the Sagavanirktok River delta. Steller's eiders are a rare occurrence and not expected to be present in the project area. The low densities of threatened eiders in the project area make it unlikely that significant numbers of spectacled or Steller's eiders would be impacted by an oil spill. However, spectacled eiders may occur in flocks in offshore habitats (Fischer, Tiplady, and Larned, 2002), increasing the risk of multiple individuals being affected if a group were to encounter spilled oil. Any consequence affecting population numbers will hinder these species' recovery from their threatened status (USDOI, MMS, 2002).

Oil spill response efforts could impact eiders if a large oil spill were to occur. The extent of consequences to eiders from oil spill response efforts would depend on the location, timing, amount, and behavior of spilled oil. Oil-spill-response activities could have a positive impact on eiders by displacing birds to areas away from the spill, thereby reducing the risk of exposure to spilled oil.

Overall, the risk of a large spill is considered low. The risk of substantial harm to ESA-listed birds is further reduced, considering the time of the year when birds are present. The risk of a spill and potential for contacting ESA-listed birds is affected by spill response and containment, which could be effective in preventing a spill reaching areas frequented by ESA-listed birds. While the effects from a large spill have the potential to affect small numbers of ESA-listed birds, this is not considered a likely event and no major impacts are anticipated (refer to Appendix C of this EA).

3.3.11.4 Bird Strikes

The effects of bird strikes have been described for the SDI expansion (Section 3.1) and facility construction (Section 3.3). Effects from the 250-foot tall drill rig would exist for about 3 years, while it is working on site (2010 through 2013). The effects from these facilities would continue during the life of the project. Adverse effects from some facilities could continue even after production ceases.

BPXA design engineers have committed to consult with the FWS on identifying and implementing ways to reduce how facility lighting attracts/disorients ESA-listed birds in the project vicinity. Effectively reducing escaped lighting is believed to reduce the potential for birds, like the spectacled eider, to strike facilities on the MPI and SDI.

There would be an anticipated increase in vehicle traffic on the Endicott Road to operate the facility, but this is much reduced from the construction phase and no substantial changes in the ability of some eiders and their broods to access coastal habitats is anticipated. The present level of mortality from roadkill is unknown. The reduced speed limit for vehicles during the nesting and/or broodrearing period could help reduce any negative effects of traffic on the Endicott Road. These negative effects are difficult to estimate, but the reporting of roadkill birds will help evaluate whether this is a substantial form of mortality to threatened eiders.

Birds could be injured or killed if attracted to or disoriented by a gas flares from the drilling facility (Wiese et al., 2005). This has not been identified as a substantial form of bird mortality at North Slope production facilities.

Increases to existing bird strike mortality is assumed to be low (<20 birds/year), however mortality could be larger due to episodic events such as a flock of spectacled eiders colliding with Liberty (SDI) Project facilities (especially during periods of darkness or inclement weather). Overall, long-term operation of the production facility will increase the potential for bird mortality, but this increase is not anticipated to be major. Per the FWS Final BO, BPXA must report all avian mortalities and collisions (including vehicle collisions) and their circumstances. The transmission of these data will help verify the assumption that collision mortality is low, and negative effects are small.

It remains unclear what would happen to Liberty (SDI) Project facilities at project termination/abandonment. The Liberty DPP states that BPXA will make no decision regarding abandonment at this time and did not detail any abandonment procedures. As the expansion of the SDI was essential to obtain resources from Federal leased lands, the long-term effects of these federally permitted facilities, especially in terms of perpetual eider strike hazard, need to be factored into when these facilities (sheet pile, buildings, gravel pad, etc.) would be removed. Information collected during a monitoring/reporting program for bird strikes would contribute toward a careful assessment of the environmental effects of various abandonment scenarios. At the present time, MMS's environmental effects analysis is based on BPXA's expectation that, ultimately, the entire facility would be removed and all bird strike hazards would be eliminated.

The U.S. Army Corps of Engineers has the authority to place the following special condition on the Department of Army, Clean Water Act 404 authorization (if issued):

- Upon abandonment, all on or above ground fills shall be removed unless otherwise identified as part of the final abandonment plan.

The rationale for the special condition refers to a General Condition on the permit form that states that upon abandonment, the site must meet the approval of the District Engineer/Commander.

3.3.11.5 Increased Bird-Predator Populations

Wildlife access to human-use foods during drilling or production operations could help increase the abundance and distribution of predatory birds (ravens, gulls) and mammals (foxes, bears) in the area. Efforts to eliminate wildlife access to human-use foods/garbage will be incorporated into the day-to-day operation of the Liberty (SDI) Project in compliance with policies developed by the NSB.

Other components of the Liberty (SDI) Project may afford foxes new denning sites. For example, the currently proposed mine rehabilitation plan includes retention of portions of an elevated earthen berm and the stockpiles of organic overburden, which could become a site of future new fox dens. Per the FWS Final BO, BPXA intends to monitor the berm and stockpiles weekly from April 15 through June 15. If denning activities are observed, the ADF&G and FWS will be contacted to develop a plan to prevent further activity. An annul report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year.

The Final BO measures are expected to be implemented, and no increased mortality to ESA-listed birds from enhanced predator populations would occur.

3.3.12 Cultural Resources

In accordance with NHPA provisions of the November 24, 2006, Memorandum of Understanding among MMS, the U.S. Army Corps of Engineers, ADNR, and BPXA:

> The MMS, after consultation with the COE and other cooperating agencies, will notify BPXA if it determines that it is necessary to assess whether the Liberty (SDI) Project may affect archaeological resources within the project area. The MMS will request that BPXA provide archaeological and, if required, traditional cultural properties reports in accordance with the National Historic Preservation Act of 1966 (16 USC § 470 et seq.). The MMS will consult with the State Historic Preservation Officer and applicable Tribal Historic Preservation Officers, if necessary. This consultation will also cover the cooperating agency permit review requiring consultations.

The SHPO, in letters to BPXA on January 26, 2007, and the U.S. Army Corps of Engineers on June 8, 2007, requested that archaeological surveys be conducted in Liberty (SDI) Project area that previously had not been surveyed. These project areas would include locations where project activities such as ice road construction, gravel extraction, SDI expansion, West Sagavanirktok River Bridge upgrade, pipeline construction, facilities installation, and new drill rig construction could occur. BPXA notified MMS on July 2, 2007, that a cultural resources survey contract has been awarded to Reanier & Associates, with a final report expected in late 2007.

The MMS, after consulting the State of Alaska AHRS database, has identified no cultural and archaeological sites offshore, nearshore, or onshore within the area of potential effect of the Liberty (SDI) Project. The SHPO concurred with the MMS determination of no effect to offshore historic or prehistoric resources. The U.S. Army Corps of Engineers agreed to the responsibility to conduct a separate consultation in accordance with NHPA for onshore resources. Refer to Appendix F for SHPO consultation correspondence.

3.3.13 Socioeconomics and Related Impacts

This section discusses the possible socioeconomic and related impacts associated with drilling and oil production. As noted in the above paragraphs, drilling and oil production could result in direct economic impacts, changes in population and employment, impacts on subsistence resources and use, sociocultural impacts, and impacts from a large oil spill and cleanup. Possible socioeconomic impacts are discussed in the Liberty FEIS (USDOI, MMS, 2002), which is incorporated by reference. It is appropriate to provide additional material, however, because of changes in the project and its alternatives. These changes alter the likely environmental impacts of the project, and substantial increases in the price of crude oil (if these prevail in the future) would increase substantially the economic benefits of the project. This section covers the following impacts: economy and sociocultural systems, subsistence, and environmental justice.

3.3.13.1 Economy and Sociocultural Systems

Economy

The direct economic impacts of the Liberty (SDI) Project were addressed in the Liberty FEIS (USDOI, MMS, 2002) and include direct and indirect jobs, royalty revenues to Federal and State governments, and tax revenues to the North Slope Borough (NSB). Additional impacts not considered in the original EIS relate to national impacts, such as those on the balance of payments.

The original EIS assumed that the total Liberty production over the economic life of the field would be 120 MMbbl and that the prevailing crude oil price would be $16.30/ bbl (see Section 3.6.2 of this EA). The revised estimate of cumulative production is 105 MMbbl—12.5% smaller than originally assumed. However, the price of crude oil is more than $70/bbl as of this writing, four times that assumed in the FEIS. The Fall *2006 Revenue Sources Book* issued by the Alaska Department of Revenue (ADOR) (ADOR, 2006) projects lower crude oil prices in the future than those at present: $41.50/bbl postfiscal-year (FY) 2014, still substantially greater than those assumed when the FEIS was written. Long-range forecasting of all commodity prices is difficult, and experience shows that forecasting oil prices is particularly challenging. Nonetheless, both the ADOR and the U.S. Energy Information Administration project crude oil prices substantially greater than $16.30/bbl by the time Liberty begins production. Thus, the revenues to the State of Alaska and the Federal Government are likely to be substantially greater than estimated in the Liberty FEIS. Liberty is obligated to pay MMS a 12.5% royalty (in value or in kind) and, because of the particular location of the lease and the agreement that the MMS has with the State of Alaska, the State will receive 27% of that 12.5% royalty, or 3.375%. Additionally, the NSB will receive tax revenues based on the *ad valorem* value of the onshore infrastructure and the prevailing tax rate.

The Liberty FEIS did not explicitly discuss potential economic impacts at the national level, but these could be material. The U.S., as recently as World War II, was self sufficient in oil but is now a net oil importer. Petroleum imports are an important component of the balance-of-payments deficit. At $41.50/bbl, Liberty's total production of 105 MMbbl has a value of $4.3 billion.

The Liberty FEIS examined the effects of construction activities on the Alaskan economy and the subsistence aspects of the economy and concluded: "We do not expect disturbances to affect the cash economies." The new project proposal should have even smaller economic effects associated with construction, because the revised plan exploits more of the existing infrastructure. Sections 3.1.13 and 3.2.10 of this EA restate estimates of the number of construction jobs in the Liberty FEIS.

Estimates of the number of workers needed for drilling and production for the current Liberty (SDI) Project provide for a greater number of workers during the initial drilling operation and fewer operators needed during long-term production. The maximum number of annual drilling jobs is estimated to be 120 over a 4-year period. Once production begins, the estimated annual number of production jobs is 20 workers over a 30-year period. The estimated level of employment, while initially higher than that given in the FEIS, is approximately the same over time and is expected to have minimal impact on the local economy.

Sociocultural Systems

The Liberty FEIS (USDOI, MMS, 2002) concluded:

> Effects on the sociocultural systems of communities near the Liberty (SDI) Project could occur as a result of disturbance from industrial activities, changes in population and employment, and effects on subsistence-harvest patterns. They could affect the social organization, cultural values, and social health of the communities. Together, effects periodically may disrupt, but not displace, ongoing social systems; community activities; and traditional practices for harvesting, sharing, and processing subsistence resources.

As noted above, the new proposed action should result in lower impacts than those anticipated for the original project. Sociocultural impacts would result from a large crude oil spill because of the disruption of subsistence harvests, as discussed above. It is important to note that the total estimated Liberty production is only a very small proportion of the oil already produced on the North Slope and also a small proportion of the oil projected to be produced in the future.

Subsistence and Area Use Patterns

The Liberty FEIS (USDOI, MMS, 2002) addressed possible impacts of this project on subsistence and subsistence-harvest patterns. Potential impacts on subsistence are rightly viewed with concern because of the key importance of subsistence and subsistence harvests to residents of the NSB.

Oil-spill contact in winter could affect polar bear hunting and sealing. During the open-water season, a spill could affect bird hunting, sealing, and whaling, as well as the netting of fish in the ocean. The OSRA analysis done for the Liberty FEIS (USDOI, MMS, 2002) offers a relative comparison of contact from a large spill originating from the Endicott SDI and contacting subsistence Environmental Resource Areas important to the community of Nuiqsut:

> The chance of a summer spill (925-barrel crude oil spill or a 1,283-barrel diesel fuel spill with no diesel remaining after 7 days) originating from the Liberty gravel Island contacting important Nuiqsut environmental resource areas ranges from a 4-15% chance of contact over a 30-day period and a 5-15% chance over a 360-day period. Percentages for winter contact are less for a 30-day period, ranging from 1-4% over a 30-day period but are slightly higher over a 360-day period, ranging from 7-21%.

The potential for bowhead whales to be affected by spilled oil from the Liberty (SDI) Project is relatively small, based on the estimated size of a spill and the relatively low (15% or less) chance of spilled oil reaching the main bowhead subsistence-harvest areas in summer or fall.

The FEIS concluded:

> We do not expect significant impacts to result from any of the planned activities such as discharges and disturbances associated with Alternative I (Liberty Development and Production Plan) or any of the other alternatives. Some significant impacts — adverse effects to spectacled eiders, king and common eiders, long-tailed ducks, subsistence-harvest patterns, sociocultural systems, and local water quality — could occur in the unlikely event of a large oil spill. However, the very low chance of such an event occurring…combined with the seasonal nature of the resources inhabiting the area (for example, eiders are present in the Liberty area 1-4 months of the year), makes it highly unlikely that an oil spill would occur and contact the resources. A resource may be present in the area but may not be contacted by oil…None of the component or combination alternatives evaluated [in this] EIS are expected to generate significant impacts from planned activities. If an unlikely oil spill occurred, similar significant effects could occur to spectacled eiders, king and common eiders, long-tailed ducks, subsistence harvests, sociocultural systems, and local water quality for all alternatives.

More specifically, with respect to subsistence-harvest patterns, the Liberty FEIS [Section II.h(1)] concluded:

> Overall, oil spills could affect subsistence resources periodically in the communities of Nuiqsut and Kaktovik. In the unlikely event of a large oil spill, many harvest areas and some subsistence resources could be unavailable for use. Some resource populations could suffer losses and, as a result of tainting, bowhead whales could be rendered unavailable for use. Tainting concerns in communities nearest the spill event could seriously curtail traditional practices for harvesting, sharing, and processing bowheads and threaten a pivotal underpinning of Iñupiat culture. There is also a concern that the International Whaling Commission, which sets the quota for the Iñupiat subsistence harvest of bowhead whales, would reduce the harvest quota following a major oil spill or as a precaution as the migration corridor becomes increasingly developed to ensure that overall population mortality did not increase. Such a move would have profound cultural and nutritional impacts on Iñupiat whaling communities. Whaling communities distant from and unaffected by potential spill effects are likely to share bowhead whale products with impacted villages. Harvesting, sharing, and processing of other subsistence resources should continue but would be hampered to the degree these resources were contaminated. In the case of extreme contamination, harvests could cease until such time as resources were perceived to be safe by local subsistence hunters. Overall, effects are not expected from routine activities and operations.
>
> Tainting concerns also would apply to polar bears and seals and beluga whales, walruses, fish, and birds. Additionally a large oil spill could cause potential short-term but serious adverse effects to long-tailed ducks and king and common eider populations. A potential loss of one or two polar bears could reduce their availability locally to subsistence users, although they are seldom hunted by Nuiqsut hunters except opportunistically while in pursuit of more preferred subsistence resources.

Addressing bowhead whales specifically, the Liberty FEIS [Section III.h(2)(2)(a)] added:

> The potential for bowhead whales to be affected by spilled oil from the Liberty project is relatively small based on the estimated size of a spill and the relatively low…chance of spilled oil reaching the main bowhead fall migration route outside the barrier islands. However, if a spill occurred and contacted bowhead habitat during the fall whale migration, it is likely that some whales would be contacted by oil. It is likely that some of these whales would experience temporary, nonlethal effects…Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales or their feeding areas from an oil spill.

No new information has been found that would invalidate this original assessment in the Liberty FEIS with respect to the alternatives considered. What has changed is the proposed action, which differs from the evaluation in the Liberty FEIS. Specifically, the new proposed action employs ultra-extended-reach drilling (uERD) from an existing facility rather than a new offshore location. Such a project reduces the offshore impacts of island and pipeline construction. This change in project scope substantially mitigates the potential impacts related to the Boulder Patch, marine mammals, and concerns of the North Slope Iñupiat communities related to the bowhead whale and subsistence whaling. Development using the existing infrastructure at Endicott further mitigates impacts by avoiding construction of a pad on the shoreline of Foggy Island Bay and an access road and pipeline crossing of the Sagavanirktok River delta. In principle, therefore, the probable impacts of the new proposed action would be the same or smaller than those identified in the Liberty FEIS. Because some response equipment would be stationed at the SDI facility, and the SDI is connected by causeway to Deadhorse where major response infrastructure and response personnel are staged, response generally would be expected to be faster and more efficient, than to a drill site without such access.

Oil production with the new proposed alternative also might result in crude oil or product spills. Small operational spills of crude oil or product are virtually certain to occur, but they would not be expected to have major impacts. As discussed in Section 3.4, large crude spills, although unlikely, also might occur. Depending on the location, timing, amount, and behavior of the spill(s), major adverse effects on certain species, subsistence-harvest patterns, and sociocultural systems might result. This conclusion is not unique to the Liberty Project; EIS's/EAs for other development projects (see, e.g., USDOI, MMS, 2003, 2004, and 2006) also conclude that a large oil spill could have significant adverse impacts.

Environmental Justice

> Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 *FR* 7629), requires each Federal agency to make the consideration of Environmental Justice part of its mission. Section 1-101 states:
>
> To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on

> minority populations and low-income populations in the United States and its territories and possessions….

Other portions of this order require agencies to develop strategies to address environmental justice (1-103); research, data collection, and analysis (Section 3-3); and requirements to collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence (4-401). The EIS's drafted after the effective date of this order must contain an impacts analysis for environmental justice.

In particular, Alaska Iñupiat Natives, a recognized minority, are the predominant residents of the North Slope Borough (NSB). Therefore, it is relevant to consider whether or not the environmental impacts of the proposed Liberty development project will have "disproportionately high and adverse" impacts on NSB residents.

The Proposed OCS Lease Sale 202 EA (USDOI, MMS, 2006b) defines a "significance threshold" for each resource category as a level of effect that equals or exceeds a designated threshold:

> The significance threshold for Environmental Justice would be disproportionate, high adverse human health or environmental effects on minority or low-income populations. This threshold would be reached if one or more important subsistence resources becomes unavailable, undesirable for use, or available only in greatly reduced numbers for a period of 1-2 years; or chronic disruption of sociocultural systems occurs for a period of 2-5 years, with a tendency toward displacement of existing social patterns. Tainting of subsistence foods from oil spills and contamination of subsistence foods from pollutants would contribute to potential adverse human-health effects.

The Liberty FEIS (USDOI, MMS, 2002) reached the following conclusion about environmental justice:

> Alaska Iñupiat Natives, a recognized minority, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Effects on Iñupiat Natives could occur because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. The Iñupiat community of Nuiqsut, and possibly Kaktovik, within the North Slope Borough, could experience potential effects. In the unlikely event that a large oil spill occurred and contaminated essential whaling areas, major effects could occur when impacts from contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together. However, effects are not expected from routine activities and operations. When we consider the little effect from routine activities and the low likelihood of a large spill event, disproportionately high adverse effects would not be expected on Alaskan Natives from Liberty development under the Proposal. Any potential effects to subsistence resources and subsistence harvests are expected to be mitigated substantially, though not eliminated.

The conclusion reached in the Liberty FEIS still holds, and the new proposed alternative for Liberty is likely to be environmentally superior to any of the original alternatives. Therefore, while environmental justice concerns are relevant, disproportionate, high adverse effects would occur only in the unlikely event that a large oil spill (because of location, season, or other factors) significantly impacted key subsistence resources. As stated in the Liberty FEIS, "any potential effects to subsistence resources and subsistence harvests are expected to be mitigated substantially, though not eliminated." For any of the Liberty Project alternatives, BPXA will implement mitigation measures to minimize the possibility and potential for a large oil spill (see Section 4.2.4; see also the environmental justice impacts discussion in the MMS Beaufort Sea Sale 202 EA (USDOI, MMS, 2006b).

3.3.14 Waste Management

All waste from the Liberty (SDI) Project would be handled in accordance with State, Federal, and local regulations. Use of permitted disposal wells and other approved disposal methods will result in zero surface discharge of drilling wastes, and, in conjunction with BPXA's waste minimization policy, will result in little or no impact from waste disposal. See Section 10 of the Liberty DPP for more information on waste handling.

3.4 FATE AND EFFECT OF OIL SPILLS

3.4.1 Risk of an Oil Spill

As noted in the original offshore Liberty Development Project documents (LGL, 1998) and the FEIS (USDOI, MMS, 2002), BPXA is required by both State and Federal law to implement approved spill-contingency plans (both with MMS and ADEC). Implementation of BPXA's spill-contingency plans also is the primary means of minimizing the risk of a spill and ensuring that spill response will be swift and effective.

However, for planning purposes and to estimate the potential direct and indirect effects of an oil spill from the Liberty (SDI) Project, an oil spill risk analysis has been completed.[1] This section summarizes the oil spill risk analysis presented in detail in Appendix A of this EA. The risk analysis and the summary below incorporate comments and techniques suggested by the North Slope Borough Science Advisory Committee (NSBSAC, 2003). In particular, the summary below provides information in a plain-language format, avoids extrapolation of data from potentially unrepresentative areas,[2] and provides information on the upper and lower confidence limits on the probability of a large spill.

To quantify the probable crude and refined petroleum (product) spill volumes associated with the operation of the Liberty (SDI) Project, a database of historical Alaska North Slope (ANS) crude oil and product spill records was developed. The historical spill database was compiled by analyzing industry and government-agency oil spill databases for ANS facilities, including wells, facilities, and other pipelines up to (but not including) Pump Station 1 (PS-1), which marks the beginning of the Trans-Alaska Pipeline System (TAPS). The spill projection method employed is based on statistical models used by MMS for ANS and other oil fields.

Figure 3.4-1 presents a flowchart of the general method used to develop the oil spill risk analyses. The spill dataset was divided into three categories: large crude oil spills, small crude oil spills, and product spills. Appendix A describes the process in detail.

[1] Appendix A provides an analysis of potential oil and hydrocarbon spills for the proposed Liberty Development project. Two types of spills are considered in this analysis (1) spills of crude oil and (2) spills of refined products (e.g., aviation fuel, gasoline, diesel fuel, turbine fuel, motor oil, hydraulic oil, transformer oil, transmission oil, and engine lube oil, etc.). Produced water spills are not considered in this analysis. In cases where a "mixed spill" occurs the respective volumes of crude oil and product are calculated by multiplying the total spill volume by the respective percentages of crude or product. For simplicity, these are referred to as crude and product spills.
[2] The NSBSAC specifically noted that extrapolation of data from the Gulf of Mexico might be inappropriate.

The data used for this analysis include historical ANS crude and product spills from 1985 through 2006, a time period believed most appropriate for this purpose.[3] The basic assumption is that the likelihood of future crude and product spills associated with the Liberty (SDI) Project can be accurately estimated from prior ANS experience, i.e., that large crude oil spill rates (per billion barrels produced) for this project will match the average of those for other ANS facilities. This assumption may overstate potential spills from the Liberty (SDI) Project because this project makes efficient use of existing facilities and features few incremental facilities. The Liberty (SDI) Project design and scope have evolved from an offshore stand-alone development in the outer continental shelf (OCS) (production/drilling island and subsea pipeline), as described in the 2002 Liberty DPP FEIS, to maximize use of the existing infrastructure involving an expansion of the Endicott SDI. As a result, development of the Liberty (SDI) Project from Endicott dramatically reduces potential environmental impacts, project footprint and does not require construction of new processing and transportation facilities.

The Liberty (SDI) Project will be developed with very few wells; up to six wells will be drilled from the expanded SDI using a purpose-built drilling rig to reach the offshore Liberty reservoir located on the OCS. The drilling rig will be powered by natural gas, so no handling and storage of large quantities of diesel fuel is required for the project. Production from the Liberty (SDI) Project wells will be tied into the existing Endicott flow line system with production sent from the SDI via the existing 28-in CRA (Corrosion Resistant Alloy) three-phase flow line to the Endicott Main Production Island (MPI) for processing. The Endicott plant internals are constructed of duplex stainless steel for production. After processing at the MPI facilities, Liberty oil will transported through the existing 16-in Endicott sales-oil pipeline (which is a U.S. Department of Transportation-regulated pipeline) to PS-1 of TAPS. This pipeline is internally inspected on a cycle of not less than once every 5 years (the last inspection was 2005) using a magnetic flux pig. The Liberty (SDI) Project will be using the Endicott facilities through a Facility Sharing Agreement (FSA) with the Duck Island Unit Owners, which is currently being negotiated. No buried subsea pipelines (included in the alternatives considered in the original FEIS) are required.

As noted above, the Liberty (SDI) Project will maximize the use of existing infrastructure; the analysis presented here conservatively assumes that the direct and indirect impacts of the Liberty (SDI) Project can be estimated based on a statistical analysis of spills of the other exploration and production fields on the North Slope. This avoids the methodological difficulties of extrapolating oil-spill experience from other areas of the country (or world), such as the Gulf of Mexico.

Because spills are random (not deterministic) phenomena, it is appropriate to use statistical (or probabilistic) methods to describe the number, volume, and likelihood of future spills.

3.4.1.1 Large Crude Oil Spills

Crude oil spills included in this analysis are subdivided into large spills (those ≥200 bbl) and small spills[4] (those <200 bbl). For large crude oil spills:

[3] See Appendix A for more information. This time period spans 22 years of ANS oil spill records and provides thousands of reliable spill records for analysis.

[4] MMS traditionally uses 1,000 bbl as the threshold for a large OCS spill. However, only one ANS spill ≥ 1,000 bbl has occurred from 1977 to the present. The Liberty FEIS used 500 bbl as a threshold, and more recent studies have considered thresholds as small as 50 bbl OCS spills. The choice of 200 bbl provides an adequate sample of large spills

- The expected number[5] of large crude oil spills throughout the operating life of the Liberty (SDI) Project is 0.09 based on the estimated production of 105 MMbbl and the ANS experience that nine large (≥ 200 bbl) crude oil spills occurred during the production of nearly 11 billion bbl (Bbbl) of crude oil produced over the period from 1985 through 2006. We have high (95%) confidence that the estimated number of large crude oil spills lies between 0.039 and 0.163.[6]
- The estimated probability (in percentage terms) that no large crude oil spill will occur from the Liberty (SDI) Project is approximately 92%,[7] if the future is like the past and the assumed model is correct.[8] We have high (95%) confidence that the actual chance that no large spill will occur during the operation of the Liberty (SDI) Project lies between 85% and 96%. That is, large crude oil spills associated with the Liberty (SDI) Project are unlikely.
- The estimated probabilities (based on the Poisson model) that there will be 1, 2, or 3 large crude spills over the life of the Liberty Field are estimated to be approximately 7.8%, 0.3%, and < 0.01%, respectively.
- The estimated probability of one or more large spills occurring over the production life of the project is 8%.
- The odds against one or more large spills occurring over the project lifetime are estimated to be approximately 11:1. The odds against two or more large spills occurring are nearly 285:1.
- If a single large crude oil spill were to occur, then a reasonable estimate of the probable spill volume (using actual data directly as well as fitting statistical models) is 1,000 bbl. Allowing for the possibility of multiple large crude oil spills, the estimated large crude oil spill volume is only slightly larger than 1,000 bbl, because having more than one large spill is very unlikely. However, because large spills are infrequent, the weighted-average large crude oil spill volume is estimated to be 85 bbl.[9]
- Because there is a distribution of large crude oil-spill volumes, it is possible that the cumulative large crude oil spill volume, given the unlikely event that one occurs, would be >1,000 bbl. Monte Carlo simulations described in Appendix A indicate that the 95%

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for statistical purposes and lowers the likelihood that estimates will be biased if the volume distribution of small spills differs from that for large spills.

[5] This is a statistical term of art and denotes the sum of the probabilities of 0, 1, 2, 3…spills times the number of spills, summed over all possible numbers of spills. Another word that might be chosen is the *estimated* number of spills. In this instance the expected or estimated number of large spills is 0.09—an impossibility because the number of large spills must be a whole number (e.g., 0, 1, 2, 3 …). The significance of the expected number is that large spills are expected to be infrequent.

[6] Technically this is known as a *confidence interval*. In statistics, a confidence interval (CI) for a population parameter (the large crude oil spill rate in this example) is an interval with an associated probability (95% in this instance) that is generated from a random sample of an underlying population such that if the sampling was repeated numerous times and the confidence interval recalculated from each sample according to the same method, a percentage (95%) of the confidence intervals would contain the true value of the population parameter in question. The use of confidence intervals was one of the specific recommendations of the NSBSAC. For additional information on confidence intervals, see http://www.cas.lancs.ac.uk/glossary_v1.1/confint.html.

[7] Note that this statement applies only to large crude oil spills. Many small spills (addressed in detail in Appendix A and summarized here) are likely to occur.

[8] This model is conceptually plausible and the adequacy of this approximation has been validated by historical experience in the Gulf of Mexico (see Eschenbach and Harper 2006).

[9] As noted, if a large spill occurs, the volume estimate is approximately 1,000 bbl, but because the probability of a large spill occurring is so low, the weighted average volume of a large spill is much lower.

confidence interval on the volume of large crude oil spills (given that one occurs) ranges from 225 to 4,786 bbl.

Finally, it is important to note that, because the project throughput of Liberty (SDI) is only a small fraction of the total ANS crude oil throughput, it is more likely that any future large crude oil spill will come from one of the other producing fields than from the Liberty (SDI) Project.

The Liberty FEIS (USDOI, MMS, 2002) offered the following comments on the chance of a large spill occurring:

> The analysis of historical oil-spill rates and failure rates and their application to the Liberty Project provides insights, but not definitive answers, about whether oil may be spilled from a site-specific project. Engineering risk abatement and careful professional judgment are key factors in confirming whether a project would be safe.
>
> We conclude that the designs for the Liberty Project would produce minimal chance of a significant oil spill reaching the water. If an estimate of chance must be given for the offshore production island and the buried pipeline, our best professional judgment is that the chance of an oil spill greater than or equal to 500 bbl occurring from the Liberty Project and entering the offshore waters is on the order of 1% over the life of the field….
>
> We base our conclusion on the results gathered from several spill analyses done for Liberty that applied trend analysis and looked at causal factors. All showed a low likelihood of a spill, on the order of a 1 - 6% chance or less over the estimated 15-20 year life of the field.

While not identical, the projections made in this report are broadly consistent with the results of the Liberty FEIS; both estimates indicate that it is unlikely that a large spill would occur. As to differences:

- The original analysis defined a large spill as one ≥500 bbl, whereas this analysis uses 200 bbl as the threshold of a large spill.[10] As shown in Appendix A, the probability that no large spill would occur (assuming a 500-bbl threshold) is 94.4%—numerically closer[11] to that estimated in the FEIS. (The 95% confidence interval on the probability that no large spill would occur assuming a 500-bbl threshold is from 88.3 to 97.9%. This confidence interval overlaps the 94 to 99% range specified in the Liberty FEIS.)
- The original spill estimates were based on the definition of a large crude oil spill from the offshore production island and buried pipeline reaching the water. This analysis addresses the occurrence of a large crude oil anywhere in the facility and makes no assumption regarding whether or not the spill reaches the water.
- The estimate developed in Appendix A is based solely on the assumed production volume of Liberty and actual spill statistics from ANS operations updated through 2006. That presented in the FEIS used data from several sources and ultimately was based on engineering judgment.

Assumptions for the purposes of analysis of large spills in this EA

For purposes of analysis, we assume one large spill occurs at any location. This "what-if" analysis of a large oil spill addresses whether such spills could cause serious environmental

[10] This choice of 200 bbl as the threshold was made on statistical grounds.
[11] This estimate is within the range of plausible estimates given in the FEIS.

impact. The large spill threshold is defined as ≥200 bbl. BPXA estimates an 8% chance of one or more large spills occurring over the production life of the project. At the 95% confidence interval, BPXA estimates a 4 to 15% chance of one or more large spills occurring over the production life of the Liberty (SDI) Project. BPXA estimates a 92% chance of no large spills occurring over the life of the Liberty (SDI) Project.

The MMS bases the analysis of effects from a large crude oil spill on the following assumptions:

- One large spill occurs.
- The large spill size threshold is defined as ≥200 bbl.
- For the purposes of analysis, the large spill size is 1,000 bbl.
- All the oil reaches the environment; the production facility and causeway absorb no oil.
- The large spill starts at the production facility or along the offshore pipeline on the causeway.
- There is no cleanup or containment. Cleanup and containment are considered mitigating factors within the effects analysis.
- The large spill could occur at any time of the year.
- The large spill weathering is as we show in the USDOI MMS Liberty FEIS Appendix A, Tables A-5, A-6 and A-7.
- A large spill that moves into or onto the landfast ice from the production facility or its pipeline does not move dramatically until the ice breaks up.
- The large spill area varies over time, as we show in Liberty FEIS Appendix A Table A-7 and is calculated from Ford (1985).
- The time and chance of contact from a large oil spill are calculated from an oil-spill-trajectory model in the Liberty FEIS (Appendix A, Tables A-12-A-13) using Liberty Island as the hypothetical spill site. These conditional probabilities provide a relative analogy for large oil spills from the SDI. Although the conditional probabilities are not site specific they provide a general framework for the stochastic behavior of large oil spills within Stefansson Sound.
- The chance of contact is analyzed from where it is highest when determining effects.

3.4.1.2 Small Crude and Refined Product Spills

Data from ANS and other areas indicate that small spills of either crude or product are more numerous than large spills, but the average size of a small spill is very much smaller than the average size of a large spill, with the result that (from 1985 through 2006) the aggregate volume of ANS small spills was only about 28% of the total volume spilled (for crude). Other factors held constant, a smaller spill is more likely to be contained, more readily cleaned up, and less likely to have adverse environmental effects than a large spill. For this reason, most spill analyses focus on larger spills. Nonetheless, small spills should be considered out of concern about chronic effects from numerous small spills.

Appendix A also estimates of the volume of small spills associated with Liberty (SDI) Project. For small oil spills:

- The estimated total crude-oil volume (for the operating lifetime of the Liberty Project) based on the observed ratio of the volume of small spills to ANS production is approximately 34 bbl.[12] The Liberty Project Description (BPXA, 2006) does not specify the economic life of the project. Assuming a 20-year project lifetime, the average small crude-oil volume spilled per year would be approximately 1.75 bbl/year.

- The 95% confidence interval on the total volume of small crude spills over the lifetime of the project ranges from 6 to 100 bbl.
- For purposes of analysis, we assume a small, 2-bbl spill covers approximately a continuous area of 0.38 acres (Payne et al., 1984).

Product spills, though numerous, are very small on average. Using the same method as that employed to project small crude spills, the following estimates are derived for the expected and 95% confidence limits on the volume of refined product spills:

- The estimated total product volume (for the operating lifetime of the Liberty Development Project) based on the observed ratio of the volume of small product spills to ANS production is approximately 42 bbl,[13] equivalent to approximately 2 bbl/year over a 20-year project lifetime.
- The 95% confidence interval on the total volume of small product spills ranges from 10 to 125 bbl.

3.4.2 Behavior of Spilled Oil

This section briefly examines the behavior of oil spilled on the ANS. Much of the information summarized below is developed in detail in the Northeast NPR-A EIS (USDOI, BLM and MMS, 1998); the Northstar EIS (U.S. Army Corps of Engineers, 1999); the Liberty FEIS (USDOI, MMS, 2002); and the Beaufort Sea Planning Area Multiple Lease Sale EIS (USDOI, MMS, 2003). An extensive discussion of the fate and effects of oil spilled on the North Slope is also included in the National Research Council (NRC) report detailing the cumulative effects of oil industry operations on the North Slope (NRC, 2003). All are incorporated by reference in the summary below.

As noted above and in the oil spill risk analysis in Appendix A, crude oil has been spilled during oil production, processing, and transportation on the North Slope. In general, spills are small and contained. However, when oil is released to the environment, the behavior of the oil is controlled by the amount and type of oil spilled, the time of year, and the local environment (USDOI, BLM and MMS, 1998). Oil composition and inherent physical characteristics also govern the behavior of a spill with regard to oil movement, level of damage done to the impacted environment, and the weathering process (USDOI, MMS, 2002; NRC, 2003; U.S. Army Corps of Engineers, 1999).

When spills occur, oil begins to naturally degrade both physically and chemically. This process is known as weathering, or aging, and can occur by spreading, evaporation, dispersion, dissolution, emulsification, microbial degradation, sedimentation, and photo-oxidation (USDOI, BLM and MMS, 1998; USDOI, MMS, 2002; NRC, 2003; U.S. Army Corps of Engineers, 1999). The weathering process is also impacted by wind, waves, current movements, and stranding onto vegetation or shoreline (USDOI, BLM and MMS, 1998).

The weathering processes and properties of Liberty crude oil are described in the Liberty

[12] For comparison, the Liberty FEIS estimated that there might be 17 spills less than 1 bbl and 6 spills greater than or equal to 1 bbl and less than 25 bbl. These estimates are broadly consistent with the estimates given in Appendix A.

[13] For comparison, the Liberty FEIS estimated that there would be 53 refined product spills of 0.7 bbl, for a total volume of 37.1 bbl over the life of the project. This is nearly identical to the volume projected in Appendix A and within the confidence interval.

FEIS (USDOI, MMS, 2002), which focused on spills to open water, spills to broken ice, and underwater spills as was appropriate for an offshore development using an buried pipeline. While spills to open water or broken ice are still possible with the proposed project, undersea spills are no longer relevant, because a buried pipeline is not included. The Liberty FEIS presents information on the behavior of oil spilled to open water and broken ice.

New information on the behavior of stranded oil has been developed since the Liberty FEIS was produced. In particular, a recent study by Irvine, Mann, and Short (2006) indicated that stranded oil can persist within boulder-armored beach soils (i.e., beaches where finer sediment and gravel are covered by boulder-sized rocks) even when moderate- to high-energy wave action would be expected to quickly weather the oil. Researchers found that oil washed onto boulder-armored beaches in the Gulf of Alaska remained in a nearly unweathered state for well over a decade. The findings emphasize the importance of considering local geomorphic features during spill response planning or when modeling the persistence of spilled oil.

Spills to land are also possible, and small spills are usually contained (USDOI, MMS, 2002; TAPS Owners, 2001), but a large spill may impact tundra (NRC, 2003). An oil spill to snow-covered tundra is not expected to spread over a large area, and if the spill occurs during winter, is not expected to penetrate the frozen soil (LGL, 1998; NRC, 2003). A spill during the summer may penetrate the soil but is not likely to penetrate deep because tundra is water-logged or flooded during summer (LGL, 1998). Vegetation also acts as a natural boom and prevents oil from spreading. However, oil can still become widely dispersed to tundra or snow if a pressurized pipeline ruptures and sprays oil into the air (LGL, 1998; NRC, 2003).

3.4.3 Oil-Spill Scenario

An oil spill scenario analysis was completed using the “spray method” of the National Oceanic and Atmospheric Administration (NOAA) GNOME (General NOAA Operational Modeling Environment) model (it was necessary to use the spray method rather than the point source method to force the oil to move past the Endicott Causeway). The GNOME model was developed by the Emergency Response Division of NOAA’s Office of Response and Restoration (OR&R). It is the oil spill trajectory model used by OR&R Emergency Response Division responders during an oil spill.

The following specifications were entered into the GNOME model to create the trajectories:

- Model Start Date: August 1, 2006
- Start Time: 12:00
- **Duration:** 24 and 72 hours (each duration shown as a separate figure)
- Wind Type: Constant
- Wind Speed: 10 knots
- **Wind Direction:** East-northeast (predominant direction 47.4% of the time during summer)
- **Oil Released:** 1,000 bbl (during a 4-hour period)
- Spill Response: None

As discussed above and summarized in detail in Appendix A, 1,000-bbl was chosen for the amount of oil spilled for this analysis as a probable spill volume. This is a conservative figure for analysis purposes, and a spill from the Liberty (SDI) Project of this volume is unlikely.

Figure 3.4-2 shows the model output for a 24-hour duration, while Figure 3.4-3 presents the output for a 72-hour duration. It is expected that BPXA would have response activities under way prior to 72 hours and thus contain the spread of the oil. However, 24 and 72 hours were chosen to represent the spread of spilled oil over a reasonable time frame. As can be seen in the figures, the causeway influences the westward movement of oil from the SDI location. At the end of 24 hours, oil has beached on the causeway and in the Sagavanirktok River delta, while after 72 hours, oil has reached the western shore of Prudhoe Bay.

3.5 EFFECTS OF ALTERNATIVES

Effects conclusions are summarized for the proposed action and alternatives in Tables 3.5-1 through 3.5-9.

3.5.1 Physical

3.5.1.1 Air Quality

The ambient air quality impact differences between the proposed action and the original Liberty Island option are negligible because either option must demonstrate compliance with the applicable ambient air quality standards and Prevention of Significant Deterioration (PSD) increment levels before the required air permit would be issued by the Alaska Department of Environmental Conservation (ADEC). For the same reason, the ambient air quality impact differences between the proposed action and either the Point Brower Pad or Kadleroshilik Pad options are negligible.

Potential stationary source emissions from the Liberty Island option are higher than the proposed action because the Liberty Island emission unit inventory included emitting equipment needed to prepare sales-quality oil. The proposed action will generally use existing equipment at the Endicott MPI, resulting in a smaller increase in potential emissions.

3.5.1.2 Sediment Suspension and Transport

As discussed in Section 3.1.2, the proposed action will result in a temporary increase in TSS concentrations of up to 430 mg/l above ambient levels in the immediate vicinity of the project site during the winter gravel placement. A large portion of the suspended material is predicted to settle within or adjacent to the footprint of the SDI pad expansion, while the finer fractions are expected to migrate up to 6 km along the Endicott Causeway. The release of fine material from the pad following the initial open-water season is expected to be negligible (Section 3.3.2). Turbidity increases associated with marine operations are expected to be negligible due to the limited need for barge support.

The two onshore development alternatives, consisting of coastal pads at Pt. Brower and on the mainland coastline near the Kadleroshilik River, are expected to have no impacts on TSS concentrations in marine waters during construction. Similarly, appropriate pad-setback distances will prevent release of fine material to marine waters during operation. No marine operations are planned for these alternatives.

Suspended-sediment concentrations and turbidity-plume characteristics associated with construction and operation of the original Liberty Island alternative were estimated previously (Ban et al., 1999). During island construction, the TSS concentration at the project site was predicted increase up to 250 mg/l. While the majority of these particles were estimated to fall out of suspension within 1 km of the island, the finer fractions were expected to create a turbidity plume extending up to 17 km to the northwest. Reshaping of the pad sideslopes after breakup was anticipated to produce a temporary increase in turbidity. The release of fine material from the island following slope protection installation was expected to be negligible. Disturbance of native seafloor sediments during installation of the subsea pipeline was estimated to increase TSS concentrations by as much as 1,000 mg/l at the excavation site. The associated turbidity plume was predicted to extend up to 2 km from the excavation site. Increased turbidity from ocean disposal of accumulated seabed material was estimated to create a 4-km-long plume with TSS concentrations as high as 1,168 mg/l at the stockpile site. Barge activities conducted in support of operations, estimated at a maximum 150 trips per season, were expected to have a modest and temporary effect on turbidity.

3.5.1.3 Oceanography

As discussed in Sections 3.3.2 and 3.3.3, the proposed action is expected to cause only minimal localized effects on oceanography. Stress cracks in the sea-ice sheet propagating from the perimeter of the SDI pad expansion could provide strudel drainage pathways at the time of river overflood. Seasonal ice roads used to support construction or drilling operations may act as a partial barrier to river overflood and divert a portion of the flow. Waves and currents in the immediate vicinity of the pad expansion will be affected during open water, but the conditions are not expected to be substantially different from those at the existing SDI facility.

The two onshore development alternatives are expected to have no impact on regional or local oceanography.

The original Liberty Island alternative is not expected to have any impact on regional oceanography. Minimal localized impacts can be anticipated. Seasonal ice roads used to support drilling and production operations may act as a partial barrier to river overflood and divert a portion of the flow. Waves and currents in the immediate vicinity of the island will be altered during open water, but the impact is expected to be limited to a distance of 2 to 3 times the island diameter (BPXA, 1998).

3.5.1.4 Marine Water Quality

The proposed action will result in a temporary increase in TSS concentrations and the creation of a sediment plume during construction. Turbidity increases associated with operations and barge support are expected to be negligible. A potential for small equipment spills (oil, diesel fuel, and hydraulic fluid) exists during both construction and operations. Operational discharges will be permitted under existing or amended Endicott NPDES permit.

The two onshore development alternatives are expected to have no impact on marine water quality. Operational discharges would be permitted under existing or amended NPDES permits for Endicott or Badami, the host facility alternatives.

The Liberty Island alternative is expected to contribute to turbidity levels temporarily during construction of the island (up to 250 mg/l) and the subsea pipeline (up to 1,000 mg/l). A turbidity plume will be created by both island and pipeline construction. Increased TSS concentrations are expected to be minimal during production (including barge activities). Small equipment spills (oil, diesel fuel, and hydraulic fluid) could occur during both the construction and operations periods. Operational discharges would be permitted under project-specific NPDES permits.

Issues associated with a crude oil spill are discussed in Section 3.5.4.

3.5.2 Biological

3.5.2.1 Benthic and Boulder Patch Communities

The proposed Liberty (SDI) Project will have much less of an impact on the Boulder Patch community than the original Liberty Island alternative (Table 3.5-1). Although both alternatives would permanently cover approximately 20 acres of benthic habitat, the SDI site is entirely outside the Boulder Patch footprint. It was projected that pipeline trenching associated with the Liberty Island would permanently bury up to 14 acres of low-relief kelp and epilithic habitat (USDOI, MMS, 2002). Although this loss is estimated to represent only 0.1% of the Boulder Patch area, the SDI expansion alternative is expected to have no direct loss impact. The area of normal benthic habitat permanently covered by either alternatives constitutes a miniscule portion of available habitat, and neither alternative would have any measurable effect on invertebrate populations. Both the Kadleroshilik and Pt. Brower alternatives are land-based developments and would result in no direct loss of benthos or Boulder Patch.

3.5.2.2 Fish and Essential Fish Habitat

The major advantage that the proposed action has over both the Kadleroshilik and Pt. Brower drilling pad alternatives is that the SDI expansion requires no trans-tundra gravel roadway construction and no trans-tundra pipeline construction (Table 3.5-2). Disturbances to freshwater habitat and freshwater fish from both activities are not issues for the SDI alternative. The only pipeline construction associated with the SDI alternative will be confined to the existing causeway running from the SDI to MPI. The new pipelines will be located entirely on existing structure and will not physically affect fish habitat. There are no indications that deepwater fish overwintering habitat exists anywhere along the proposed route of the ice road that will run from the mine site to the SDI. The section of ice road that will run from the SDI to MPI in support of pipeline construction is in the vicinity of possible fish overwintering habitat, but disturbance can likely be avoided if the road is constructed over grounded ice and as close to the causeway gravel beach as possible.

Gravel roadway construction would require three river crossings for the Pt Brower alternative and two for the Kadleroshilik alternative. There are no specific design details for these crossings, but issues of potential disturbance to fish overwintering habitat and disruptions to fish migrations in summer would need to be addressed. The upgrade of the West Sagavanirktok River Bridge for the Liberty (SDI) alternative would occur in the vicinity of a known major fish overwintering area (see Section 3.2.3). The absence of any details concerning the potential construction project prevents any meaningful impact assessment at this time.

The SDI expansion will require 860,000 yd^3 of gravel, while the Pt. Brower alternative would require 1,600,000 yd^3 (725,000 yd^3 for the pad, 725,000 yd^3 for roadways), the Kadleroshilik alternative 2,260,000 yd^3 (540,000 yd^3 for the pad, 1,820,000 yd^3 for roadways), and Liberty Island 797,600 yd^3 (island only). While proper mine-site planning and reclamation could enhance freshwater fish habitat in all cases, the SDI alternative would potentially leave the smallest footprint.

The SDI and the original offshore Liberty Island alternatives would eliminate about the same area of coastal fish habitat. This area is miniscule compared to the amount of coastal habitat available to fish during the open-water season, and the loss would not have a measurable effect on fish populations.

The nearshore shallows in and around the proposed Liberty (SDI) Project area and Endicott Causeway can be considered important fish habitat for a number of anadromous and amphidromous species from both the Sagavanirktok and Colville rivers (see Section 3.3.6). Based on proximity, a large oil spill associated with the SDI and Pt. Brower alternatives, and to a lesser extent from the original offshore Liberty Island alternative, could dramatically impact shallow-water habitat of the delta.

3.5.2.3 Marine Mammals

Impacts to marine mammal species resulting from the SDI, Pt. Brower, and Kadleroshilik alternatives will be reduced compared to potential impacts of the offshore island alternative (Table 3.5-3). Potential impacts to marine mammals from noise and activity disturbances of the offshore island alternative could result during all phases of the development. Noise and activity disturbance could occur during ice-road construction and use, gravel hauling for island construction, installation of the subsea pipelines and island facilities, island drilling and production activities, and vessel-based and helicopter support during all phases of the development. Ringed, and possibly bearded, seals could be affected by disturbances from the offshore island development during all portions of the year.

In contrast to the offshore island alternative, most activities associated with the other three alternatives would be land-based and would have little effect on marine mammals.

3.5.2.4 Marine and Coastal Birds

The main project components that would have minor effects on marine and coastal birds for the various alternatives are the development pad or island, communication towers, access roads, pipeline routes, construction schedule, and gravel mine site size and location. A summary of these project components and their effects on marine and coastal birds is summarized in the Table 3.5-4. Processing facility locations for the various alternatives are Endicott MPI, Badami, and the originally proposed offshore Liberty Island. Processing facilities on the originally proposed offshore Liberty Island would expose more seabirds to collision mortality during spring and fall migrations than either of the existing processing facilities at Endicott MPI or at Badami. Large oil spills from any of the alternatives could potentially have major effects on marine and coastal birds and their habitats.

3.5.2.5 Terrestrial Mammals

The main project components that would have minor effects on terrestrial mammals under the various alternatives are the development pad or island, access roads, pipeline routes, construction schedule, and the gravel mine site size and location. A summary of these project components and their effects on caribou, muskoxen, grizzly bears, arctic foxes, and arctic ground squirrels is summarized in the Table 3.5-5. Processing facility locations for the various alternatives include Endicott MPI, Badami, and Liberty Island.

3.5.2.6 Wetland and Vegetation

The SDI expansion poses the smallest potential impact to wetlands and vegetation (Table 3.5-6). Onshore developments at Pt. Brower and the Kadleroshilik River would require the construction of the gravel pads and roads. This would require a much larger gravel mine than that proposed for the SDI expansion. The placement of gravel fill for the Pt. Brower and

Kadleroshilik River alternatives would cover approximately 100 and 150 acres of tundra, respectively. In addition, ice roads would be used to construct the necessary roads, pads, and pipelines to tie the Liberty development with the existing Prudhoe Bay infrastructure. Onshore developments would also greatly increase the potential impact to vegetation from oil spills.

The Liberty Island alternative is comparable to SDI expansion regarding the proposed and potential impacts to wetlands and vegetation. The primary difference between the alternatives is the proposed new pipeline construction. Liberty Island would involve 1.5 mi of new onshore pipeline. This would require additional ice road activity as well as increase the impact from potential spills. Using the existing Endicott Causeway for the new pipelines associated with SDI expansion eliminates the need for additional ice roads and greatly reduces the potential impact from spills.

3.5.2.7 Threatened and Endangered Species

Bowhead Whale

Potential impacts to bowhead whales would be greatest for the offshore island alternative compared to the SDI, Pt. Brower, and Kadleroshilik alternatives (Table 3.5-7). The SDI, Pt. Brower, and Kadleroshilik alternatives are primarily land-based options for Liberty development that would result in few potential impacts to bowhead whales. Any potential impacts to bowhead whales would be most likely to occur during the fall migration in August and September. The southern portion of the bowhead migration corridor is located approximately 15 km offshore, and the Liberty land-based alternatives would likely have little effect on bowhead whales. Marine vessel traffic during the sealift of the ***LoSal™*** EOR process plant would have the potential to temporarily displace bowheads along their migratory route. Industrial noise from the offshore island alternative during the fall bowhead migration would have the potential to cause a slight offshore displacement of the southern edge of the migration corridor (McDonald et al., 2006).

Polar Bear

Activities associated with ice-road construction and use for the Liberty (SDI) Project, Pt. Brower, and Kadleroshilik alternatives would have the potential to cause disturbances that may affect polar bears during the initial construction periods. However, annual construction of ice roads would not be planned, and potential impacts would result only during construction of these alternatives. Annual ice-road construction would be planned in support of the offshore island alternative, thus increasing the overall potential of disturbance to polar bears. Denning polar bears could be disturbed by various types of activities during winter or spring when they emerge from dens.

ESA-listed Birds

Potential impacts to spectacled and Steller's eiders would be reduced for the Liberty (SDI) Project alternative compared to the Pt. Brower and Kadleroshilik alternatives (Table 3.5-8). The construction of gravel roads and pad on tundra habitats would cover approximately 107 and 169 acres for the Pt. Brower and Kadleroshilik alternatives, respectively. This tundra would be lost as potential habitat for spectacled or Steller's eiders. The SDI option would not require construction of gravel roads or pads that cover tundra habitats, and the only tundra habitat that would be lost during construction would result from gravel mining. Gravel mining would also occur for the Pt. Brower and Kadleroshilik alternatives.

The potential for noise and activity disturbance to affect spectacled and Steller's eiders would also be reduced for the SDI alternative compared to the Pt. Brower and Kadleroshilik alternatives. Gravel roads would be constructed in areas which have previously been subjected to little disturbance and would cover approximately 7.3 and 15.2 mi for the Pt. Brower and Kadleroshilik alternatives respectively. In contrast, no new roads would be constructed for the SDI alternative. Increased traffic levels along the Endicott Road resulting from construction and operation of the SDI alternative could disturb eiders near the road, although many eiders and other waterfowl would likely be habituated to traffic.

The potential for noise and activity disturbance on pads to affect spectacled or Steller's eiders would be greater for the Pt. Brower and Kadleroshilik alternatives than for the SDI alternative. The Pt. Brower and Kadleroshilik pads would be surrounded by tundra that could be used by threatened eiders, possibly as nesting habitat. The expanded pad for the SDI alternative would be surrounded by marine waters that may be used by spectacled eiders for resting and feeding.

The potential for eider mortality due to collision with structures on pads would likely be greater for the SDI and offshore island alternatives than for the Pt. Brower and Kadleroshilik alternatives. Eider collisions would be most likely to occur during fall migration when flocks of birds are flying at low elevation. Divoky (1984) reported that the primary migration corridor during fall for king and common eiders in the Prudhoe Bay area was offshore between the barrier islands and the 20-m isobath. Day, Prichard, and Rose (2005) reported collisions of 36 eiders (all common or king eiders) with facilities at Northstar Island and the Endicott facilities between 2001 and 2004. Little information is available on fall migration corridors for spectacled eiders in the Prudhoe Bay area, but spectacled eiders migrating in offshore areas near the coast would have the potential to collide with structures on the SDI and offshore island pads. Migrating eiders would be most susceptible to collision during periods of poor visibility such as fog or at night. However, due to the low density of spectacled and Steller's eiders in the project area, collisions of threatened eiders with structures would be unlikely for any other alternatives.

3.5.3 Socioeconomics and Related Impacts

There are no material differences in the economic, subsistence, sociocultural, and environmental justice impacts associated with the variants among the new alternatives being considered. Effects of all these alternatives are discussed in Sections 3.1.12 (effects associated with the SDI expansion), 3.2.9 (effects associated with onshore construction), and 3.3.12 (effects associated with drilling and oil production).

3.5.4 Oil Spills

The risk of a spill and potential effects of oil spills from the offshore island and other likely alternatives are detailed in the Liberty FEIS (USDOI, MMS, 2002), which concluded:

> We do not expect significant impacts to result from any of the planned activities such as discharges and disturbances associated with Alternative I (Liberty Development and Production Plan) or any of the other alternatives. Some significant impacts—adverse effects to spectacled eiders, king and common eiders, long-tailed ducks, polar bears, subsistence-harvest patterns, sociocultural systems, and local water quality—could occur in the unlikely event of a large oil spill. However, the very low chance of such an event occurring…combined with the seasonal nature of the resources inhabiting the

area (for example, eiders are present in the Liberty area 1-4 months of the year), makes it highly unlikely that an oil spill would occur and contact the resources. A resource may be present in the area but may not be contacted by oil…None of the component or combination alternatives evaluated [in this] EIS are expected to generate significant impacts from planned activities. If an unlikely oil spill occurred, similar significant effects could occur to spectacled eiders, king and common eiders, long-tailed ducks, polar bears, subsistence harvests, sociocultural systems, and local water quality for all alternatives.

The onshore Liberty alternatives at Pt. Brower and Kadleroshilik are expected to have the same or lesser impacts, because they are onshore.

It is clear that a large oil spill from any of the developments might result in major adverse impacts on various species and, therefore, on the availability of subsistence resources with attendant sociocultural and environmental justice impacts.

Oil production with any of the Liberty alternatives also might result in crude oil or product spills. Small operational spills of crude oil or product will occur and, as discussed in Section 3.4, large crude spills, although unlikely, also might occur. Depending on the location, timing, and behavior of a large spill, major adverse effects on certain species, subsistence-harvest patterns, and sociocultural systems would result. Section 3.3 provides more detail on the impacts of oil spills to environmental resources and sociocultural systems.

For any alternative, BPXA would implement mitigation measures (through the ODPCP) to minimize the possibility and potential for a large oil spill.

3.6 CUMULATIVE EFFECTS

3.6.1 Introduction

Climate change is a factor of the existing and future environment. It is a natural process (as, for example, is predation) and is not an "action" for cumulative analysis.

As defined by the National Environmental Policy Act [40 CFR 1508.7 and 1508.25 (a) (2)]:

> Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.
>
> Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.
>
> To determine the scope of environmental impact statements, agencies shall consider…. Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

Cumulative impacts were addressed at length in Liberty FEIS (USDOI, MMS, 2002), which is incorporated by reference. The general conclusions reached in this document were:

> Potential cumulative effects on the bowhead whale, subsistence, sociocultural systems, spectacled eider, Boulder Patch, polar bear, and caribou are of primary concern and warrant continued close attention and effective mitigation practices.
>
> The incremental contribution of the Liberty Project to cumulative effects is likely to be quite small. Construction and operations related to the Liberty Project would be confined to a relatively small geographic area, and oil output

> would be a small percentage (approximately 1%) of the total estimated North Slope/Beaufort Sea production.
>
> The Liberty Project would contribute a small percentage of spills…to resources in State and Federal waters in the Beaufort Sea from potential offshore oil spills. Any subsequent spills are not expected to contact the same resources or to occur before those resources recover from the first spill.
>
> Potential Environmental Justice effects would focus on the Iñupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. If the one large spill assumed in the cumulative case (although not from the Liberty Project) occurred and contaminated essential whaling areas, major effects could occur when impacts from contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together. Such impacts would be considered disproportionately high adverse effects on Alaskan Natives.

The proposed action differs from those addressed in the FEIS. The current project eliminates the offshore impacts of island and pipeline construction and dramatically mitigates the potential offshore impacts related to the Boulder Patch, marine mammals, and concerns of the North Slope Iñupiat communities related to the bowhead whale and subsistence whaling and made issues related to offshore pipeline design moot. The decision to use the existing infrastructure at Endicott further mitigates impacts by avoiding construction of a pad on the shoreline of Foggy Island Bay and an access road and pipelines crossing the Sagavanirktok River delta.

The Liberty FEIS also offered several comments designed to place possible impacts in perspective. These are shown in Table 3.6-1, which also incorporates the above comment on the revised system design.

The Liberty FEIS focused on oil and gas developments, as these are the main agents of industrial-related change on the North Slope. In particular, the FEIS considered continued operation of the Trans Alaska Pipeline System (and associated marine transportation link) and past, present, and reasonably foreseeable future development/production (within the next 15 to 20 years). The FEIS noted the possibility that if oil prices were to rise substantially, it might be commercially feasible to develop presently stranded gas resources. The FEIS acknowledged this possibility but given the uncertainty associated with construction of a gas transportation system in the foreseeable future, did not include this project in the analysis of possible cumulative effects. In the intervening years, there has been continued interest in such a development, but it is unclear whether or not this project will go forward and what form it might take. Therefore, it is not included in this update.

The Liberty FEIS reached the following conclusion regarding cumulative effects:

> The MMS does not expect any significant cumulative impacts to result from any of the planned activities associated with the exploration and development of North Slope and Beaufort Sea oil and gas fields…. In the event of a large offshore oil spill, some significant adverse impacts could occur to spectacled eiders, long-tailed ducks, common eiders, subsistence resources, sociocultural systems, and local water quality. However, the probability of such an event combined with the seasonal nature of the resources inhabiting the area makes it highly unlikely that an oil spill would occur and contact these resources….

3.6.2 Cumulative Effects Analyses in Recent NEPA Documents

Since publication of the Liberty FEIS, several additional reports have been published, including EIS's for the TAPS Right-of-Way Renewal (USDOI, BLM, 2002); Beaufort Multiple Sale (USDOI, MMS, 2003); Alpine Satellite Development Plan (USDOI, BLM, 2004a); Northwest National Petroleum Reserve-Alaska Final Integrated Activity Plan (USDOI, BLM and MMS, 2004b); EA for Lease Sale 195 in the Beaufort Sea Planning Area (USDOI, MMS, 2004); the Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan (USDOI, BLM, 2005); the EA for Lease Sale 202 in the Beaufort Sea Planning Area (USDOI, MMS, 2006b); and the EIS for Lease Sale 193 in the Chukchi Sea Planning Area (USDOI, MMS, 2007b). Additionally, the Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope of the National Research Council completed a comprehensive study of cumulative environmental effects of oil and gas activities on Alaska's North Slope in 2003 (NRC, 2003). A useful report also has been published on Arctic Climate Impact Assessment (ACIA, 2005) that provides pertinent data and information. These are incorporated by reference.

Results of these newer analyses are broadly consistent with the conclusions of the Liberty FEIS regarding possible cumulative effects. If anything, these newer documents suggest that cumulative effects for all past, present, and reasonably foreseeable future projects might be somewhat greater than originally projected in the Liberty FEIS. For example, the NRC offered the following observation on socioeconomic changes on the North Slope:

> Modern western culture, including oil development and the revenue stream it created, has resulted in major, important, and probably irreversible changes to the way of life in North Slope communities. The changes include improvements in schools, health care, housing, and other community services as well as increased rates of alcoholism, diabetes, and circulatory disease. There have been large changes in culture, diet, and the economic system. Many North Slope residents view many of these changes as positive. However, social and cultural shifts of this magnitude inevitably bear costs in social and individual pathology. These effects accumulate because they arise from several sources, and they interact.

According to the *Petroleum News*, Vol. II, No. 43 published October 22, 2006, Savant Alaska tracts are east of Prudhoe Bay, adjacent to Liberty, and extend east towards BP's offshore/onshore Badami oil field along the Mikkelsen Bay fault zone. The proposed Kupcake No. 1 drilling prospect is "a conventional exploration well targeting several hundred feet of Beaufortian-age sediments located at a depth of approximately -10,600 feet." The proposed exploration site is approximately 8,000 feet west of the Liberty No. 1 discovery well. Also, some new impacts (e.g., those from climate change) have assumed increased importance.

The projected production from Liberty is now estimated to be 105 MMbbl—12.5% smaller than the 120 MMbbl estimated in the Liberty FEIS. Oil prices are volatile and notoriously difficult to forecast; the FEIS used an Alaska Department of Revenue forecast of $16.30/bbl. As this is written, crude oil prices exceed $70/bbl. The *Fall 2006 Revenue Sources Book* (ADOR, 2006) projects lower crude-oil prices in the future than those at present: $41.50 per bbl post-FY 2014.[14] Even so, this revised price estimate is much higher than that assumed in the FEIS. Thus,

[14] The forecasting assumptions used by the State of Alaska Department of Revenue are deliberately (and appropriately) conservative. The Energy Information Administration base level crude oil price forecast for 2014 ranges from $44 to $50 per bbl (see http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html). In recent years, official government forecasts have typically underestimated the price of crude oil.

although the revised total production estimate from Liberty is smaller than originally assumed, the oil revenues from Liberty are likely to be substantially greater than originally estimated.

Because future oil prices are likely to be substantially greater than assumed in the Liberty FEIS by a factor of approximately 2.5 based on the above priced forecasts, the positive economic impacts from both Liberty and other oil and gas developments included in the FEIS are likely to be substantially greater than estimated originally.

Regarding production, total Liberty output can be placed in context by comparing it to estimated cumulative production from ANS fields through 2011; Liberty accounts for 1/155 of the total cumulative production, which is smaller than projected in the Liberty FEIS. Also, Liberty's output would account for only a relatively small proportion of production post-2011. Because the expected number of oil spills is believed to be proportional to total output, the likelihood of a spill from Liberty operations is substantially smaller than for all fields as a group.

Therefore, Liberty's output is expected to account for a very small percentage of total ANS output (and smaller than originally estimated), but the revenues from Liberty are likely to be substantially larger than originally estimated. Because of changes to the proposed Liberty design, the probable environmental impacts of Liberty are likely to be more modest than originally estimated. Finally, possible cumulative impacts from all past, present, and reasonably foreseeable developments might be the same or slightly larger than originally estimated. Thus, Liberty offers greater economic benefits than originally estimated and lower impacts in both proportional and absolute terms. More detailed comments are offered below.

3.6.3 Resource-Specific Cumulative Effects

The Beaufort Sea Multiple Sale EIS (USDOI, MMS 2003) included a comprehensive cumulative analysis of past, present, and reasonably foreseeable actions in the Beaufort Sea area, including the area of the current proposed action. The multiple-sale EIS cumulative analysis was updated with available new information in the Sale 195 EA (USDOI, MMS 2003), and again in the Sale 202 EA (USDOI, MMS 2006). The cumulative information and analysis in these documents, as well as in the Liberty FEIS are referenced and summarized below. These documents are incorporated by reference.

3.6.3.1 Air and Water Quality, Benthos, and Boulder Patch

The MMS cumulative analysis contained in the multiple-sale EIS (USDOI, MMS, 2003) concluded:

> A spill could affect water quality for 10 or more days in a local area. The effects of discharges and offshore construction activities are expected to be short term, lasting as long as the individual activity and to have the greatest impact in the immediate vicinity of the activity.

This conclusion was supported in the recent analysis (USDOI, MMS, 2006a).

Regarding air quality, the Liberty FEIS concluded that the cumulative effects of all projects affecting the North Slope in the past and occurring now have caused generally little deterioration in air quality, which remains better than required by national standards. Moreover, the Liberty FEIS concluded that reasonably foreseeable future developments would not change this situation.

Based on the information contained in this EA, the current Liberty (SDI) Project is not expected to contribute substantially to overall cumulative impacts to water quality, benthos, and the boulder patch.

3.6.3.2 Fishes and Essential Fish Habitat

Cumulative effects of Alaska North Slope oil and gas activities include those related to possible oil spills and climate changes. Recent analyses (see e.g., USDOI, MMS, 2006a) of climate change effects conclude:

> The climate of the Arctic is changing and affecting fish distributions. Evidence of such change is discussed in the Arctic Climate Impact Assessment report (ACIA, 2005) (the chapter on fish can be found at: http://www.acia.uaf.edu/PDFs/ACIA_Science_Chapters_Final/ACIA_Ch13_Final.pdf). Trends in instrumental records over the past 50 years indicate a reasonably coherent picture of recent environmental change in northern high latitude (ACIA, 2005). It is probable that the past decade was warmer than any other in the period of the instrumental record…. Climate change can affect fish production (e.g., individuals and/or populations) through a variety of means…. Direct effects of temperature on the metabolism, growth, and distribution of fishes occur. Food-web effects also occur through changes in lower trophic-level production or in the abundance of predators, but such effects are difficult to predict. Fish-recruitment patterns are strongly influenced by oceanographic processes such as local wind patterns and mixing and by prey availability during early lifestages. Recruitment success sometimes is affected by changes in the time of spawning, fecundity rates, survival rate of larvae, and food availability.

Regarding possible impacts from oil spills, the Liberty FEIS (USDOI, MMS, 2002) noted:

> While small numbers of fish in the immediate area of an offshore or onshore oil spill may be killed or harmed, an oil spill assumed for this analysis is not expected to have a measurable effect on fish populations. Subsistence and commercial fishing are likely to have a measurable cumulative effect on freshwater and migratory fish populations. However, due to a lack of survey information, the cumulative effect of these activities, and the amount of time required for each population to recover, is unknown.

This conclusion has not changed.

3.6.3.3 Marine Mammals

Recent analyses (USDOI, MMS, 2006b) of possible cumulative effects on other marine mammals conclude:

> Due to the ongoing effects of climate change in the Arctic, continued close attention and effective mitigation practices with respect to nonendangered marine mammal populations and distributions are warranted, particularly with respect to ringed seals, which likely would be among the first marine mammals to show the negative effects of climatic warming.

3.6.3.4 Marine and Coastal Birds

Possible cumulative impacts on marine and coastal birds have been reviewed in the EIS's/EAs incorporated by reference.

Specific potential effects of cumulative factors may include the loss of small numbers of spectacled eiders and other waterbirds as projects are developed. Minor declines in fitness, survival, or production of young resulting from exposure of these bird populations to disturbances, habitat loss, mortality from increased predator populations or collision with structures, warrant continued close attention and implementation of effective mitigation practices for every project on the Arctic Coastal Plain. There are no indications that these forms of disturbance or collision mortality have resulted in major impacts to marine or coastal birds, including ESA-listed species. Direct mortality can quickly lead to population-level effects. Incremental increases in collision risk (considering the Liberty and other anticipated projects) are not expected to result in major impacts. Required Section 7 consultation under the Endangered Species Act serves to ensure that listed bird populations are not jeopardized and that any incidental take is minimized to the maximum extent practicable (Refer to Appendix C of this EA). Required data collection will improve the body of knowledge regarding the effectiveness of these measures.

As the potential for oil/gas exploration moves further from the Prudhoe Bay area, habitat losses and disturbance effects increase. At the present time, scientific evidence does not suggest that bird populations are limited by nesting habitat, they but could be affected when using sensitive habitats in nearshore coastal areas. Current developments have avoided sensitive areas, and evidence suggests that major impacts to bird populations have not occurred. The minor incremental increases in disturbances or habitat loss from the Liberty (SDI) Project would not appreciably increase negative effects to marine and coastal birds, and major impacts are not anticipated.

Mortality from a large oil spill, typically an unlikely event on a case-by-case basis, becomes more likely in the region as more projects are developed, as infrastructure ages, and as more technically-demanding areas are pioneered. One large spill could represent a major effect for any of several marine or coastal bird species; recovery of these species from such mortality would not be expected to occur if their populations are exhibiting a declining trend, as several species/species groups are. This has not occurred, and the incremental increases from the Liberty (SDI) Project, in maximizing use of existing infrastructure, does not appear to substantially increase this risk. In most situations, current response strategies and practices appear capable of meeting spill risk, but spill response could become more challenging as coastal conditions change.

Continued effects from climate change could benefit some of these species but likely would harm others. It is simply too soon to accurately predict what these effects will be.

The proposed Liberty (SDI) Project avoids or minimizes contributing to the combined impact of past projects where possible. Some potential impacts cannot be avoided, but some conservation measures could help avoid impacts from future projects. As a consequence, we conclude that the combined net effects would not constitute a major impact.

3.6.3.5 Terrestrial Mammals

The Liberty FEIS (USDOI, MMS, 2002) considered possible cumulative impacts on terrestrial mammals including caribou, muskoxen, grizzly bears, and arctic foxes. Impacts could result from encroaching oil development, activities such as gravel mining, the construction of roads and gravel pads, and possible oil spills. Although the FEIS illustrated various possible effects, the overall FEIS conclusion was that these effects would not be significant.

3.6.3.6 Threatened and Endangered Species

Bowhead Whales

Bowhead whales are a key subsistence resource and important to the sociocultural identity of several ANS communities (see Section 2.15). For this reason, Alaskan Natives have continued to express concerns regarding the possibility of any adverse effects on this key resource. And for this reason, EIS's (particularly those dealing with offshore developments) have devoted considerable attention to possible impacts on this resource. Key potential impacts of oil and gas activities in the cumulative case could include those resulting from noise (avoidance) and oil spills (temporary nonlethal effects).

The Liberty FEIS (USDOI, MMS, 2002) concluded that potential cumulative effects would be important, but were unlikely. Because of the changes to the recommended alternative, adverse impacts are even less likely with the new project design. The recent MMS analysis of cumulative effects (USDOI, MMS, 2006a) notes:

> Overall, we conclude…that the cumulative effects on bowhead whales would not be significant. However, we also conclude, as we did in the multiple-sale EIS (USDOI, MMS, 2003), that cumulative effects on bowhead whales are of primary concern and, thus, warrant continued close attention and effective mitigation practices.

Per the informal consultation dated October 19, 2007 (refer to Appendix D of this EA), NMFS stated "…while the Liberty project may affect these whales, our assessment…finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur)."

Polar Bears

Recent analysis (USDOI, MMS, 2006a) of possible cumulative impacts of oil and gas activities on polar bears stated: "the main effects of concern to polar bears are climate change, overharvest, and oil and fuel spills."

Per the FWS *Federal Register* notice dated January 9, 2007, entitled *Endangered and Threatened Wildlife..Proposed Rule To List the Polar Bear (Ursus maritimus) as Threatened Throughout Its Range ...*, the following statement regarding oil and gas activities is quoted:

> Historically, oil and gas activities have resulted in little direct mortality to polar bears, and that mortality which has occurred, has been associated with human bear interactions as opposed to a spill event. However, oil and gas activities are increasing as development continues to expand throughout the United States Arctic and internationally, including in polar bear terrestrial and marine habitats. The greatest concern for future oil and gas development is the effect of an oil spill or discharges in the marine environment impacting polar bears or their habitat.

ESA-listed Birds

The proposed action would not contribute a major amount to cumulative impacts on ESA-listed birds.

3.6.3.7 Cultural Resources

The Liberty FEIS (USDOI, MMS, 2002) concluded that the cumulative effects of proposed projects would likely disturb the seafloor more often, but remote-sensing surveys made before approval of any Federal or State lease actions should keep these effects low. Federal laws would preclude effects to most archeological resources from these planned activities. The Chukchi Sea Sale 193 FEIS (USDOI, MMS, 2007b) restates this conclusion.

3.6.3.8 Socioeconomics and Related Impacts

Economy

Cumulative effects on the economy could come from changes in regional project development and consequent changes in the local and State revenue stream, as well as changes in employment. These effects are noted in the Beaufort Sea Multiple-Sale EIS (USDOI, MMS, 2003), which noted:

> ...The oil and gas industry with interests in and near Prudhoe Bay and the Trans-Alaska Pipeline System have a strong interest in using the pipeline system many years into the future. The pipeline system represents a tremendous capital investment. Extending the useful life of the pipeline allows society to receive returns from its investment further into the future than would be the case if oil development on the North Slope ceased. In November 2002 an EIS was written and the TAPS Right-of-Way was renewed for another 20 years by both State and Federal agencies.
>
> The oil and gas industry has reduced the costs of drilling wells and bringing new fields into production. This has made it more economic to develop fields that require more pipeline, both onshore and offshore, to connect to the existing pipeline system. Examples of this are the onshore pipelines that in recent years extended eastward and westward from Prudhoe Bay to the Badami and Alpine prospects, respectively. These onshore pipelines, and other possible future extensions proximate to the Beaufort Sea coast, make it more economic to develop offshore prospects. This can be done by extending pipelines northward to the offshore, including the OCS. The North Star development is an example of an extension of pipeline northward from previously existing pipeline infrastructure to the offshore....
>
> The cumulative gains in direct employment would include additive jobs in petroleum exploration, development, and production, plus oil spill cleanup. The direct employment would generate indirect and induced employment and associated personal income for all the workers.

Sociocultural Systems

Cumulative effects on sociocultural systems could come from changes to subsistence-harvest patterns, social organization and values, and other issues, such as stress on social systems. These effects are noted in the Beaufort Sea Multiple-Sale EIS (USDOI, MMS, 2003) and other more-recent Chukchi Sea Sale 193 analysis (USDOI, MMS, 2007b), which noted:

> We conclude that potential overall cumulative impacts on subsistence and sociocultural systems from noise, disturbance, large oil spills, and global climate

> change would be significant, warrant continued close attention, and the development, monitoring, and enforcement of effective mitigation practices. Additionally, the potential effects of the lease sale are assessed within the context of climate change. If any new major effect due to climate changes were to occur, MMS would require changes to exploration or development/production designs and activities.

The Liberty FEIS (USDOI, MMS, 2002) traced other effects, including increases in population growth and employment that might cause long-term disruptions, to (1) the kinship networks that organize the Iñupiat communities' subsistence production and consumption, (2) extended families, and (3) informally derived systems of respect and authority (mainly respect of elders and other leaders in the community). Cumulative effects on social organization could include decreasing importance of the family, cooperation, sharing, and subsistence as a livelihood, and increasing individualism, wage labor, and entrepreneurship. Chronic disruption could affect subsistence-task groups and displace sharing networks, but it would not displace subsistence as a cultural value. Impacts to sociocultural systems have occurred, but there are many contributing factors (e.g., greater social mobility, access to media, particularly television and the media), and the relative importance of oil and gas activities is unclear.

In assessing changes to sociocultural systems, it is important also to consider the possible impacts associated with decreasing throughput and revenues, which will occur in any event, but would have greater impact if development of new fields does not occur. As noted in the Northeast NPR-A Final Amended IAP/EIS:

> Because of impacts from climate change on long-standing traditional hunting and gathering practices that promote health and cultural identify, and, considering the limited capacities and choices for adaptation and the ongoing cultural challenges of globalization to indigenous communities, North Slope peoples would experience cultural stresses, as well as impacts to population, employment, and local infrastructure. The termination of oil activity could result in the outmigration of non-Iñupiat people from the North Slope, along with some Iñupiat who may depend on higher levels of medical support or other infrastructure and services that may [not] be available in a fiscally constrained, post-oil production circumstance.

Because of its possible impacts on subsistence, climate change also could have major sociocultural consequences. This point is made in the proposed OCS Lease Sale 202 EA (USDOI, MMS, 2006b) as follows:

> Because of rapid and long-term impacts from climate change on long-standing traditional hunting and gathering practices that promote health and cultural identity, and considering the limited capacities and choices for adaptation and the ongoing cultural challenges of globalization to indigenous communities, we conclude that communities in the Arctic would experience significant cultural stresses, as well as major impacts on population, employment, and local infrastructure. If subsistence livelihoods are disrupted, communities in the Arctic could face increased poverty, drug and alcohol abuse, and other social problems.

It should be noted, however, that decisions on Liberty and other ANS projects are unlikely to affect climate change in any material way, although all ANS exploration, development, and production projects would contribute to the net effect of overall cumulative impacts in the region.

Subsistence and Area Use Patterns

Some of the key conclusions of the Beaufort Sea Multiple-Sale EIS (USDOI, MMS, 2003) relative to subsistence-harvest patterns included (for references see original):

> …past, present, and reasonably foreseeable projects on the North Slope [might result in] one or more important subsistence resources becoming unavailable or undesirable for use for 1-2 years, a significant adverse effect. Sources that could affect subsistence resources include potential oil spills, noise and traffic disturbance, and disturbance from construction activities associated with ice roads, production facilities, pipelines, gravel mining, and supply efforts. The communities of Barrow, Nuiqsut, and Kaktovik would potentially be most affected, with Nuiqsut potentially being the most affected community because it is within an expanding area of oil exploration and development both onshore (Alpine, Alpine Satellite, and Northeast and Northwest National Petroleum Reserve-Alaska) and offshore (Northstar and Liberty15).

Generally, similar conclusions were reached in more-recent EIS's, as summarized by MMS (USDOI, MMS 2006a). For example, the Alpine Satellite Development Plan FEIS (USDOI, BLM, 2004a) [see original for contained references] noted that:

> Development has already caused increased regulation of subsistence hunting, reduced access to hunting and fishing areas, altered habitat, and intensified competition from non-subsistence hunters for fish and wildlife. Additive impacts that could affect subsistence resources include potential oil spills, seismic noise, road and air traffic disturbance, and disturbance from construction activities associated with ice roads, production facilities, pipelines, gravel mining, and supply efforts. Based on potential cumulative, long-term displacement and/or functional loss, habitat available for caribou may be reduced or unavailable for use. Changes in population distribution due to the presence of oilfield facilities or activities may affect [the] availability for subsistence harvest[s] in traditional subsistence use areas…. Overall, impacts to subsistence harvest[s] and use[s] may have synergistic impacts with community health, welfare, and social structure. To the extent that subsistence hunting success is reduced in traditional use areas near Nuiqsut because of the presence of oilfield facilities and activities, subsistence hunters will need to travel to more distant areas to harvest sufficient resources in order to meet community needs. Greater reliance on more distant subsistence use areas will result in greater time spent away from the community for some household members and competition for resources with members of other communities. These changes in subsistence patterns may result in stress within households, family groups, and the community.

The Northeast NPR-A Final Amended IAP/EIS (USDOI, BLM, 2005) reached the following conclusions regarding cumulative effects on subsistence:

> Exploration and development activities on the North Slope have greatly impacted subsistence activities, as noted during public scoping testimony. In the Planning Area, exploration and development could originate from Inigok, Point Lonely, and Umiat vicinity, and could encompass important subsistence harvest

[15] When this was written, Liberty was believed to be an offshore development. The proposed action for Liberty is now expansion of an existing pad.

> areas for moose, fish, caribou, and furbearers, affecting subsistence users in Nuiqsut, Atqasuk, Barrow, and Anaktuvuk Pass. Subsistence hunters traveling in nearly every direction from Nuiqsut would have to pass through some kind of development en route to subsistence harvest areas. Iñupiat hunters are reluctant to use firearms near oil production facilities and pipelines, so subsistence users would be unlikely to harvest subsistence resources in these areas. Aircraft have interfered with hunts by scaring game away from hunters and the increase in air traffic by fixed-wing aircraft and helicopters would make this worse and over a much greater area if development goes forward. This issue has been raised several times by residents of Nuiqsut, who have also noted that oil and gas development is impacting traditional use areas and their ability to pass on knowledge of subsistence resources in these areas, and use of these resources, to their children.

This same EIS also addressed the impacts of climate change on subsistence resources:

> Climate change and the associated effects of anticipated warming of the climate change regime in the Arctic could significantly affect subsistence harvests and uses if warming trends continue…. Every community in the Arctic is potentially affected by the anticipated climactic shift and there is no plan in place for communities to adapt to or mitigate these potential effects. The reduction, regulation, and/or loss of subsistence resources would have severe effects on the subsistence way of life for residents of Nuiqsut, Atqasuk, Barrow, and Anaktuvuk Pass. If the loss of permafrost, and conditions beneficial to the maintenance of permafrost, arise as predicted, there could be synergistic cumulative effects on infrastructure, travel, landforms, sea ice, river navigability, habitat, availability of fresh water, and availability of terrestrial mammals, marine mammals, waterfowl and fish, all of which could necessitate relocating communities or their populations[s], shifting the population[s] to places with better subsistence hunting and causing a loss of dispersal of community.

Similar conclusions were reached in the EA for Lease Sale 202 in the Beaufort Sea Planning Area (USDOI, MMS, 2006b). It is appropriate to note, however, that the proportional contribution of the Liberty Project to these effects is small. The likelihood of a large oil spill is relatively small, certainly in comparison to the possible contribution of other fields, and the project has been engineered to minimize the additional footprint of facilities.

It is also appropriate to address the possible impact of climate change on the cumulative effects on subsistence in this section. The proposed OCS Lease Sale 202 (USDOI, MMS, 2006b) offered the following summary statement on the possible effects of climate change on subsistence-harvest patterns:

> Because polar marine and terrestrial animal populations would be particularly vulnerable to changes in sea ice, snow cover, and alternations in habitat and food sources brought on by climate change, rapid and long-term impacts on subsistence resources (availability), subsistence-harvest practices (travel modes and conditions, traditional access routes, traditional seasons and harvest locations), and the traditional diet could be expected over the lifetime of Sale 202 development.

Environmental Justice

As noted in other sections of this document that address environmental justice, Alaskan Iñupiat Natives, a recognized minority, are the predominant residents of the North Slope Borough, the area potentially most affected by cumulative oil and gas developments. Effects on Iñupiat Natives could occur because of their reliance on subsistence foods, and cumulative effects might affect subsistence resources and harvest practices. Potential effects from noise, disturbance, and oil spills on subsistence resources and practices and sociocultural patterns could affect many NSB communities. The Liberty FEIS (USDOI, MMS, 2002) concluded:

> Potential effects would focus on the Iñupiat community of Nuiqsut, and possibly Kaktovik, within the North Slope Borough. However, effects are not expected from routine activities and operations. If the one large spill assumed in the cumulative case (although not from the Liberty Project) occurred and contaminated essential whaling areas, major effects could occur when impacts from contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together. Such impacts would be considered disproportionately high adverse effects on Alaskan Natives. Oil-spill contamination of subsistence foods is the main concern regarding potential effects on Native health. The MMS believes that serious mitigation for such impacts begins with a commitment to preventing them by employing the highest standards of pipeline technology that include extra-thick-walled pipelines, pipeline burial depths more than twice the maximum 100-year ice gouging event, and advanced leak detection systems.

The current Liberty Project eliminates the potential for impacts from offshore pipelines. More recent reports (see e.g., USDOI, MMS, 2006a) also conclude that oil and gas developments have the potential to cause disproportionate impacts on Alaska Natives. Here is an illustrative summary statement from the Sale 202 EA (USDOI, MMS, 2006b):

> Potential significant impacts to subsistence resources and harvests and consequent significant impacts to sociocultural systems would indicate significant cumulative environmental justice impacts—disproportionate, high adverse environmental and health effects on low-income, minority populations in the region. We still conclude that potential environmental justice effects would focus on the Iñupiat communities of Barrow, Atqasuk, Nuiqsut, and Kaktovik within the NSB; such cumulative effects would be considered disproportionately high adverse effects on Alaska Natives. Any potential effects are expected to be mitigated substantially, although not eliminated.

As noted above, climate change could have cumulative impacts on subsistence resources, subsistence-harvest patterns, and (in consequence) sociocultural impacts. This would have implications for environmental justice. The EA for Proposed OCS Lease Sale 202 (USDOI, MMS, 2006b) offered the following summary:

> Potential impacts on human health from contaminants in subsistence foods and long-term climate change impacts on marine and terrestrial ecosystems in the Arctic—affecting subsistence resources, traditional culture, and community infrastructure of subsistence-based indigenous communities on the North Slope—would be an expected and additive contribution to cumulative environmental justice impacts.

Climate changes are not materially dependent on decisions regarding Liberty or other ANS development options.

Section 4

Mitigation Measures

4. MITIGATION MEASURES

This section describes the mitigation measures considered in the design of the proposed Liberty (SDI) Project. Tables 4-1 and 4-2 summarize mitigation actions and expected benefits at the design, construction, and operation phases.

In 2005, BPXA proposed to develop the Liberty Project using uERD from a newly constructed pad on the shore of Foggy Island Bay. This reduced the potential environmental impacts to the Boulder Patch, marine mammals, and addressed concerns of Inupiat residents of the North Slope related to bowhead whale and subsistence whaling.

In August 2006, BPXA proposed to develop the project at the Endicott Satellite Drilling Island (SDI). This decision further mitigated potential impacts by taking advantage of existing infrastructure at the SDI and on the Endicott Main Production Island (MPI). Because this option eliminates the need for construction of a new pad on the shore of Foggy Island Bay and associated roads and pipelines through undeveloped lands, anticipated impacts to wetlands were reduced.

4.1 MITIGATION OF IMPACTS COMMON TO THE CONSTRUCTION AND OPERATIONS PHASES

Mitigation common to both the construction and operation phases are:

- Oil spills
- Personnel training
- Compliance with Lease Sales 124 and 144 stipulations
- Preventing wildlife access to human food and garbage

4.1.1 Oil Spills

The proposed action will mitigate the effects of oil spills during the operation of the Liberty (SDI) Project, compared to the project originally analyzed in the 2003 Liberty FEIS (USDOI, MMS, 2003). For example, the offshore pipeline has been eliminated and use of the present infrastructure is maximized.

No new oil or three-phase flow pipelines are required for the Liberty (SDI) Project. Two new pipelines will be constructed to support the Liberty (SDI) Project: a 10-in diameter ***LoSal™*** water injection pipeline and 6-inch gas pipeline routed along the inter-island causeway from the MPI to the SDI. These pipelines will be on new vertical support members on the lagoon side of the causeway. Production from the Liberty (SDI) Project wells will be transported form the SDI to the MPI for processing via the existing 28-inch flowline which is constructed of corrosion resistant alloy (CRA). The existing 16-in-diameter Endicott sales oil line will be used to export Liberty oil to Pump Station 1 of TAPS. This line has isolation valves installed at both sides of the causeway bridges. The pipeline is monitored for leaks using the industry-standard mass-balance line-pack compensation system and is pigged according to DOT requirements.

The proposed Liberty (SDI) Project will incorporate other design measures to assure that the potential for spills and leaks has been minimized to the extent practicable. These features include lined, bermed areas for storage tanks, discharge detection technology, tank overfill-protection technology, well control design, and pad design and grading. Major quantities of diesel fuel are not anticipated to be stored on the SDI because the drilling rig will be fueled by natural gas.

Liberty (SDI) Project planning includes oil spill prevention measures, as well as spill response preparedness. BPXA will submit an application to the Alaska Department of Environmental Conservation to amend the E*ndicott and Badami Oil Discharge Prevention and Contingency Plan* to cover the operations of the Liberty (SDI) Project at the Endicott facility, as allowed by 30 CFR 254.3. The facilities are in close proximity and share similar trajectory, sensitive resource, and response logistic elements. Following State approval, the amended plan will be submitted to MMS for its approval. MMS spill response planning regulations (30 CFR 254.53) provide for submitting a response plan developed under State requirements for facilities within 3 mi of the natural shoreline.

Per MMS regulation 30 CFR 254.5(b), Oil Spill Response Plans (OSRPs) submitted to meet response planning requirements must be consistent with National Contingency Plan and appropriate Area Contingency Plans. In Alaska, OSRPs must be consistent with The Alaska Federal and State Preparedness Plan for Response to Oil and Hazardous Substance Discharges and Releases (Unified Plan) and the appropriate Subarea Contingency Plan. For activities occurring in the Beaufort Sea, the appropriate subarea plan is the North Slope Subarea Contingency Plan. As the Unified Plan and the North Slope Subarea Contingency Plan are updated, it is incumbent upon the operators to review their OSRPs to ensure that their response activities and operations remain consistent with the provisions of these plans.

A required component of an OSRP is to identify sensitive areas along the coastline that could be impacted by an oil spill, and evaluate if the sites can be protected from the oil's impact by deploying protective booming or other spill response methods. The North Slope Subarea Contingency Plan Sensitive Areas section is undergoing a review to identify priority protection sites from Brownlow Point to the Canadian border and from Cape Halkett to the Chukchi Sea. The impetus for this update to the east is Shell Offshore Inc.'s planned exploration activities occurring in 2007 and to the west expanding exploration and development in the National Petroleum Reserve-Alaska (NPR-A).

An initial meeting of the Sensitive Areas Workgroup (SAW) was held on May 10, 2007, in Fairbanks, Alaska, to review the coastline and identify areas of critical concern for the eastern segment of the North Slope. A similar meeting was held on June 14, 2007, to identify sites located west of Prudhoe Bay. Following the identification of those sites representatives from Alaska Clean Seas (ACS), the FWS, North Slope Borough, and Spilltek conducted aerial surveys of the coastline to evaluate the selected sites to determine if protective measures are possible and what equipment and personnel requirements would be necessary to implement response tactics. The survey of the eastern sites occurred in early July 2007; and the western sites in August 2007.

The sites identified as polar bear aggregation areas (Barrow, Cross Island, Barter Island, and Flaxman Island) have been identified as such and will be included in the next update of the ACS Technical Manual Atlas, which is incorporated into the North Slope Subarea Contingency Plan. All new sites identified during the July and August 2007 surveys conducted from the Canadian border to Flaxman Island and NPR-A west to the Chukchi Sea will be presented to the Alaska

Region Response Team Sensitive Areas Workgroup for review and approval on November 14, 2007. Once approved, the manual will be updated to incorporate all the changes.

For activities conducted on the OCS, operators are required to review their entire plans biennially to determine if their plans require changes to meet new requirements or reflect changes in their operations. For activities located on State of Alaska submerged lands, plans must be resubmitted for approval every 5 years in accordance with ADEC regulations. If there are major changes that negatively impact the operator's ability to respond to a spill, the operator is required to notify the MMS within 15 days of the change so that MMS may evaluate the operator's response capabilities and determine what actions may be required by the operator until response capabilities are reestablished.

4.1.2 Personnel Training

BPXA has developed health, safety, and environmental (HSE) and technical training programs that should address the requirements of 30 CFR Subpart B, Stipulation No. 3 (Orientation Program of Lease Sale 144), and Stipulation No. 2 (Protection of Biological Resources) of Lease Sale 124. Those stipulations are focused on projects located in the OCS. BPXA will evaluate its existing training programs with respect to these MMS requirements and the specific circumstances of an Endicott-based development prior to initiating construction and drilling operations, and consult with the MMS to assure the programs comply with MMS requirements.

General topical areas in BPXA's HSE and technical training programs that Liberty personnel will have to take as applicable to their job include the following:

- uERD drilling
- Well control
- Permit and regulatory compliance
- Pollution prevention and spill reporting
- Biological resource protection and wildlife interaction (e.g., polar and grizzly bears)
- Safety and health

4.1.3 Compliance with Lease Sale 124 and 144 Stipulations

NOTE: There were seven Lease stipulations applied to leases in Sale 144. The same seven stipulations with two additional stipulations were applied to Sale 124 leases. The two additional stipulations are now incorporated by the following laws/regulations:

- **Protection of Archaeological Resources**. This stipulation is addressed through the National Historic Preservation Act (NHPA), Section 106 consultation with the Alaska State Historic Preservation Officer (SHPO). Documentation for this consultation can be found at Appendix F.
- **Oil Spill Response Preparedness**. This stipulation is now addressed in the 30 CFR 254 regulations.

For the purposes of this EA, the numbering sequence of Lease Sale 144 will be used, and the additional two stipulations from Lease Sale 124 are not included, because they are addressed through laws/regulations.

4.1.3.1 Stipulation No. 1, Protection of Biological Resources

Stipulation Summary

The Regional Supervisor, Field Operations (RS/FO) may require the lessee to conduct biological surveys needed to determine the extent and composition of biological populations and habitats requiring additional protection. As a result of these surveys, the RS/FO may require the lessee to relocate the site of operations, modify the operation and/or establish that operations will not have adverse effects, or ensure that special biological resources do not exist. In addition, the lessee is required to report any area of biological significance discovered during the conduct of any operations on the lease, and make every effort to preserve and protect the biological resource from damage until the RS/FO provides direction with respect to resource protection.

Planned BPXA Compliance

The proposed project is located near the Stefansson Sound Boulder Patch, a special biological resource. Selection of the SDI pad location rather than an offshore island in Foggy Island Bay avoids impacts to Boulder Patch habitats.

The MMS has identified aggregations of polar bears at coastal bone piles as sensitive resources that must be protected in the event of an oil spill.

4.1.3.2 Stipulation No. 2, Orientation Program

Stipulation Summary

The lessee must develop a proposed orientation program for all personnel involved in the Liberty (SDI) Project. The program must address environmental, social, and cultural concerns that relate to the area, including the importance of not disturbing archaeological and biological resources and habitats. The program will include distribution of information cards on endangered and/or threatened species in the sale area. The program shall be designed to increase the sensitivity and understanding of the personnel to community values, customs, and lifestyles in areas in which such personnel will be operating. The orientation program also shall include information concerning avoidance of conflicts with subsistence, commercial fishing activities, and pertinent mitigation. The program shall be attended at least once a year by all personnel involved in onsite exploration or development and production activities. The lessee shall maintain a record of all personnel who attend the program onsite for so long as the site is active, not to exceed 5 years.

Planned BPXA Compliance

BPXA requires all North Slope field contractors complete an 8-hour “unescorted” training program provided by the North Slope Training Cooperative. All attendees receive a Field Environmental Handbook, an Alaska Safety Handbook, and a North Slope Visitor’s Guide. The unescorted training includes review of the Alaska Safety Handbook, personal protective equipment, camps and safety orientation, hazard communications, HAZWOPER Level 1, Environmental Excellence, and cultural awareness modules.

The program includes an explanation of the applicable laws protecting cultural and historic resources, and stresses the importance of not disturbing archeological, cultural and historic resources, and biological resources and habitats while providing guidance on how to avoid disturbance. For example, the goal of BPXA’s Polar Bear Interaction Plan for the Operating

Units is to ensure that bears that encounter industry activity are detected quickly and responded to appropriately through monitoring, avoidance, or active deterrence by appropriate personnel.

Federal Occupational Safety and Health Administration (OSHA) regulations and guidance provide training standards for individual positions. Training for individual positions vary with the activities performed. Individual training may include an electrical safety program; emergency preparedness and action plans; hazards communication program; HAZWOPER (Levels 3-5); lockout/tagout procedures for control of hazardous energy; emergency shut down systems; cranes, chain hose, and sling/rope inspection program; drilling and workover operations; machinery guarding; tank/vessel cleaning procedures; confined space entry program; first aid material and training; eye and face protection; hearing conservation program; personnel protective equipment; respiratory protection program; safety and environmental meetings.

As discussed in Section 4.1.10, BPXA will evaluate its existing training programs with respect to MMS requirements and the specific circumstances of an Endicott-based development.

4.1.3.3 Stipulation No. 3, Transportation of Hydrocarbons

Stipulation Summary

Pipelines are the preferred transportation mode for production.

Planned BPXA Compliance

BPXA plans to use existing Endicott flowlines and the existing Endicott sales oil pipeline to transport Liberty production.

4.1.3.4 Stipulation No. 4, Industry Site-Specific Bowhead Whale Monitoring Program

Stipulation Summary

A monitoring program is required for exploratory operations conducted during the bowhead whale migration.

Planned BPXA Compliance

Not applicable to this proposed development and production project.

4.1.3.5 Stipulation No. 5, Subsistence Whaling and Other Subsistence Activities

Stipulation Summary

The lessee must conduct operations in a manner that prevents unreasonable conflicts between industry activities and subsistence activities. Prior to submitting a DPP, the lessee shall consult with the potentially-affected communities and the Alaska Eskimo Whaling Commission to discuss potential conflicts with the siting, timing, and methods of proposed operations and safeguards or mitigation measures which could be implemented to prevent unreasonable conflicts. The lessee shall make every reasonable effort to assure that development and production activities are compatible with whaling and other subsistence hunting activities and will not result in unreasonable interference with subsistence harvests.

A discussion of resolutions reached during this consultation process and any unresolved conflicts shall be included in the DPP. In particular, the lessee shall show in the plan how mobilization of the drilling unit and crew and supply boat routes will be scheduled and located to minimize conflict with subsistence activities. Those involved in the consultation shall be identified in the plan. The lessee shall notify the RS/FO of all concerns expressed by subsistence hunters during the operations and of steps taken to address such concerns.

Planned BPXA Compliance

Fall bowhead whaling is conducted by Nuiqsut whalers from Cross Island located about 10 mi northwest of Endicott. As discussed elsewhere, major marine support activities are not envisioned for the Liberty (SDI) Project at this time. Currently, there will be one sealift for the ***LoSal*™** plant to the Endicott MPI (BPXA is also considering the option of sealifting the drill rig to the SDI, but the base case involves road transport of modules from southern Alaska). Refer to Section 4.2.9 of this EA for a description of proposed sealift mitigation. Typically sealifts occur prior to September and fall subsistence whaling depending upon ice and weather conditions. Should the sealift be delayed into the subsistence whaling season, then that activity would be coordinated with the AEWC and with Barrow and Nuiqsut Whalers' Associations through a Conflict Avoidance Agreement or other communications mechanisms. BPXA has also consulted with a number of North Slope organizations including the AEWC about the project during the pre-application phase process. These consultations will continue through other phases of the project.

4.1.3.6 Stipulation No. 6, Agreement Between the United States of America and the State of Alaska

Stipulation Summary

An advisory regarding the terms of the subject agreement.

Planned BPXA Compliance

No compliance activity required.

4.1.3.7 Stipulation No. 7, Agreement Regarding Unitization

Stipulation Summary

An advisory regarding the terms of an agreement between the United States of America and the State of Alaska.

Planned BPXA Compliance

No compliance activity required.

4.1.4 Preventing Wildlife Access to Human-use Food and Garbage

Compliance with regulations governing waste management and feeding of wildlife will reduce the potential for increasing populations of bird predators within the oilfields such as foxes, bears, glaucous gulls, and common ravens, which can dramatically decrease nesting-bird production. Segregation of food waste and disposal in animal-proof containers will reduce wildlife access to human food and garbage. According to BPXA's North Slope Wildlife Avoidance and Interaction Plan, feeding wildlife (regardless of species) is prohibited both by the

State of Alaska (5 AAC 92.230) and BPXA policy. According to BPXA's Polar Bear Interaction Plan for the Operating Units:

> …the majority of dumpsters approved for food waste disposal in the oil fields are now bear-proof. Food wastes should not be deposited in any of the remaining non-bear proof dumpsters. All garbage that contains food should be bagged before being deposited into animal-proof dumpsters. The dumpsters are owned by the North Slope Borough or contractors and are replaced periodically. The dumpsters are generally in high visibility and high traffic areas. All personnel are instructed to check the area for wildlife before exiting a building to deposit garbage in the dumpsters. Animal activity (including grizzly bears, foxes and gulls) near the dumpsters should be monitored, and if problems arise, corrective measures taken. Environmental Advisors on the Slope should be notified of any open or deformed dumpsters. Garbage and other food-related waste should not be left in trucks (either on the flatbed or inside the vehicle). Personnel should avoid carrying garbage or food around with them as these items may attract bears. Each unit will comply with their existing waste management procedures, available from the Environmental field and technical staff of each unit.

4.2 CONSTRUCTION PHASE - MITIGATION

To minimize environmental impacts, all major construction involving offshore and on-tundra activities will take place during winter, including the bridge upgrade, expansion of the SDI and gravel mining at the Duck Island mine site.

4.2.1 Cultural Resources

Gravel for the project would be obtained from a new site in the Sagavanirktok River floodplain, adjacent to the existing Duck Island mine site. Prior to any gravel mining activities on previously unsurveyed locations, BPXA will conduct archeological and cultural resource surveys to assure that any sites are avoided and/or resources protected. BPXA has contracted the archaeological and cultural surveys to Reanier & Associates, Inc. in the area of the proposed Liberty (SDI) Project in support of the development of the Liberty Prospect. The area will be identified on maps provided by BPXA. Deliverables include the following: review the scope area of the proposed work; field surveillance of identified area; provide field observation report; provide final Archeological and Cultural Resources Reconnaissance report. Copies of the final report are submitted to BPXA, MMS, Alaska SHPO and the NSB Inupiat History Language and Culture Commission. The field work was conducted July - August 2007, with a final report scheduled for completion by the end of 2007.

A contract archeologist meeting the Secretary of the Interior's professional standards will be employed to perform these archaeological and cultural resource surveys. If cultural resources not identified during archeological surveys are discovered during construction, work will be halted and the State Historic Preservation Officer will be contacted. In addition, U.S. Army Corps of Engineers, MMS cultural resource personnel, and the NSB Inupiaq History, Language, and Culture Commission will be consulted. A decision will be made, following these discussions, to avoid, protect, or remove the resource, using appropriate scientific and culturally-sensitive techniques.

Ice Roads

Ice roads will be used for temporary gravel haul from the mine site to the SDI and inter-island (MPI to SDI) pipeline construction. Ice roads will be located within the nearshore areas and offshore to the island. Onshore ice roads for pipeline construction can be breached at river and stream crossings if necessary prior to breakup, and all ice roads will melt during breakup.

4.2.2 Boulder Patch Communities

The only potential impacts to Boulder Patch communities would come from excessive propeller downwash from barge and tug traffic that could disturb epilithic fauna and kelp of the Boulder Patch (see Section 3.1.5). BPXA currently plans a sealift directly to the Endicott MPI and will route any barge traffic to avoid the Boulder Patch community, particularly the research sites such as Dive Site 11 (Dunton, 2005), thus eliminating the potential for physical and scientific loss.

4.2.3 Fish and Essential Fish Habitat

The NMFS (refer to Appendix E for NMFS correspondence) determined that construction and operation of the proposed project would not adversely affect EFH and anadromous fish if the following necessary conservation measures are followed:

- The applicant should use vegetated swales and/or an oil/water separator (or equivalent system) that remove total suspended solids (TSS) and oil and grease from the parking lot maintenance and monitoring plans for this system.
- Work on the new Sagavanirktok River bridge should follow timing window restrictions to the best extent practicable. Timing window [avoidance period due to spawning] for the Sagavanirktok River August 15 to September 15.

4.2.3.1 Gravel Mining

Once mining operations are completed, the mine site will be rehabilitated according to the agency-approved mining and rehabilitation plan (Attachment D to the April 2007 DPP, and Appendix I of this EA). Mitigation to overwintering fish habitat is accomplished by mining outside the active floodplain and routing the ice road (based on bathymetric surveys and field reconnaissance of the area) using the existing river channel (avoiding overwintering fish habitat).

4.2.3.2 Ice Roads

A 3-mi-long ice road that would run parallel to the lagoon side of the inter-island causeway may be located near potential fish overwintering habitat (see Section 3.2.3). However, it is expected that the ice road would be limited for the most part to the grounded-ice area along the southwest shore of the causeway and as close to the gravel beach. As a result, possible damage to any potential fish overwintering habitat should be avoided.

4.2.3.3 West Sagavanirktok River Bridge Work

At least two deep-water holes are located at the existing West Sagavanirktok River Bridge and pipeline crossing (see Section 3.2.3). These areas have been well documented as overwintering sites for a number of freshwater and anadromous species and may be a spawning area for broad whitefish. The project will make all attempts to minimize impacts to these areas during upgrade of the bridge superstructure.

Information defining the overwintering holes is from the late 1990s. The river is a dynamic system and some of the holes may have changed location. BPXA will conduct open-water surveys during the summer of 2007 and refine the bathymetry of the bridge area. Particular attention will be given to deep holes that could provide overwintering habitat for fish. The ADNR Office of Habitat Management and Permitting and the U.S. Army Corps of Engineers will be the permitting agencies for the West Sagavanirktok River bridge upgrade.

4.2.4 Marine Mammals

The overall impact on marine mammals from the Liberty (SDI) Project construction activities during winter is unlikely to be major. Conducting construction activities during the winter when beluga whales (and Pacific walruses) are absent will eliminate potential disturbances from those activities.

Marine mammals are unlikely to be seriously impacted by summer erosion because BPXA plans to install sheetpile slope protection on the north and east sides of the SDI which are the side most prone to erosion. Installation of the sheet pile wall is planned to be concurrent with the winter gravel placement thus minimizing erosion.

4.2.5 Marine and Coastal Birds

The abundance and distribution of bird predators would be reduced by designing facilities in a way that eliminates any new bird nesting, or fox denning sites.

Per the FWS Final BO, BPXA has committed search Liberty (SDI) Project structures for raven-nesting activities from March 1 through June 30 each year. Monitoring would take place every 4 days and, if nesting materials are found, they will be removed and disposed of to prevent their reuse by ravens. An annual report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year.

Other components of the Liberty (SDI) Project may afford foxes new denning sites. For example, the currently proposed mine rehabilitation plan includes retention of portions of an elevated earthen berm and the stockpiles of organic overburden, which could become a site of future new fox dens. Per the FWS Final BO, BPXA intends to monitor the berm and stockpiles weekly from April 15 through June 15. If denning activities are observed, the ADF&G and FWS will be contacted to develop a plan to prevent further activity. An annul report summarizing monitoring efforts will be provided to the FWS by BPXA through MMS before December 31 each year.

Obstruction of brood movements due to increased traffic on roadways will be mitigated by reducing traffic speeds along the Endicott Road during broodrearing. BPXA informed FWS that speed limits on the Endicott road system are reduced from 45 mph to 35 mph between July 1 and August 15. These actions will enhance road crossing.

Per the FWS Final BO, BPXA proposes to minimize the use of *Arctophila* ponds for ice road water sources. The *Arctophila* ponds are a habitat type favored by listed eiders but also are used by marine and coastal birds.

4.2.6 Terrestrial Mammals

Identification of active grizzly bear dens and arctic fox den structures prior to winter construction activities will allow avoidance of these structures and will minimize injury or disturbance to hibernating grizzly bears and destruction of existing fox den sites.

Construction during winter will reduce disturbance to caribou and muskoxen, which generally are not on the Arctic Coastal Plain in the project vicinity during winter. However, while most major gravel placement occurs during winter, summer activities associated with smoothing, grading, and installing other facilities on the expanded SDI have the potential to disturb terrestrial mammals.

Obstruction of caribou movements and collision mortality due to increased traffic on the Endicott Road will be mitigated by reducing traffic speeds along the road during the summer insect season, when the caribou may be present in large numbers. These actions also would enhance road-crossing success by the animals.

4.2.7 Wetlands and Vegetation

The selected mine site is in a portion of the Sagavanirktok River floodplain. After mine site closure, the mine will be rehabilitated according the mine site rehabilitation plan (Appendix D of the April 2007 DPP, and Appendix I of this EA). Wetlands and vegetation impacts will be mitigated due to activities occurring in the winter versus summer, use of ice pads to stage equipment and overburden, and locating the excavation as closely as practicable to the existing road system.

An ice road will be used to transport gravel from the mine site to the SDI. As discussed in Section 3.2.7, tussock-type tundra and areas with elevated microsites or irregular topography are more susceptible to damage from ice roads than are wetter meadow-type communities. To the extent possible, surveying the ice-road route to avoid potentially higher risk areas and routing along the Sagavanirktok River channel to the maximum extent feasible will minimize the impact from construction activities.

Increased traffic along the Endicott Road to support construction activities will generate additional road dust. The reduced speed limit along the Endicott Road (from 45 mph to 35 mph between July 1 and August 15) will moderate the amount of dust generated. This, in addition to the current road-watering program, should provide some relief to adjacent vegetation from the effects of dust fallout.

4.2.8 Threatened and Endangered Species

Bowhead Whales

Construction activities are unlikely to have any major effect on bowhead whales. The construction activity with the greatest potential to impact bowhead whales is the proposed sealift to the Endicott MPI. Scheduling of the sealift to be completed prior to August 31 should mitigate possible deflection of the bowhead whale migration. Most whales migrate offshore of the SDI and outside of the barrier islands passing by during September. Per the informal consultation dated October 19, 2007 (refer to Appendix D of this EA), NMFS stated the following mitigation factors:

- The project would be sited to provide a natural barrier to sound transmission into normal bowhead whale habitat.
- Drilling muds, cuttings, and produced waters would not be discharged into the Beaufort Sea but reinjected into the underlying formations.
- Mitigation is already designed into the project in the site selection and usage of pre-existing facilities.

Based on these factors, the NMFS stated "…while the Liberty project may affect these whales, our assessment…finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur)."

Polar Bears

Potential impacts from ice roads on denning polar bears will be mitigated per FWS LOA condition #6, which prohibits activities within 1 mi of known polar bear dens. Preconstruction surveys (FLIR surveys) should determine den sites near the ice-road corridor.

Current North Slope waste-management practices incorporate methods to minimize attraction of wildlife to development. Continued implementation of these practices will help prevent interactions with polar bears that could potentially result in hazing or destruction of bears, or in injury to oil field workers.

ESA-protected Birds

Many of the same activities that impact marine and coastal birds would affect ESA-protected species. Consequently, mitigation measures that reduce construction impacts to marine and coastal birds (Section 4.2.5) also would reduce adverse effects to ESA-protected species and are not repeated here (Refer to Appendix C of this EA).

Per the FWS Final BO, BPXA has committed to ensuring vessels do not enter the Ledyard Bay Critical Habitat Unit located in the Chukchi Sea, where large numbers of flightless spectacled eiders molt.

BPXA has stated they would evaluate the mine site and water source lakes (for ice road construction) for suitability as eider nesting habitat but does not indicate if that information would influence the design of the mine or use of these lakes. Lake studies and permitting are required by the State of Alaska to estimate the volume of water that can be withdrawn without causing adverse effects. Per the FWS Final BO, BPXA proposes to minimize the use of *Arctophila* ponds, a habitat type favored by listed eiders. Given the limited number of years that ice roads will be constructed, the recharge by spring melt, and the avoidance of preferred habitat types, adverse effect to listed eiders are not anticipated to result form water withdrawal activities.

4.2.9 Subsistence and Area Use Patterns

Per correspondence received from BPXA on July 17, 2007, the following sea lift mitigation was provided to MMS:

The logistical base case for the Liberty Development Project is for transportation to the North Slope of Alaska via truckable modules. Presently, a sealift is only anticipated to support the would be the ***LoSal™*** process plant and other equipment to the Endicott main production island (MPI), which is scheduled for summer 2012. The greatest potential for activity related to construction of the Liberty SDI option to impact bowhead whales would result from a sealift of the ***LoSal™*** process plant and other equipment to the MPI.

Summer is defined here as the early portion of the open-water season from July through late-August. Bowhead whales are unlikely to occur in the project area prior to mid-August and summer sealift activities would be unlikely to affect bowhead whales. Small numbers of bowhead whales could be affected by the sealift activities should these activities extend beyond mid-August. Bowhead whales have been known to respond to vessel noise and activities, and the sealift could have the potential to cause a temporary deflection of some bowhead whales at the southern edge of the migration corridor. Any deflection to migrating bowheads would occur while the sealift vessel was transiting the near shore waters of the Beaufort Sea. The potential deflection effects to bowhead whales could occur over several days.

The MMS has identified the following areas as sensitive to subsistence whaling activities within the Beaufort Sea:

- The area between 10 mi west of Point Barrow to Harrison Bay extending 35 miles seaward from the north coast of Alaska between September 1 and October 25 for whaling and whale migration and feeding activities, and
- The area between Prudhoe Bay and 40 mi east of Cross Island extending 25 mi north of Cross Island between September 5 and 20 for Nuiqsut whaling activities.

To the greatest extent possible, BPXA will plan all operations to avoid impacts to the bowhead migration and the annual bowhead hunt. Mitigation will, in all but exceptional cases, be achieved by scheduling sealift operations to avoid the migration timing and periods of the annual hunt. Typically, depending upon ice and weather conditions, sealifts in the central Beaufort Sea can be completed in August prior to the main migration of bowhead whale and subsistence whaling. Should the sealift be delayed for any reason, then BPXA would coordinate this activity with the Alaska Eskimo Whaling Commission (AEWC) and Barrow and Nuiqsut whaling Captains' Associations through a Conflict Avoidance Agreement (CAA) or other communication mechanisms. Consistent with safe navigation and ice conditions, the sealift may be routed inshore to avoid migrating bowhead whales and subsistence whaling.

BPXA currently enters into an annual CAA with the AEWC and Nuiqsut whaling Captains' Associations for Northstar open water activities. The annual CAA may be entered into jointly with other industrial (e.g., Shell, ConocoPhillips, etc) activities or separately by BPXA.

At such time that BPXA is aware that sealift activities will occur, BPXA shall:

- Consult with the NSB, AEWC and the Barrow and Nuiqsut whaling Captains' Associations. Typically, consultation is conducted via formal and informal meetings with the above identified entities. Consultation includes, but is not limited to, telephone, face-to-face meetings and written correspondence. Presentations are conducted for the full commission and attending whaling captains at the AEWC miniconvention and with whaling captains associations at the CAA postseason meetings.
- The year prior to sealift activities, BPXA works with the AEWC on a CAA reflecting upcoming open water activities. There are several mechanisms for formal consultation. These include the following: (1) open water activities presentation at the annual AEWC meeting, and (2) the annual "open water" meeting.

Additionally, BPXA monitors impacts in consultation with NMFS, the North Slope Borough, and other stakeholders. Over the past 6 years, BPXA has developed and implemented a study using directional hydrophone arrays to locate bowhead whales and related their locations to sound levels emanating from Northstar. BPXA has also completed a multiyear study of impacts to ringed seals.

The Liberty (SDI) Project area is not an area of high subsistence activities. Fall bowhead whaling is conducted by Nuiqsut whalers from Cross Island located about 10 mi northwest of Endicott. The Liberty (SDI) Project currently includes a single sealift in the 2012 open-water season of the ***LoSal™*** plant and other equipment. As is typical for most sealifts to the central Beaufort Sea, this sealift is scheduled to be completed early in August prior to the main migration of the Bowhead whale and fall subsistence whaling depending upon weather and ice conditions.

Should the sealift be delayed into September for any reason, BPXA will coordinate this activity with the AEWC and Barrow and Nuiqsut Whaling Captains' Associations through a CAA or other communication mechanisms. Consistent with safe navigation and ice conditions, the sealift may be routed inshore to avoid migrating bowhead whales and subsistence whaling.

4.2.10 Water Quality

Turbidity will be minimized by conducting gravel-fill operations in the winter when nearshore circulation is more muted compared to the open-water season. Turbidity should be further reduced through the installation of the sheet pile wall on the north and east sides of the expanded SDI. Installation will be done concurrent with winter gravel placement. The potential for small equipment spills (oil, diesel fuel, and hydraulic fluid) will be mitigated though proper training and awareness of personnel. Best management practices will be followed for fuel handling, storage, and dispensing. The amendment to the *Endicott and Badami Oil Discharge Prevention and Contingency Plan* for the Liberty (SDI) Project will detail measures to be taken to reduce the possibilities of a spill reaching marine waters. Also, the drainage plan for the expanded SDI provides for internal drainage of stormwater and low points to reduce the possibility of spills entering marine waters.

4.3 OPERATIONS PHASE - MITIGATION

4.3.1 Benthic and Boulder Patch Communities

The Boulder Patch will be largely isolated from the normal construction and operational activities of the Liberty (SDI) Project because of uERD technology, and also because barge traffic will be routed around the Boulder Patch to reduce turbulence (Section 3.1.5.1). Leak-detection systems and routine pipeline inspections (including pigging of the Endicott sales oil line) will reduce the likelihood of a major oil spill from existing pipelines that could reach nearshore benthic communities. Continuous and rigorous training of oil spill response teams increases the probability that that any spill, should it occur, will be contained and damage to the coastal benthos minimized. Approved discharges (principally the brine reject from the ***LoSal™*** EOR plant) into surrounding waters stemming from production activities will be monitored according to the requirements of the NPDES permit to ensure compliance with regulatory guidelines.

4.3.2 Fish and Essential Fish Habitat

The NMFS (refer to Appendix E for NMFS correspondence) determined that construction and operation of the proposed project would not adversely affect EFH and anadromous fish if the following necessary conservation measures are followed:

- The applicant should use vegetated swales and/or an oil/water separator (or equivalent system) that remove total suspended solids (TSS) and oil and grease from the parking lot maintenance and monitoring plans for this system.
- Work on the new Sagavanirktok River bridge should follow timing window restrictions to the best extent practicable. Timing window [avoidance period due to spawning] for the Sagavanirktok River August 15 to September 15.

Per an email from the U.S. Army Corps of Engineers, Alaska District, to MMS on October 22, 2007, it was stated that the Corps has placed the aforementioned conservation measures as a Special Condition of the 404 permit, and will monitor the permittee. If the permittee is found to be in noncompliance, the Corps will suspend the permit, and the NMFS will be contacted regarding possible mitigation/corrective measures.

Fish protection measures are essentially the same as for benthic communities above; routine pipeline inspections will reduce the chance of a major oil spill from new or existing pipelines that could reach coastal or freshwater fish habitat. Continuous training by oil spill response teams increases the likelihood that any spills will be contained and potential damage to the fish habitat is minimized. Approved discharges (principally the brine reject from the ***LoSal™*** EOR plant) into surrounding waters stemming from production activities will be monitored according to the requirements of the NPDES permit to ensure compliance with regulatory guidelines.

4.3.3 Marine Mammals

The greatest potential impact on marine mammals from operations at Liberty (SDI) Project facilities would be the effects of a large oil spill. Preventative maintenance and monitoring of all operational aspects will be given the highest priority. Oil spill prevention is the greatest single measure that can be taken to prevent major consequences for all marine mammals in the area. The existing *Endicott and Badami Oil Discharge Prevention and Contingency Plan* is currently under revision to include the Liberty (SDI) Project and is scheduled for submittal to ADEC in December 2007. Refer to Appendix B for the existing ODPCP, which is marked as DRAFT, because it is currently under revision.

4.3.4 Marine and Coastal Birds

Refer to Section 4.2.8 of this EA (ESA-protected Birds).

4.3.5 Terrestrial Mammals

Use of existing infrastructure, such as the Endicott SDI, MPI, and the Endicott Road, mitigates habitat loss from the construction of new facilities, such as production pads, access roads, and pipelines. Should culverts be required for the Liberty (SDI) Project (e.g., for the mine site access road), foxes creating dens in culverts and other structures will be discouraged by inspection and removal of the dens. In addition, the structures and culverts will be designed to discourage these activities (i.e., use of screens, fences, or construction materials that are unattractive to the animals).

Compliance with regulations governing waste management and feeding of wildlife will assist with preventing skewed distributions of predator species such as arctic fox, red fox, and grizzly bears. To reduce attraction, food waste will be segregated and disposed of in animal-proof containers. See Section 4.1.4 for further details.

Biological resource protection and wildlife interaction plans inform project personnel of the importance of wildlife and resource protection, reduce potential for harassment of wildlife, and illustrate how personnel actions have a potential to negatively affect terrestrial mammal resources. Restriction of on-tundra activities during spring and summer reduces the potential disturbance to terrestrial mammals.

Environmental and safety training programs assist in preventing fuel spills, vehicle collision mortalities, and other avoidable effects to terrestrial mammals and their habitats, and ensure compliance with permit requirements.

4.3.6 Wetlands and Vegetation

Operational impacts associated with the SDI expansion would have minimal direct impact to wetlands and vegetation. The primary risk would be associated with a large oil spill. Prevention, responsible monitoring, and a reliable response plan are all critical to mitigating damage to wetlands and vegetation.

4.3.7 Threatened and Endangered Species

4.3.7.1 Bowhead Whales

The greatest potential impact on bowhead whales from operations at Liberty (SDI) Project facilities is from a large oil spill or a large fuel spill related to sealift operations. Preventive maintenance and monitoring of all operational aspects will be given the highest of priority to minimize the chance of an oil spill. Oil spill prevention is the greatest single measure that can be taken to prevent major consequences for bowhead whales.

Adequate preparation for oil spill response on terrestrial, delta, and offshore habitats requires that a variety of properly maintained equipment and supplies be available and accessible, and that response personnel have proper training. Implementation of the response strategies detailed in the existing *Endicott and Badami Oil Discharge Prevention and Contingency Plan* and USCG-required spill response for vessels should mitigate the impact of both small and large spills should they occur.

Per the informal consultation dated October 19, 2007 (refer to Appendix D of this EA), NMFS stated the following mitigation factors:

- The project would be sited to provide a natural barrier to sound transmission into normal bowhead whale habitat.
- Drilling muds, cuttings, and produced waters would not be discharged into the Beaufort Sea but reinjected into the underlying formations.
- Mitigation is already designed into the project in the site selection, and usage of pre-existing facilities.

Based on these factors, the NMFS stated "…while the Liberty project may affect these whales, our assessment…finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur)."

4.3.7.2 Polar Bears

This analysis includes the mitigation measures that BPXA has committed to in writing to date. Other mitigation measures may be evaluated for the purposes of minimizing impacts and determining whether certain major effects could be rendered minor, if such measures become part of the proposal prior to its approval or as a condition of its approval.

Polar bears are known to investigate human activities, especially when certain attractants such as food are present. Continuation of current North Slope practices on food handling and disposal will help reduce the potential for human/bear interactions. Reducing these encounters will play an important role in reducing the impacts of the Liberty (SDI) Project on polar bears. BPXA will mitigate potential impacts to polar bears from human encounters by adhering to their Polar Bear Interaction Plan and by working closely with the USDOI, FWS according to the terms of the Letters of Authorization for incidental take of marine mammals they receive for BPXA-operated North Slope oil fields.

The MMS has identified aggregations of polar bears at coastal bone piles as sensitive resources that must be protected in the event of an oil spill. The MMS will ensure these areas are added to the ACS Technical Manual map and, thus, are addressed in the project's required OSRP.

Section 1.6 Scenario 3 Part (xi) Wildlife Protection of the current Endicott OSRP provides a description of activities to be taken to protect wildlife from being impacted by a spill. In addition to containment and control of an oil spill, BPXA will use polar bear guards and security staff trained to carry out hazing activities, to protect both polar bears and workers at remote locations. Specific wildlife protection actions are identified in the ACS Technical Manual under the Wildlife Protection Tactics. BPXA has hazing and incidental take authorizations from FWS for polar bears and other marine mammals for spill response activities.

4.3.7.3 ESA Listed Birds

The FWS BO (Refer to Appendix C of this EA) outlines the following mitigation measures which would avoid or minimize adverse effects to threatened eiders and other marine and coastal birds:

- Ensure vessels do not enter Ledyard Bay Critical Habitat Unit
- Reduction of speed limits on the Endicott road between July 1 and August 15
- Reduce access to solid waste and garbage by predators and scavengers
- Removal and disposal of raven nesting structures, and submit annual report
- Monitor berm and stockpiles for fox den sites, and submit annual report
- Work with the FWS to design, install, and operate strobe lights for the Endicott SDI, which should operate from late June through the end of November
- Report all avian mortalities and collisions (including vehicle collisions) and their circumstances to the FWS

Monitoring committed to by BPXA and required by FWS BO will inform agencies on the effectiveness of these mitigation measures.

4.3.8 Cultural Resources and Subsistence and Area Use Patterns

Any archeological or cultural resources will have been identified prior to or during construction and appropriate protection measure implemented as required by regulations (see Sections 4.2.1; and 4.2.9, above).

4.3.9 Air Quality

Air quality impacts of operation activities and mitigation are described in the air quality control permit application submitted to ADEC (April 2007). Potential impacts of operations to air quality will be mitigated principally through selection of the most efficient equipment, implementation of best available control technology (BACT) where applicable, and use of natural gas instead of diesel fuel to power the drilling rig.

4.3.10 Water Quality

The potential for small equipment spills (oil, diesel fuel, and hydraulic fluid) will be mitigated though proper personnel training and adherence to best management practices for handling, storage, and dispensing of fuel. The expanded SDI has been designed to confine surface-water drainage to the work surface and will also reduce the risk of any incidental equipment spills reaching marine waters. The project will have zero surface discharges of drilling wastes. Operational discharges will conform to the stipulations of the existing or renewed Endicott NPDES permit.

Section 5

Consultation and Coordination

5.1 CONSULTATION AND COORDINATION

MMS and BPXA have consulted with regulatory agencies and other stakeholders both before and subsequent to the decision to develop from onshore using uERD (August 2005) and more recently, to develop Liberty from the Endicott SDI (August 2006). These consultations have included informal meetings and briefings and formal pre-application meetings (January-March 2007). The purpose of these consultations has been to obtain comments and input on potential development alternatives, provide project progress updates, and clarify regulatory requirements. MMS and BPXA have consulted and coordinated with following agencies and organizations since August 2005:

- **Federal Agencies**
  - U.S. Army Corps of Engineers
  - U.S. Environmental Protection Agency
  - National Marine Fisheries Service
  - USDOI, Fish and Wildlife Service
  - State Agencies
  - Alaska Department of Natural Resources, Office of Project Management and Permitting
  - Alaska Department of Natural Resources, Office of Habitat Mgt and Permitting
  - Alaska Department of Natural Resources, Division of Oil and Gas
  - Alaska Department of Environmental Conservation, Division of Spill Prevention and Response
  - Alaska Department of Environmental Conservation, Div of Air Quality
  - Alaska Department of Natural Resources, Division of Mining, Land and Water
  - Alaska Oil and Gas Conservation Commission
- **Local Agencies and Organizations**
  - North Slope Borough Planning and Community Affairs Department
  - North Slope Borough Wildlife Department
  - North Slope Borough Planning Commission
  - North Slope Borough Mayor's Office
  - City of Barrow
  - Native Village of Kaktovik
  - Inupiat Community of the Arctic Slope
  - Native Village of Barrow
  - Arctic Slope Regional Corporation
  - Kuukpik Corporation
  - Alaska Eskimo Whaling Commission

In addition to these consultations, BPXA entered into two memoranda of understanding (MOU) with regulatory agencies to detail applicant-agency consultation processes, roles and responsibilities and the permitting processes. One MOU was executed by BPXA with the MMS, U.S. Army Corps of Engineers and State of Alaska, and the other with the State of Alaska, Department of Natural Resources.

On February 17, 2006, MMS notified FWS and NMFS (pursuant to 50 CFR 402.08) that BPXA had been designated as the non-Federal representative for ESA consultations for the Liberty development project. BPXA also is the applicant in this proposed Federal action. As the designated non-Federal representative, BPXA conducted informal consultations with FWS and NMFS and prepared requisite Biological Assessments (BA). Refer to Appendices C and D of this EA for a copy of the February 17, 2006, correspondence.

On May 4, 2007, MMS notified NMFS (pursuant to 50 CFR 600.920(c) of BPXA's designation as the non-Federal representative for EFH consultation. Refer to Appendix E for a copy of the May 4, 2007, correspondence.

The MMS reviewed the BA's submitted by BPXA for ESA and the EFH analysis. The MMS prepared formal consultation letters to FWS and NMFS. Refer to Appendices C, D, and E for copies of all consultations.

The MMS consulted with the Alaska State Historic Preservation Office (SHPO) under Section 106 of the National Historic Preservation Act (NHPA). Refer to Appendix F for a copy of the consultation.

On May 11, 2007 (pursuant to Executive Order 13175), MMS invited Federally Recognized Tribes to hold formal Government-to-Government consultations. Refer to Appendix G for Government to Government consultations. Environmental Justice and Government-to-Government consultations are discussed in this EA at Section 2.15.5.

The MMS made the DPP and EIA available for 60 days to allow public review and comment. This public comment period ended on July 9, 2007. The following agencies and organizations responded in writing to either the MMS or the U.S. Army Corps of Engineers:

Federal Government:

- USDOI, Office of Environmental Policy and Compliance
- USDOI, FWS, Fairbanks Office, Project Planning Branch
- USEPA, Region 10, Aquatic Resources Unit

State of Alaska:

- Office of Project Management and Permitting
    - Office of Habitat Management and Permitting
    - State Pipeline Coordinator's Office
    - Department of Environmental Compliance

Local Government:

- North Slope Borough, Planning Department and Mayors Office

Non-Governmental Responses:

- Pacific Environment
- Natural Resources Defense Council
- Northern Alaska Environmental Center
- Alaska Wilderness League
- Alaska Eskimo Whaling Commission

Section 6

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2.5.4 2.5.5	Hydrogen Ion Concentration (pH)/Acidity/Alkalinity	Greg Hearon	Coastal Frontiers Corporation
2.5.5	Trace Metals	John H. Trefry	Florida Institute of Technology
2.5.6	Hydrocarbons	John H. Trefry	Florida Institute of Technology
2.6	**Fresh Water Environment**		
2.6.1	Sagavanirktok River	John Pickering	PN&D Engineers
2.6.2	Lakes	John Pickering	PN&D Engineers
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Section 7

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Tables and Figures

Table 1-1
Comparison of Components of Proposed Action and Alternatives

COMPONENT	PROPOSED ACTION Endicott SDI Expansion	OFFSHORE ISLAND FEIS Offshore Proposed Action plus Alternatives	ONSHORE ALTERNATIVE Pt. Brower	ONSHORE ALTERNATIVE Kadleroshilik
WELL PAD				
Location	Endicott SDI	Liberty Island	Pt. Brower	Kadleroshilik
Gravel Volume	860,000 yd^3	797,600 yd^3	490,000 yd^3	440,000 yd^3
Maximum Footprint Area	20 acres	22.4 acres	45 acres	40 acres
Working Surface	704 ft x 1,394 ft	345 ft x 680 ft	2,715 ft x 630 ft	2,000 ft x 630 ft
Slope Protection	Sheetpile N. & E. none W. & S.	Gravel bags/Sheetpile	Gravel bags	Gravel bags
Rock Riprap	6,000 yd^3	N/A	N/A	N/A
WELLS				
Oil Producer	1 to 4	14	up to 6*	up to 6*
Water Injector	1 or 2	6		
Gas Injector	N/A	2		
Disposal Well	N/A	1		
PROCESSING HOST				
Location	Endicott MPI	Liberty Island	Endicott MPI	Badami
Facility Upgrade at Host	None	Standalone facilities including: 65,000 bpd oil separation capacity, 120 million scfd gas compression capacity, 75,000 bpd seawater treatment capacity, and a full camp and utility system	Liberty slugcatcher at Endicott MPI	Expand oil separation from 38,000 to 55,000 bpd, expand gas compression and flare system capacity from 35 to 70 million scfd
POWER GENERATION				
Location	Endicott MPI	Liberty Island	Endicott	Badami
Power-line Installation	Buried in Causeway	N/A	Buried in Road	Buried in Road
***LoSal*™ FACILITIES**				
Location	Endicott MPI	N/A	Pt. Brower Pad	Kadleroshilik Pad
NEW OIL PIPELINE**				
Type	N/A***	Sales Oil	3-Phase	3-Phase
Route	N/A	Liberty Island to Badami Pipeline	Pt. Brower Pad to Endicott	Kadleroshilik Pad to Badami
Design	N/A	Single-Wall Steel Pipe Buried Subsea	Single-Wall Steel Pipe on VSMs	Single-Wall Steel Pipe on VSMs
Onshore Length	N/A	1.5 mi	15.2 mi	11.5 mi
Offshore Length	N/A	6.1 mi	N/A	N/A
River Crossings - Number	N/A	N/A	3	2
River Crossings - Type	N/A	N/A	Road bridges	Road bridges
Leak Detection System	N/A	MBLPC, PPA, LEOS, or Equivalent	LEOS	LEOS
Construction Season	N/A	Winter	Winter	Winter

Table 1-1 (Cont'd)
Comparison of Components of Proposed Action and Alternatives

COMPONENT	PROPOSED ACTION Endicott SDI Expansion	OFFSHORE ISLAND FEIS Offshore Proposed Action plus Alternatives	ONSHORE ALTERNATIVE Pt. Brower	ONSHORE ALTERNATIVE Kadleroshilik
GRAVEL MINE SITE				
Location	Sag Delta	Kadleroshilik	Sag Delta	Sag & Kadleroshilik
Acres Disturbed	50	31	63	89
Number of Haul Days	90	45 to 60	90	90
Distance from Well Pad	10 mi	6 mi	6.3 mi	3.1 mi
ROAD				
Route	N/A	N/A	Pt. Brower Pad to Endicott Road (7.3 mi)	Kadleroshilik Pad to Endicott Road (15.2 mi)
Gravel Volume	N/A	N/A	550,000 yd^3	1,130,000 yd^3
Maximum Footprint	N/A	N/A	70 ft x 38,500 ft	70 ft x 80,256 ft
Maximum Footprint Area	N/A	N/A	62 acres	129 acres
Working Surface	N/A	N/A	30 acres	62.6 acres
Bridges (Number)	1 (upgrade West Sag Bridge)	N/A	3	7
Culverts (Number)	N/A	N/A	40±	80±
ICE ROAD				
Freshwater	22 million gal	N/A	44 million gal	88 million gal
LOGISTICS				
Barge Trips (approx.)	1	60/year	N/A	N/A
Road trips (approx.)	2,100/year	N/A	2,100/year	2,100/year
Helicopter trips (approx.)	N/A	760/year	N/A	N/A
Staging area (approx. number and size)	1 @ 5 acres	1 onshore 20 acres; 1 offshore 10 acres	1 @ 5 acres	1 @ 5 acres

* The number of wells required for the Pt. Brower and Kadleroshilik alternatives is the same as for the proposed action (Endicott SDI). Since the original offshore proposal, BP has concluded that the Liberty reservoir can be produced with considerably fewer wells (up to 6 total) than originally anticipated. In addition, for these alternative options, BPXA was considering drilling up to two water source wells to provide water for waterflood; these are not included in the well count above.

** The current capacity of the Endicott sales oil pipeline system is 100,000 bbl/day, and the current capacity of the Badami sales oil line system is 35,000 bbl/day.

*** The project will include new gas and water lines on the existing 3-mile-long Endicott causeway.

Table 2.1-1
Location and Elevation of the Stations Referenced in this Section
Source: NCDC (2005)

Station	Latitude	Longitude	Elevation above Sea Level (m)
Barrow	71°17'N	156°46'W	9.5
Barter Island	70°08'N	143°38'W	11.9
Deadhorse	70°12'N	148°29'W	18.6
Kuparuk	70°19'N	149°35'W	19.5
Prudhoe Bay	70°15'N	148°20'W	22.9

Table 2.1-2
Temperature Summary for Barrow (1975-2004)
Source: NCDC (2005)

Month	Average Temperatures (°C)			Extreme Temperatures (°C)			
	Average	Average High	Average Low	Record High	Date	Record Low	Date
Jan	-25.0	-21.8	-28.3	-0.6	1/24/91	-47.2	1/3/75
Feb	-26.0	-22.7	-29.4	2.2	2/4/82	-46.6	1/2/93
Mar	-24.6	-21.1	-28.2	1.1	3/21/98	-43.3	3/14/95
Apr	-17.5	-13.7	-21.3	3.3	4/30/95	-28.3	5/6/84
May	-6.4	-3.8	-9.0	8.3	5/23/96	-28.3	5/6/84
Jun	1.8	4.4	-0.8	22.2	6/18/96	-11.1	6/2/94
Jul	4.6	7.9	1.3	26.1	7/13/93	-3.9	7/27/92
Aug	3.7	6.3	0.9	23.3	8/5/99	-6.1	8/31/80
Sep	-0.4	1.6	-2.4	16.7	9/19/95	-17.2	9/28/75
Oct	-9.1	-6.8	-11.7	5.0	10/3/77	-32.7	10/27/96
Nov	-18.1	-14.9	-21.2	1.7	11/16/96	-38.9	11/22/92
Dec	-23.3	-20.1	-26.6	0.0	12/23/83	-45.0	12/24/94
Annual	-11.7	-8.7	-14.7	26.1	7/13/93	-47.2	1/3/75

Table 2.1-3
Mean Temperatures for North Slope Climatological Stations
Source: NCDC (2005)

Station	Observation period	T(°C) Annual	T(°C) Warmest Month (July)	T(°C) Coldest Month (February)
Barrow	1975-2004	-11.7	4.6	-26.0
Deadhorse	1999-2003	-11.3	7.8	-27.4
Prudhoe Bay	1986-1999	-11.2	8.7	-27.8
Kuparuk	1983-2004	-11.5	8.6	-28.2
Barter Island	1949-1988	-12.2	4.5	-27.3

Table 2.1-4
Precipitation Statistics for North Slope Climatological Stations
Source: NCDC (2005)

Station	Observation Period	P (cm) Mean	P (cm) Maximum	P (cm) Minimum
Barrow	1975-2004	10.9	18.5	4.4
Prudhoe Bay	1986-1999	10.8	18.8	7.4
Kuparuk	1983-2004	10.1	18.5	5.9
Barter Island	1949-1988	15.7	32.7	7.4

Table 2.1-5
Snowfall Statistics for North Slope Climatological Stations
Source: NCDC (2005)

Station	Observation Period	Snowfall (cm) Mean	Snowfall (cm) Maximum	Snowfall (cm) Minimum
Barrow	1975-2004	79.5	130.6	36.1
Prudhoe Bay	1986-1999	84.1	133.4	21.1
Kuparuk	1983-2004	78.2	128.3	16.3
Barter Island	1949-1988	106.2	221.7	48.5

Table 2.1-6
Mean Monthly and Annual Wind Speed for Barrow, Barter Island, and Deadhorse
Source: NCDC (2005)

Month	Wind Speed (kt)		
	Barrow	Barter Island	Deadhorse
Jan	9.5	12.5	10.4
Feb	9.1	11.3	9.9
Mar	8.7	10.3	10.6
Apr	9.0	9.1	10.9
May	9.6	10.0	11.1
Jun	8.9	9.3	10.3
Jul	9.2	8.9	10.5
Aug	9.6	9.0	10.2
Sep	10.0	10.0	9.2
Oct	10.2	12.0	9.8
Nov	9.7	11.4	9.7
Dec	9.6	10.9	10.0
Annual	9.4	10.4	10.2

Table 2.1-7
Days per Month with Wind Speed Greater Than 30 kt at Barrow (1987-2003)
Source: NCDC (2005)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12	16	5	4	1	0	1	6	11	16	16	13

Table 2.1-8
Summary of 2005 Ambient Air Quality Data for GPB A-Pad and CCP
Source: NCDC (2005)

Location	Pollutant	Averaging Time	Ambient Standard (ppm)	Measured Concentration (ppm)	Percent of Standard
A-Pad	NO_2	Annual	0.053	0.004	7.5
	SO_2	Annual	0.031	0.001	3.2
		24-hour	0.14	0.003	2.1
		3-hour	0.5	0.005	1.0
	O_3	1-hour	0.12	0.051	42.5
CCP	NO_2	Annual	0.053	0.013	24.5
	SO_2	Annual	0.031	0.000	0.0
		24-hour	0.14	0.007	5.0
		3-hour	0.5	0.009	1.8
	O_3	1-hour	0.12	0.051	42.5
	PM_{10}	Annual	50 µg/m^3	3.7 µg/m^3	7.4
		24-hour	150 µg/m^3	38.9 µg/m^3	25.9

Table 2.3-1
Estimated Bluff Retreat Rates along the Alaskan Beaufort Sea Coast

Location	Estimated Bluff Retreat Rate	Investigator
Tigvariak Island to Point Thomson	2.1 m/yr	Hopkins and Hart (1978)
Brownlow Point	9.2 m/yr	Leffingwell (1919)
Flaxman Island	3.3 m/yr (1952-1982)	Miller and Gadd (1983)
Heald Point (Western Shoreline)	0.3 to 0.6 m/yr (entire study area) 1.2 to 1.5 m/yr (sector containing massive ice)	Leidersdorf et al. (1996)
Point Storkersen	0.8 m/yr (1949-1996) 1.2 m/yr (short-term)	Coastal Frontier Corp. (1996)

Table 2.3-2
Estimated Bluff Retreat Rates in Foggy Island Bay
Source: Coastal Frontiers (1997a, 2006)

Location	Maximum Short-Term Bluff Retreat Rate	Average Long-Term Bluff Retreat Rate
West Site	1.6 m/yr (1988-1995)	0.6 m/yr (1949-1995)
East Site	2.7 m/yr (1949-1955)	0.8 m/yr (1949-1995)
East Kadleroshilik Site	2.7 m/yr (1949-1955)	1.1 m/yr (1949-2003)
Pt. Brower Site	East Side – 9.6 m/yr (1949-1955) West Side – 2.0 m/yr (1955-1968)	East Side – 2.0 m/yr (1949-2003) West Side – 0.2 m/yr (1993-2003)

Table 2.4-1
Tidal Characteristics at Prudhoe Bay – Station ID 9497645
Source: NOS (2006)

Datum	Elevation (above Mean Lower Low Water)
Mean Higher High Water	20.9 cm
Mean High Water	17.7 cm
Mean Sea Level	10.3 cm
Mean Low Water	2.3 cm
Mean Lower Low Water	0.0 cm

Table 2.4-2
Predicted Maximum Still Water Levels for Westerly Storms
Source: OCTI (1997), Resio and Coastal Frontiers (2007)

	Still Water Level (m, MSL)			
Return Period (years)	Original Island Site	East Shore Crossing	West Shore Crossing	Endicott SDI Pad Expansion
1	0.61	0.70	0.61	n/a
10	1.25	1.37	1.25	1.14
25	n/a	n/a	n/a	1.36
50	1.71	1.83	1.68	1.51
100	1.89	2.04	1.86	1.66
200	n/a	n/a	n/a	1.81

Table 2.4-3
Predicted Significant Wave Height (H_s) and Peak Periods (T_p) for Westerly Storms
Source: OCTI (1997)

Return Period (years)	Original Island Site		East Shore Crossing		West Shore Crossing	
	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)
1	2.01	7.5	0.58	7.5	0.52	7.5
10	2.84	8.0	0.70	8.0	0.64	8.0
50	3.48	10.4	0.82	10.3	0.73	10.3
100	3.72	11.4	1.04	11.4	0.88	11.4

Table 2.4-4
Predicted Significant Wave Height (H_s) and Peak Periods (T_p) for Easterly Storms
Source: OCTI (1997)

Return Period (years)	Original Island Site		East Shore Crossing		West Shore Crossing	
	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)
1	1.46	7.6	0.46	6.9	0.46	6.9
10	1.95	8.4	0.52	7.3	0.52	7.3
50	2.47	10.8	0.52	9.4	0.52	9.3
100	2.80	11.8	0.52	10.0	0.52	9.9

Table 2.4-5
Predicted Significant Wave Height (H_s) and Peak Periods (T_p) near the Endicott SDI Expansion for Westerly Storms
Source: Resio and Coastal Frontiers (2007)

	Return Period (years)									
	10		25		50		100		200	
Site No. (1)	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)	Hs (m)	T_p (sec)	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)
7	1.80	8.9	2.01	10.2	2.13	11.1	2.29	11.9	2.41	12.8
8	1.80	8.9	2.01	10.1	2.16	11.0	2.29	11.8	2.44	12.7
9	1.77	8.9	1.95	10.1	2.10	11.0	2.23	11.8	2.38	12.7

(1) Sites 1 through 6 are omitted due to sheltering by the Endicott Causeway and SDI.

Table 2.4-6
Predicted Significant Wave Height (H_s) and Peak Periods (T_p) near the Endicott SDI Expansion for Easterly Storms
Source: Resio and Coastal Frontiers (2007)

	Return Period (years)									
	10		25		50		100		200	
Site No.	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)	Hs (m)	T_p (sec)	H_s (m)	T_p (sec)	H_s (m)	T_p (sec)
1	0.34	9.1	0.37	10.3	0.40	11.1	0.43	11.9	0.46	12.7
2	0.52	9.1	0.61	10.2	0.67	11.0	0.70	11.8	0.70	12.6
3	0.55	9.0	0.61	10.1	0.70	10.9	0.70	11.7	0.70	12.4
4	0.95	9.0	1.01	10.1	1.01	10.9	1.01	11.7	1.01	12.4
5	1.31	9.0	1.40	10.1	1.46	10.9	1.46	11.7	1.46	12.4
6	1.37	9.0	1.43	10.1	1.46	10.8	1.46	11.6	1.46	12.3
7	1.59	9.0	1.62	10.0	1.62	10.8	1.62	11.5	1.62	12.2
8	1.62	9.0	1.62	10.0	1.62	10.8	1.62	11.5	1.62	12.2
9	1.62	9.0	1.62	10.0	1.62	10.8	1.62	11.5	1.62	12.2

Table 2.4-7
Predicted Landfast Ice-Sheet Thickness in Foggy Island Bay
Source: Vaudry (2007)

Date	10-Yr Minimum Ice Thickness (cm)	Average Sheet Ice Thickness (cm)	100-Yr Maximum Ice Thickness (cm)
November 1	23	33	58
December 1	53	64	91
January 1	76	91	124
February 1	104	122	158
March 1	130	152	191
April 1	155	180	213
May 1	173	196	226
June 1	183	201	229

Table 2.4-8
Exceedence Probability Distribution of Ice Drift Speeds
Source: Colony (1979), Cornett and Kowalchuk (1985), St. Martin (1987), Thorndike and Cheung (1977a,b), Vaudrey (1987, 1989a)

	Per Cent > Net Daily Ice Movement Rate (kt)							
Season	>0.2	>0.4	>0.6	>0.8	>1.0	>1.5	>2.0	Average Speed (kt)
Freeze-Up	50.0	17.7	8.1	3.8	1.9	0.4	0.3	0.3
Breakup	34.0	14.4	6.2	2.8	0.8	0	0	0.2

Table 2.4-9
Ice Movement Summary for Stefansson Sound Near Point Brower
Source: OSI (1976, 1978a,b, 1980)

Year	Net Ice Movement by Month (cm)				Percent of Time Ice Moving <1 cm/hr
	January	February	March	April	
1975-76	61	61	30	0	99.3
1976-77	30	0	30	61	99.7
1977-78	183	91	61	0	100.0
	152	61	61	0	100.0

Table 2.5-1
TSS Measurements in the ANIMIDA Study Area During the Open-Water Season
Source: Rummel (1987), Dunton et. al (2005)

Year	n	TSS Mean ± SD (mg/l)	TSS Maximum (mg/l)	TSS Minimum (mg/l)
1999	31	30 ± 27	119	2.9
2000	51	8.2 ± 4.8	26	1.7
2001	34	5.1 ± 2.1	8.7	0.9
2002	32	2.1 ± 1.3	4.4	0.2
2004	45	13 ± 16	64	0.5

Table 2.5-2
TSS Measurements in Foggy Island Bay During the Open-Water Season
Source: Rummel (1987), Dunton et. al (2005)

Year	n	TSS Mean ± SD (mg/l)	TSS Maximum (mg/l)	TSS Minimum (mg/l)
1999	7	14 ± 3	19	10
2000	5	10 ± 2	12	8
2001	6	6.5 ± 1.1	9	6
2004	7	14 ± 19	51	0.5

Table 2.5-3
TSS Measurements in the ANIMIDA Study Area as a Function of Runoff or Wind Conditions
Source: Trefry et al. (2004a)

Season	Runoff or Wind Conditions	Total Suspended Sediment
Under Ice	Pre-river runoff	TSS typically 0.1 to 0.5 mg/l
	During river runoff (top 2 m of water under ice)	TSS ranges from 1 to 50 mg/l
Open-water	Winds calm to 5 kt (calm to 2.5 m/sec)	TSS typically 1 to 4 mg/l
	Winds 5 to 10 kt (2.5-5 m/sec)	TSS typically 3 to 8 mg/l
	Winds 10 to 20 kt (5-10 m/sec)	TSS typically 5 to 15 mg/l
	Winds >20 kt (>10 m/sec)	TSS 50 to >100 mg/l

Table 2.5-4
Concentrations of Trace Metals in Sediments from Foggy Island Bay and the Coastal Beaufort Sea

Sample		Silver Ag (µg/g)	Aluminum Al (%)	Arsenic As (µg/g)	Barium Ba (µg/g)	Beryllium Be (µg/g)	Cadmium Cd (µg/g)	Cobalt Co (µg/g)	Chromium Cr (µg/g)	Copper Cu (µg/g)	Iron Fe (%)
Foggy Island Bay[1] (1999-2002) (n = 26)	Mean	0.09	3.7	11	397	1.0	0.18	6.8	55	16.5	21.
	Range	<0.01-0.26	1.6-6.3	7-18	233-674	0.5-2.0	0.08-0.37	3.8-11.4	28-86	7-31	1.0-3.5
Foggy Island Bay[2] (2004-2005) (n = 14)	Mean	0.10	4.3	11.4	470	0.84	0.20	8.8	67	21	2.4
	Range	0.04-0.22	2.2-6.3	5-20	220-700	0.35-1.7	0.05-0.38	5-12	32-96	8-41	1.3-3.4
Coastal Beaufort Sea[3] (n = 192)	Mean	0.11	4.2	10.2	430	1.2	0.24	8.2	61	20	2.2
	Range	0.03-0.44	1.1-7.3	4.2-28	155-753	0.3-2.3	0.03-0.82	2.2-18.6	13-104	3.6-50	0.7-3.9
Coastal Beaufort Sea[4]	Range	0.01-0.13	-	10-43	-	-	0.06-0.43	3-18	15-125	6-83	0.8-4.8
Sagavanirktok River Suspended Sediment[5] (1999-2004, n = 54)	Mean	-	6.0	11.5	685	-	-	-	-	32	3.4
	Range	-	4.0-8.8	8-15	541-1110		-	-	-	29-39	2.6-4.7
World Average Coastal/Marine[6]	-		8.4	5	460	3	0.17	13	60	56	4.1
Effects Range Median[7] (ERM)	-	3.7	-	70	-	-	9.6	-	-	-	-
Effects Range Low[7] (ERL)	-	1.0	-	8.2	-	-	1.2	-	-	-	-

[1]Brown et al. (2004)

[2]Brown et al. (2006)

[3]Trefry et al. (2003)

[4]Sweeney and Naidu (1989); Valette-Silver et al. (1999)

[5]Rember and Trefry (2004); Trefry et al. (2004, 2006)

[6]Salomons and Förstner (1984)

[7]Long et al. (1995)

Table 2.5-4 (Cont'd)
Concentrations of Trace Metals in Sediments from Foggy Island Bay and the Coastal Beaufort Sea

Sample		Mercury Hg (µg/g)	Manganese Mn (µg/g)	Nickel Ni (µg/g)	Lead Pb (µg/g)	Antimony Sb (µg/g)	Thallium Tl (µg/g)	Vanadium V (µg/g)	Zinc Zn (µg/g)	Total Organic Carbon TOC (%)	Silt + Clay (%)
Foggy Island Bay[1] (1999-2002) (n = 26)	Mean	0.035	272	23	9.5	0.48	0.38	86	66	0.75	47
	Range	0.010-0.074	167-532	8-39	5-18	0.3-1.0	0.2-0.8	37-153	30-108	0.1-3.4	2-100
Foggy Island Bay[2] (2004-2005) (n = 14)	Mean	0.053	340	28	11.4	0.43	0.36	98	83	0.86	63
	Range	0.023-0.097	170-520	13-44	4-20	0.19-0.71	0.22-0.53	46-149	41-136	0.25-2.4	7-93
Coastal Beaufort Sea[3] (n = 192)	Mean	0.046	306	28	10.0	0.56	0.44	96	81	1.0	60
	Range	0.003-0.20	62-898	6-48	3.2-22.3	0.15-1.1	0.12-0.92	27-173	15-157	0.01-4.4	1-99
Coastal Beaufort Sea[4] (n = 10-150)	Range	0.04-0.15	105-650	7-75	11-25	0.8-3.1	-	31-240	28-170	-	2-100
Sagavanirktok River Suspended Sediment[5] (n = 54)	Mean	-	590	61	14	-	-	-	133	1.4	-
	Range	-	519-614	50-76	4-23	-	-	-	115-214	0.7-2.7	-
World Average Coastal/Marine[6]	-	0.19	850	35	12	1.2	-	145	95	-	-
Effects Range Median[7] (ERM)	-	0.71	-	-	218	-	-	-	410	-	-
Effects Range Low[7] (ERL)	-	0.15	-	-	46.7	-	-	-	150	-	-

[1]Brown et al. (2004)

[2]Brown et al. (2006)

[3]Trefry et al. (2003)

[4]Sweeney and Naidu (1989); Valette-Silver et al. (1999)

[5]Rember and Trefry (2004); Trefry et al. (2004, 2006)

[6]Salomons and Förstner (1984)

[7]Long et al. (1995)

Table 2.5-5
Concentrations of Dissolved Trace Metals in Foggy Island Bay and the Coastal Beaufort Sea

Sample		Arsenic As (µg/l)	Barium Ba (µg/l)	Cadmium Cd (ng/l)	Chromium Cr (µg/l)	Copper Cu (µg/l)	Mercury Hg (ng/l)	Lead Pb (ng/l)	Zinc Zn (µg/l)	Dissolved Organic Carbon DOC (mg/l)	Salinity
Foggy Island Bay[1] (2000-2004) (n = 15)	Mean	0.5	24	24	0.09	0.5	0.8	12	0.21	1.5	-
	Range	0.3-1.2	19-28	20-28	0.08-0.14	0.4-0.7	0.5-1	3-27	0.2-0.3	0.9-2.5	15-32
Coastal Beaufort Sea[1] (2000-2004) (n = 118)	Mean	0.6	24	22	0.08	0.5	0.8	7	0.16	1.7	-
	Range	0.2-1.2	10-40	15-39	0.05-0.15	0.3-0.8	0.3-1.5	3-27	0.12-0.42	0.9-3.8	15-32
World Average Coastal/Marine[2]	-	1.5	15	-	0.18	0.1	1	20	0.3	1-2	20-35
Sagavanirktok River[3]	Range	0.05-0.13	25-35	-	0.08-0.17	0.2-1	0.3-1	15-50	0.1-0.4	2-9	<0.3
Typical World River Water[4]	-	1	-	20	0.5	1.5	10	30	0.6	-	<0.2

Table 2.6-1
Summary of Hydrologic Data for the Sagavanirktok River

Source: PND (2006b)

Sagavanirktok River Location	Length (miles)	Drainage Area (mi^2)	Period of Record	Peak Discharge	
				Date	Flow (cfs)
River Mouth (whole river)	180	5,750		8/27/92	300,000[b]
USGS Gauge 15908000 near PS3	80	1,860	1982-06	8/16/02	48,300
USGS Gauge 15910000 at Sagwon	85	2,208	1969-79	--	62,000[c]
West Channel Bridge[a]	170	5,310[a]	1970-06	8/27/92	135,000[b]

Notes:

a. Drainage area at the Endicott Road and Badami Pipeline crossings is approximately 5,310 square miles, contributing to flows distributed between the West and East channels.

b. Estimate by Veldman and Ferrell (2002)

c. Maxir

[1]Trefry et al. (2004, 2006)

[2]Donat and Bruland (1995)

[3]Rember and Trefry (2004); Trefry et al. (2004, 2006)

[4]Salomons and Förstner (1984); Donat and Bruland (1995)

Table 2.6-2
Summary of Annual Breakup vs. Rainfall Floods at the Sagavanirktok River West Channel Bridge
Source: PND (2006b)

Year	Breakup Flood Peaks				Rainfall Flood Peaks			
	Date	Stage (ft)	Flow (cfs)	Ref.	Date	Stage (ft)	Flow (cfs)	Ref.
1970			20,000	a				
1971			25,000	a				
1972			23,000	a				
1980	May 23	17.0	10,500	b				
1981	May 23	16.5	16,500	b				
1982	June 7	14.6	62,000	b	Aug 4	8.7	3,700	c
1983	June 1	16.1	39,000	b	July 4	9.1	4,800	d
1984	May 23	14.7	10,800	b	Aug 4	10.7	9,600	d
1985		12.0		b	July 3	10.5	8,900	e
1986	June 8	12.5	15,500	b, e	Aug 1	10.4	9,100	e
1987	May 27	17.5	15,300	b, e	Aug 11	9.8	11,800	e
1988	June 4	10.5	13,500	f	Aug 14	9.1	7,200	f
1989	June 1	15.1	87,500	b	June 25	10.3	12,500	f
1990	May 19	12.1	28,500	b, f	June 18	9.2	7,600	f
1992					Aug 27		135,000	h
1993	May 29	13.6		g				
1995	May 16	14.8		g				
1997	June 1	12.5		g				
1998	May 22	13.5		g				
1999	May 26	11.6		g				
2000	June 8	14.2		g				
2001	June 10	13.3		g				
2002	May 22	14.0		g				
2003	June 4	13.4		g, j				
2004	May 19	14.8		g				
2005	May 15	13.4		g				
2006	May 28	12.0	17,200	g, j				

All elevations are ARCO MLLW datum.
References (see PND, 2006b):
a. Earl and Wright (1980)
b. McDonald (1981-85, 1990a, 1990b)
c. Gallaway and Britch (1983). Flow from 1985 rating curve
d. Flow estimated from USGS PS3 data and 1985 rating curve
e. Envirosphere (1987, 1990, 1991). Flow from rating curve
f. SAIC (1991, 1993a, 1993b)
g. Bell and Associates (1993, 1995-2006)
h. Veldman and Ferrell (2002). Estimated from post-flood investigation
j. PND (2003, 2006b)

Table 2.6-3
Breakup Flood Frequency and Magnitude at the Sagavanirktok River West Channel Bridge
Source: PND (2006b)

Average Recurrence Interval (yrs)	Annual Exceedance Probability	Flood Magnitude (cubic feet per second, cfs)			
		Estimated Flow	Expected Probability	5% Confidence Limit (lower)	95% Confidence Limit (upper)
2	50%	22,000	22,000	16,000	29,000
10	10%	50,000	55,000	37,000	84,000
50	2%	87,000	110,000	58,000	182,000
100	1%	107,000	148,000	68,000	243,000
200	0.5%	130,000	198,000	79,000	319,000

Table 2.7-1
Abundance and Biomass of Epilithic Flora and Fauna from 0.05-m^2 Scrapes Collected off Rocks in the Boulder Patch, 1979 and 1980
Source: Dunton and Schonberg (2000)

TAXA	Number/m^2	Standard Deviation	Grams/m^2	Standard Deviation
PROTOZOA				
Sarcodina				
Foraminifera				
Cornuspira sp.	16.67		0.030	
Cornuspira foliacea	6.67		0.059	0.058
Cornuspira involvens	6.67		0.014	0.015
Dentalina sp.	1.00		0.001	
Elphidiella sp.	16.61	15.72	0.009	0.006
Elphidiella arctica	56.67	32.99	0.009	0.007
Guttulina sp.	2.17	1.65	0.002	0.002
Lagena sp.	4.44		0.002	
Miliolidae	549.15	488.03	0.014	0.015
Miliolinella sp.	467.47	545.40	0.018	0.025
Nonionidae	8370.63	10082.80	0.470	0.361
Triloculina sp.	4408.00		0.212	
Unknown forms	1104.27	1716.46	0.061	0.100
BACILLARIOPHYTA				
Amphipleura sp.			2.378	5.291
Unknown diatoms			0.010	0.007
RHODOPHYTA				
Lithothamnium sp.			0.724	0.289
Neodilsea integra			30.627	23.018
Odonthalia dentata			2.994	4.894
Phycodrys rubens			43.129	45.228
Phyllophora truncata			29.538	13.764
Rhodomela confervoides			4.091	3.715
Unknown algae			0.311	0.473
PHAEOPHYTA				
Laminaria sp.			7.512	4.807
Laminaria saccharina			42.054	22.212
Laminaria solidungula			6.496	7.621
PORIFERA				
Choanites lutkenii			7.994	6.931
Halichondria panicea			1.436	2.299
Haliclona rufescens			2.500	3.452
Leucandra sp.			0.198	0.242
Phakellia cribosa			11.604	8.491
Unknown porifera			0.215	0.269
CNIDARIA				
Hydrozoa				
Abietinaria sp.			0.007	
Calicella sp.			0.003	

Table 2.7-1 (Cont'd)
Abundance and Biomass of Epilithic Flora and Fauna from 0.05 m^2 Scrapes Collected off Rocks in the Boulder Patch, 1979 and 1980
Source: Dunton and Schonberg (2000)

TAXA	Number/m^2	Standard Deviation	Grams/m^2	Standard Deviation
Calicella syringa			0.058	0.113
Campanulina quadrata			0.087	
Campanulinidae			0.002	
Corymorpha sp.			0.002	
Eudendrium sp.			0.003	0.002
Lafoeina maxima			0.371	0.772
Obelia sp.			0.009	0.010
Rathkea sp.			0.017	
Sertularia cupressoides			7.526	3.915
Sertularia sp. *cf. albimaris*			1.718	2.369
Unknown hydrozoa			0.032	0.046
Anthozoa				
Gersemia sp.			0.003	0.000
Gersemia fruticosa			0.297	
Gersemia rubiformis			2.359	1.805
Unknown anenome	6.74	4.04	0.031	0.052
RHYNCOCOELA	46.02	27.86	0.048	0.041
NEMATODA	77.73	79.03	0.015	0.013
ANNELIDA				
Polychaeta				
Allia sp.	3.33		0.003	
Ampharete sp.	3.33		0.003	
Ampharete acutifrons	3.33		0.003	
Ampharetidae	3.33		0.003	
Anaitides groenlandicus	2.22		0.002	
Antinoella sarsi	3.33		0.010	0.009
Autolytus sp.	10.00		0.010	
Brada villosa	8.36	6.63	0.026	0.051
Capitella capitata	27.79	20.79	0.026	0.028
Capitellidae	3.33		0.003	
Chaetozone setosa	2.17	1.65	0.007	0.009
Chone sp.	10.56	0.79	0.003	0.001
Cirratulidae	6.67		0.009	
Cirratulus cirratus	121.32	51.41	2.538	1.686
Eunoe nodosa	161.11	224.70	2.601	3.631
Exogone naidina	445.75	262.50	0.046	0.031
Exogone dispar	17.22	8.64	0.006	0.002
Flabelligera sp.	4.07	2.31	0.006	0.004
Flabelligera affinis	3.54	2.38	0.029	0.054
Harmothoe sp.	3.33		0.383	0.537
Harmothoe imbricata	3.33		1.527	
Hesionidae	5.47	2.88	0.005	0.002

Table 2.7-1 (Cont'd)
Abundance and Biomass of Epilithic Flora and Fauna from 0.05 m² Scrapes Collected off Rocks in the Boulder Patch, 1979 and 1980
Source: Dunton and Schonberg (2000)

TAXA	Number/m²	Standard Deviation	Grams/m²	Standard Deviation
Lumbrineris fragilis	9.30	4.52	0.010	0.005
Nereimyra aphroditoides	3.22	0.74	0.003	0.001
Nereis sp.	6.67	4.71	0.005	0.002
Nereis zonata	19.97	12.20	0.641	1.181
Nicolea zostericola	14.57	12.06	0.117	0.160
Paramphitrite tetrabranchia	3.33		0.480	
Pholoe minuta	4.22	2.60	0.011	0.008
Pista cristata	5.00	2.36	0.013	0.014
Polycirrus sp.	3.33		0.003	
Polycirrus medusa	20.56	24.36	0.239	0.237
Polydora sp.	1.00		0.001	
Polydora caulleryi	10.59	12.00	0.006	0.002
Prionospio cirrifera	3.33		0.003	0.000
Pygospio elegans	19.67	37.47	0.005	0.005
Schistomeringos sp.	5.67	3.30	0.008	0.006
Sphaerodorum sp.	3.33		0.003	
Sphaerosyllis erinaceus	2.96	0.64	0.003	0.001
Spinther sp.	6.67		0.003	
Spinther miniaceus	4.00		0.004	
Spinther sp. *cf. oniscoides*	3.33		0.040	
Spio filicornis	21.67	33.23	0.006	0.006
Spirorbis sp.	633.33	553.25	0.076	0.059
Spirorbis granulatus	140.46	146.73	0.148	0.206
Spirorbis spirillum	88.49	110.85	0.013	0.008
Syllidae	20.00		0.003	
Terebellidae	24.17	16.88	0.309	0.304
Terebellides stroemi	19.97	13.31	0.022	0.025
Unknown polychaetes			0.588	0.859
MOLLUSCA				
Gastropoda				
Aplacophora				
Amphineura sp.	3.83	4.01	0.002	0.002
Polyplacophora				
Amicula sp.	6.67		0.820	
Amicula vestita	16.84	14.74	11.776	12.268
Prosobranchia				
Amauropsis purpurea	3.33		0.003	
Lacuna sp.	3.33		0.007	
Margarites sp.	4.58	2.70	0.082	0.152
Margarites costalis	13.33		0.180	
Oenopota sp.	5.50	6.36	0.044	0.046
Plicifusus sp.	10.00		0.100	

Table 2.7-1 (Cont'd)
Abundance and Biomass of Epilithic Flora and Fauna from 0.05 m^2 Scrapes Collected off Rocks in the Boulder Patch, 1979 and 1980
Source: Dunton and Schonberg (2000)

TAXA	Number/m^2	Standard Deviation	Grams/m^2	Standard Deviation
Polinices sp.	6.67		0.003	
Solariella sp.	5.78	1.54	0.010	0.011
Solariella varicosa	2.78	0.79	0.004	0.003
Unknown gastropod	16.81	10.93	0.068	0.033
Bivalvia				
Astarte sp.	6.67	4.71	0.028	0.035
Boreacola vadosa	4.44		0.002	
Musculus sp.	148.35	104.08	0.036	0.024
Musculus discors	223.89	47.93	5.858	7.926
Macoma calcarea	3.33		0.060	
Portlandia arctica	3.33		0.013	
Unknown bivalve	10.50	13.44	0.004	0.004
Opisthobranchia				
Retusa obtusa	10.00		0.003	
PRIAPULIDA				
Priapulus caudatus	3.33		0.543	
ARTHROPODA				
Halicaridae	50.69	50.03	0.012	0.006
Pycnogonidae				
Nymphon brevitarse	2.22		0.002	
CRUSTACEA				
Copepoda				
Cyclopoida	34.10	50.36	0.016	0.024
Harpacticoida	2.17	1.65	0.002	0.002
Cumacea				
Brachydiastylis resima	8.37	9.23	0.010	0.011
Diastylis sp.	3.33		0.003	
Leucon sp.	7.78	7.86	0.004	0.003
Leucon nasicoides	4.82	1.70	0.004	0.002
Ostracoda	5.96	3.79	0.004	0.002
Cirripedia	3.33		0.010	
Balanus sp.	4.00		0.004	
Unknown cirripedia	4.44		0.002	
Tanaidacea				
Leptognathia gracilis	5.00	2.36	0.003	0.000
Isopoda				
Munna sp.	10.54	7.54	0.005	0.002
Pleurogonium sp.	3.31	2.44	0.002	0.001
Unknown isopod	5.63	3.02	0.003	0.001
Amphipoda				
Acanthonotozoma sp. *cf. serratum*	8.11	7.93	0.037	0.019
Anonyx nugax	19.00	24.64	0.119	0.180

Table 2.7-1 (Cont'd)
Abundance and Biomass of Epilithic Flora and Fauna from 0.05 m^2 Scrapes Collected off Rocks in the Boulder Patch, 1979 and 1980
Source: Dunton and Schonberg (2000)

TAXA	Number/m^2	Standard Deviation	Grams/m^2	Standard Deviation
Apherusa sp.	41.11	21.69	0.018	0.017
Apherusa megalops	69.28	142.54	0.037	0.071
Atylus sp.	3.33		0.003	
Atylus carinatus	3.67	0.47	0.006	0.003
Boeckosimus plautus	28.20	44.31	0.175	0.304
Calliopiidae	5.00		0.005	
Dulichia sp.	2.22		0.002	
Dulichia spinosa	6.67		0.004	
Gammaracanthus loricatus	3.67	0.47	2.244	0.600
Gammarus setosa	2.22		0.007	
Halirages sp.	130.46	236.77	0.056	0.058
Halirages nilssoni	5.30	2.44	0.032	0.027
Hyperoche medusarum	4.44	3.14	0.021	0.004
Metopa boecki	6.67		0.003	
Metopella carinata	8.02	5.93	0.004	0.003
Monoculodes sp.	14.33	10.99	0.011	0.012
Monoculodes kroyeri	15.19	12.88	0.006	0.004
Monoculodes longirostris	9.44	8.64	0.032	0.016
Monoculodes packardi	6.58	2.93	0.004	0.001
Monoculodes schneideri	16.67		0.003	
Monoculodes tuberculatus	60.26	104.92	0.049	0.063
Oedicerotidae	3.31	2.44	0.002	0.001
Onisimus litoralis	4.00		0.076	
Orchomene minuta	2.78	0.79	0.018	0.022
Paroediceros propinquis	6.67	4.71	0.008	0.007
Pleusymtes sp.	39.67	5.19	0.081	0.013
Pleusymtes karianus	39.93	48.97	0.041	0.032
Pontoporeia femorata	3.33		0.017	
Rhachotropis sp.	3.67	0.47	0.004	0.000
Rhachotropis inflata	10.00		0.013	
Stenula sp.	14.42	23.70	0.006	0.008
Stenothoidae	3.17	0.24	0.002	0.002
Weyprechtia pinguis	7.17	5.40	0.022	0.019
Unknown amphipod	12.47	11.22	0.006	0.003
BRYOZOA				
Alcyonidium sp.			0.789	0.737
Callopora lineata			1.882	1.164
Crisia sp.			0.006	0.004
Cyclostomata			0.105	0.215
Dendrobeania sp.			0.733	1.252
Eucratea loricata			3.284	3.304
Flustra sp.			0.020	

Table 2.7-1 (Cont'd)
Abundance and Biomass of Epilithic Flora and Fauna from 0.05 m^2 Scrapes Collected off Rocks in the Boulder Patch, 1979 and 1980
Source: Dunton and Schonberg (2000)

TAXA		Number/m^2	Standard Deviation	Grams/m^2	Standard Deviation
Flustrella sp.				0.310	
Hippothoa hyalina				4.637	2.242
Unknown bryozoan				1.989	2.626
ECHINODERMATA					
Asteroidea		14.89	6.98	0.169	0.182
UROCHORDATA					
Ascidiacea					
Chelyosoma macleayanum		3.24	2.80	1.262	1.409
Mogula sp. *cf. siphonalis*		2.78	0.79	2.376	1.732
Mogula griffithsiii		2.17	1.65	0.136	0.152
Styelidae		3.33		0.060	
Styela rustica		2.22		0.016	
Unknown ascidean		3.33		0.626	0.870
CHAETOGNATHA					
Sagitta elegans		17.11	7.23	0.054	0.043
CHORDATA					
Osteichthyes					
Liparis sp.		2.22		0.231	
Liparis herschelinus		2.22		0.389	
Myoxocephalus scorpioides		3.33		23.837	
Stichaeidae		2.22		0.262	
TOTALS	**158 Taxa**	**18,441**	**15,671**	**283**	**210**

Table 2.8-1
Fish Species Found in the Marine Coastal and Freshwater Coastal Regions of the Central Alaskan Beaufort Sea

Type	Common Name	Scientific Name	Inupiat Name
Anadromous	Arctic cisco	*Coregonus autumnalis*	Qaaktaq
	Bering cisco	*Coregonus laurettae*	Tiipuq
	Rainbow smelt	*Osmerus mordax*	Ilhaugniq
	Chum salmon	*Oncorhynchus keta*	Iqalugruaq
	Pink Salmon	*Oncorhynchus gorbuscha*	Amaqtuuq
Amphidromous*	Broad whitefish	*Coregonus nasus*	Aanaakliq
	Least cisco	*Coregonus sardinella*	Iqalusaaq
	Humpback whitefish	*Coregonus pidschian*	Piquktuuq
	Dolly varden	*Salvelinus malma*	Iqalukpik
Freshwater	Arctic grayling	*Thymallus arcticus*	Sulukpaugaq
	Lake trout	*Salvelinus namaycush*	Iqaluaqpuk
	Round whitefish	*Prosopium cylindraceum*	Savigunnaq
	Northern pike	*Esox lucius*	Siulik
	Burbot	*Lota lota*	Tittaaliq
	Alaska blackfish	*Dallia pectoralis*	Iluuginiq
	Longnose sucker	*Catostomus catostomus*	Milugiaq
	Ninespine stickleback	*Pungitius pungitius*	Kaklalisauraq
	Arctic lamprey	*Lampetra Japonica*	Nimigiaq
	Threespine stickleback	*Gasterosteus aculatus*	
	Slimy sculpin	*Cottus cognatus*	
Nearshore Marine	Fourhorn Sculpin	*Myoxocephalus quadricornis*	Kanayuq
	Arctic flounder	*liopsetta glacialis*	Puyyagiaq
	Arctic cod	*Boregogadus saida*	Iqalugaq
	Saffron cod	*Eleginus gracilis*	Uugaq
	Capelin	*Mallotus villosus*	Panmigriq
	Pacific herring	*Clupea harengus*	Uqsruqtuuq
	Pacific sandlance	*Ammodytes hexapterus*	
	Kelp Snailfish	*Liparis tunicatus*	

* Have some components of their populations that remain in freshwater year round

Table 2.10-1
Common, Scientific and Inupiaq Names and Status of Bird Species Occurring in the Liberty Area

Common Name	Scientific Name[a]	Inupiaq Name[b]	Status[c]	Occurrence[d]
LOONS (MALGITCH) AND GREBES				
Red-throated loon	*Gavia stellata*	Quqsruaq		C/B
Pacific loon	*Gavia pacifica*	Malgi	--	C/B
Yellow-billed loon	*Gavia adamsii*	Tuutlik	BCC	U/B
WATERFOWL (TINMIAGRUICH) AND WATERBIRDS				
Greater white-fronted goose	*Anser albifrons*	Kigiyuk	--	C/B
Snow goose	*Chen caerulescens*	Iqsragutitik	--	U/B, C/M
Canada goose	*Branta canadensis*	Iqsragutilik	--	C/B
Brant	*Branta bernicla*	Niglignaq		C/B
Tundra swan	*Cygnus columbianus*	Qugruk	--	C/B
King eider	*Somateria spectabilis*	Qinalik		C/B
Common eider	*Somateria mollissima*	Amaulik	--	C/B
Long-tailed duck	*Clangula hyemalis*	Aahaaliq		C/B
Scoters	*Melanitta* spp.	Tuungaagruk		U/B, U/S
SHOREBIRDS				
Semipalmated sandpiper	*Calidris pusilla*	Livilivillakpak	--	C/B
Pectoral sandpiper	*Calidris melanotos*	Puviaqtuuq	--	C/B
Red-necked phalarope	*Phalaropus lobatus*	Qayyugun	--	C/B
Red phalarope	*Phalaropus fulicarius*	Quksruaq	--	C/B
Dunlin	*Calidris alpina*	Siyukpaligauraq	BCC	C/B
RAPTORS AND OWLS				
Peregrine falcon	*Falco peregrinus*	Kirgavik	BCC	U/M
Gyrfalcon	*Falco rusticolus*	Aatqarruaq	--	U/B
Rough-legged hawk	*Buteo lagopus*	Qilqik	--	U/B
Golden eagle	*Aquila chrysaetos*	Tinmiaqpak	--	U/B
Short-eared owl	*Asio flammeus*	Nipaituktaq	--	C/B
Snowy owl	*Bubo scandiacus*	Ukpik	--	C/B
SEABIRDS				
Jaegers	*Stercorarius* spp.	Migiaqsaayuk, isunnaq	--	C/B
Glaucous gull	*Larus hyperboreus*	Nauqavasrugruk	--	C/B
Sabine's gull	*Xema sabini*	Aqargiyiaq	--	U/B
Arctic tern	*Sterna paradisaea*	Mitqutaiiaq	BCC	C/B
PASSERINES				
Lapland longspur	*Calcarius lapponicus*	Qupatuk, putukiituk	--	C/B
Snow bunting	*Plectrophenax nivalis*	Amautligaq	--	U/B
Common raven	*Corvus corax*	Tulugaq	--	C/B

Notes:
[a] Scientific names from the American Ornithologist Union Check-list Area (http://www.aou.org/aou/birdlist.html).
[b] Inupiaq names in Birds of Central Beringia, a taxonomic List in English, Russian, Inupiaq, Siberian Yupik, and Latin (http:/www.nps.gov/akso/beringia/berinotesnov97.htm).
[c] BCC = USFWS Birds of Conservation Concern, US Fish and Wildlife Service Status Region 7 (Alaska Region) (US Fish and Wildlife Service, 2002).
[d] Occurrence information: C = Common, U = Uncommon, B = Breeding, M = Migration, S = Summer

Table 2.10-2
Occurrence, Estimated Numbers and Trends for Common Birds in the Liberty Area

		Estimated Numbers			
Common Name	**Occurrence**	**Arctic Coastal Plain 1986-2005 (mean and trend)[a,b,c,d]**	**Arctic Coastal Plain 2005 [a,b,c]**	**Beaufort Sea Coast (Colville to Canning Rivers) [e]**	**Liberty Area**
LOONS AND WATERFOWL					
Red-throated loon	early June-late Sept.	3,145 ↑↓	3,038 ± 555	124	8[e]
Pacific loon	late May-late Sept.	26,783 ↔	24,955 ± 1,541	278	8 ± 3[g] (13[e])
Yellow-billed loon	mid May-mid Sept.	2,833 ↔	1,871 ± 493	15	2[e]
Greater white-fronted goose	mid May-mid Sept.	124,465 ↑	129,403 ± 14,795	935	1,098[e]
Snow goose	mid May-mid Sept.	3,124 ↑	14,695 ± 7,891	3,816 [f]	1,494[f]
Canada goose	early June-late July	18,330 ↔	21,200 ± 6,041	491	1,038[e]
Brant	late May-early Sept.	9,980 ↑	15,609 ± 9,123	982	251[e]
Tundra swan	mid May-early Oct.	9,961 ↑	12,002 ± 1,664	20	103[e]
Northern pintail	late May-mid Sept.	224,011 ↔	156,754 ± 24,051	123	220[e]
King eider	late May-Oct.	13,084 ↑	14,934 ± 1,232	32	13 ± 11[g]
Common eider	late May-Oct.	2,537	2,581	3,275	36 ± 7[g]
Long-tailed duck	late May-Oct.	107,923 ↓	84,241 ± 13,529	48,433	236 ± 35[g] (1,136[e])
Scoters	late May-early Sept.	10,437 ↑	7,733 ± 3,373	1,388	19 ± 10[g] (20[e])
SHOREBIRDS					
Semipalmated sandpiper	late May- Oct.	-	-	<30,000 ↓	23.1 [g] km^2
Pectoral sandpiper	late May-Oct.	-	-	<30,000 ↔	26.9 [g] km^2
Red-necked phalarope	late May-Oct.	-	-	<30,000 ↓	12.3 [g] km^2
Red phalarope	late May-Oct.	-	-	<30,000 ↓	8.7 [g] km^2
Dunlin	late May-Oct.	-	-	<30,000 ↓	9.4 [g] km^2
Small shorebirds	late May-Oct.	43,236 ↓	26,653 ± 2,277		
SEABIRDS					
Jaegers	early May-mid Sept.	6,903 ↓	5,804 ± 555	6	-
Glaucous gull	early May-Nov.	17,112 ↔	18,955 ± 3,514	1,915	59 ± 13[g] (604[e])
Sabine's gull	early May-early Sept.	11,576 ↔	11,657 ± 1,541	81	-
Arctic tern	early May-early Sept.	23,505 ↑	30,688 ± 2,774	100	5[e]
RAPTORS AND OWLS					
Rough-legged hawk[d]	late April-early Oct.	-	-	-	2[e]
Golden eagle	April-early Sept.	428	48	-	1[e]
Short-eared owl	mid-May-mid Sept.	83 ↔	35 ± 26	-	-
Snowy owl	Year round	747 ↔	191 ± 76	-	4[e]

Table 2.10-2 (Cont'd)
Occurrence, Estimated Numbers and Trends for Common Birds in the Liberty Area

		Estimated Numbers			
Common Name	Occurrence	Arctic Coastal Plain 1986-2005 (mean and trend)[a,b,c,d]	Arctic Coastal Plain 2005 [a,b,c]	Beaufort Sea Coast (Colville to Canning Rivers) [e]	Liberty Area
PASSERINES					
Lapland longspur					63.4 [g] km^2
Common raven	Year round	65 ↔	25 ± 21	-	2[e]

Notes:

- dash indicates no population estimate or number of birds recorded was available.

[a] Population numbers are minimal estimates, and annually variable with standard errors ranging from 5 percent to over 75 percent of the estimated population.

[b] Population estimates for all nesting waterfowl and loons (except king eiders) with visibility correction factors applied to duck species are long-term averages from 1986-2005 from Mallek, Platte, and Stehn (2006). Population estimates for colonial nesting species, snow goose and brant, may not reflect true population size. Estimates for common eiders from Dau and Larned (2005)

[c] Population estimates for pre-nesting king eiders, raptors and owls, and common raven are long-term averages from 1992-2004 from Larned et al. (2005). Visibility correction factors not applied, averages are minimum population estimates used to track population trend.

[d] Population trend symbols: ↑ = increasing, ↓ = decreasing, ↔ = stable with 90% Confidence from Mallek et al. (2006) and Larned et al. (2005), Alaska Shorebird Group (2004).

[e] Average on-transect counts from aerial coastal surveys during July and August 1999 to 2002 from the Colville River to the Canning River (Noel, ODoherty, and Johnson, 2003). Population estimates for shorebirds based on Colville River Delta and Simpson Lagoon estimates (Appendix 7; Alaska Shorebird Group, 2004).

[f] Estimated based on July 2006 broodrearing survey (unpublished data, LGL Alaska Research Associates, Inc., 2006) and number of total nests (2 adults/nest) on Howe Island during 2006 (Rodrigues, McKendrick, and Reiser, 2006).

[g] Maximum nearshore numbers Prudhoe Bay to Tigvariak Island (<10 m depth = within barrier islands) during June, July and August 1999 and 2000 (Fisher and Larned, 2004). Shorebird and Lapland Longspur density based on mean breeding season bird densities in 1994 at Prudhoe Bay, Kaleroshilik and Badami study sites (Troy Ecological Research Associates, 1995).

Table 2.11-1
Terrestrial Mammal Species Known or Suspected to Occur in the Liberty Area

Common Name	Scientific Name	Inupiaq Name	Abundance
LARGE MAMMALS			
Lynx	*Lynx canadensis*	Niutuiyiq	rare
Caribou	*Rangifer tarandus*	Tuttu	abundant
Muskox	*Ovibos moschatus*	Umifmak	common
Moose	*Alces alces*	Tuttuvak	uncommon
Grizzly (brown) bear	*Ursus arctos*	Akjaq	common
Gray wolf	*Canis lupus*	Amabuq	rare
Wolverine	*Gulo gulo*	Qavvik	uncommon
Arctic fox	*Alopex lagopus*	Tibiganniaq	common
Red fox	*Vulpes vulpes*	Kayuqtuq	uncommon
SMALL MAMMALS			
Arctic ground squirrel	*Spermophilus parryii*	Siksrik, sigrik	abundant
Ermine (short-tailed weasel)	*Mustela erminea*	Itibiaq	common
Least weasel	*Mustela nivalis*	Naulayuq	uncommon
Tundra hare	*Lepus othus*	Ukallisugruk	rare
Snowshoe hare	*Lepus americanus*	Ukalliatchiaq	rare
Brown lemming	*Lemmus trimucronatus*	Aviffapiaq	uncommon
Collared lemming	*Dicrostonyx groenlandicus*	Qixafmiutaq	common
Northern red-backed vole	*Clethrionomys rutilus*	Aviffaq	rare?
Tundra vole	*Microtus oeconomus*	Aviffaq	uncommon
Singing vole	*Microtus miurus*	Aviffaq	common
Barrenground shrew	*Sorex ugyunak*	Ugrugnaq	common?
Tundra shrew	*Sorex tundrensis*	Ugrugnaq	uncommon?
OTHER MAMMALS			
Mink	*Mustela vison*	Itibiaqpak	rare
River otter	*Lontra canadensis*	Pamiuqtuuq	rare
Porcupine	*Erethizon dorsatum*	Qifabluk	rare
Coyote	*Canis latrans*	Amabuuraq	rare

Source: Modified from Table 3.3.4-1 in USDOI, Bureau of Land Management (2004)
Notes: ? indicates that occurrence in the Liberty area is uncertain; and species designated as rare are at the limit of their range

Table 2.15-1
Demographic and General Resource Information for North Slope Borough Villages

Attribute	Barrow	Anaktuvuk Pass	Atqasuk	Kaktovik	Nuiqsut	Point Hope	Point Lay	Wainwright
Land area (sq. miles)	18.4	4.6	4.8	0.8	9.2	6.3	30.5	17.6
Water area (sq. miles)	2.9	0.1	0.1	0.2	0.0	0.1	4.0	24.9
Total population	4,581	282	228	293	433	757	247	546
Percent American Indian and Alaska Native	64.0	88.3	94.3	84.0	89.1	90.6	88.3	90.3
Percent male	51.7	51.8	53.4	52.6	59.6	55.1	57.5	53.3
Percent female	48.3	48.2	46.9	47.4	40.4	44.9	42.5	46.7
Median age (years)	28.8	25.7	26.3	32.1	23.8	21.8	20.8	24.5
Percent 65 years and over	3.4	5	5.7	7.5	4.4	5.2	2.8	6.8
Median 1999 household income (dollars)	$67,097	$52,500	$66,607	$55,625	$48,036	$63,125	$68,750	$54,722
Percent Families below poverty level 1999	7.7	3.2	25	9.9	3.2	13.9	11.4	8.5
Year incorporated	1959	1959	1982	1971	1975	1966	Unincorporated	1962
Housing units (total)	1,620	106	59	90	100	213	68	179
Percent lacking complete plumbing facilities	11.1	17.6	80.4	67	85.1	56.3	82.8	51.7
Percent lacking complete kitchen facilities	9.3	17.6	0	14.8	18.4	28.4	46.9	19.5
Percent without telephone service	3.7	0	25.5	18.2	17.5	23	31.3	18.1

Table 2.15-1 (Cont'd)
Demographic and General Resource Information for North Slope Borough Villages

Attribute	Barrow	Anaktuvuk Pass	Atqasuk	Kaktovik	Nuiqsut	Point Hope	Point Lay	Wainwright
Health Services (Primary and Alternate)	Samuel Simmonds Memorial Hospital; Borough Volunteer Fire Dept./EMS/Search &Rescue/ Medevac	Anaktuvuk Pass Health Clinic; Anaktuvuk Pass Volunteer Fire Dept.	Atqasuk Health Clinic; Atqasuk Volunteer Fire Dept.	Kaktovik Health clinic; Kaktovik Volunteer Fire Dept.	Nuiqsut health clinic; Nuiqsut Volunteer Fire Dept.	Point Hope Health Clinic; Point Hope Volunteer Fire Dept.	Point Lay Clinic; Point Lay Volunteer Fire Dept.	Wainwright Health Clinic; Wainwright Volunteer Fire Dept.
Transportation	Air service; seasonal marine service	Air service; no roads, Cat-trains haul cargo from TAPS haul road in winter.	Air service; seasonal land access, cat-trains haul cargo from Barrow in winter	Air service; seasonal marine access	Air service and access to Dalton Highway 4 months/yr.	Air service; seasonal marine and land access,	Air service; seasonal marine and land access	Air service; seasonal marine and land access
Schools	Separate elementary, middle, and high schools, and Ilisagvik College	Nunamiut School: pre-school through grade 12, vocational and adult education	Meade River School: pre-school through grade 12, and adult education	Harold Kaveolook School: pre-school through grade 12, and adult education	The Trapper School: pre-school through grade 12, and adult education	The Tikigaq School: pre-school through grade 12, and adult education	The Cully School: pre-school through grade 12, and adult education	The Alak School: pre-school through grade 12, and adult education
Communications	phones, mail, cable TV and Internet, 3 TV and 3 radio stations	phone, mail, public radio, and cable television	Phone, mail, public radio, and cable television	phone, mail, public radio, cable TV and Internet	phone, mail, public radio, cable TV and Internet	phone, mail, public radio, cable TV and DSL internet services	phone, mail public radio and cable TV	phone, mail, public radio and cable TV
Alcohol	Sale banned, but importation or possession permitted	Sale and possession banned	Sale and possession banned	Sale and possession banned	Sale and possession banned	Sale and possession banned	Sale and possession banned	Sale and possession banned

Alaska Community Database, available electronically at: Http://www.dced.state.ak.us/dca/commdb/CF_COMDB.htm;
The North Slope Borough Website, available electronically at: Http://www.north-slope.org/nsb/HomeruleBrochure/BrwInfo.htm;
Various local Alaskan websites:
http://www.kingeider.net/king55.html ;
http://www.welcometoalaska.com/Communities/anaktuvukpass.htm;
http://explorenorth.com/library/communities/alaska/bl-commindex.htm ;
http://www.kaktovik.com/
http://www.nsbsd.org/ (NSB school information)
http://www.prudhoebay.com/
http://www.prudhoebay.com/communities_Nuiqsut.htm

Table 2.15-2
Annual Cycle of Subsistence Activities for Nuiqsut

	Winter					Spring		Summer			Fall	
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Fish	High		Low to Medium	Low to Medium	Low to Medium	Low to Medium	High		Low to Medium	Low to Medium	Low to Medium	High
Birds/Eggs	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	High	Low to Medium	Low to Medium	Low to Medium	High
Berries								Low to Medium	Low to Medium	High		
Moose	Low to Medium	Low to Medium								Low to Medium	High	Low to Medium
Caribou	Low to Medium	High	Low to Medium	Low to Medium	High	High	High	Low to Medium	Low to Medium	High	High	High
Furbearers	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	High	High					Low to Medium
Polar Bear	High	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium				Low to Medium	Low to Medium
Seals	Low to Medium	Low to Medium			Low to Medium	High	Low to Medium			Low to Medium	High	Low to Medium
Whales										Low to Medium	High	

(blank) No to Very Low Levels of Subsistence Activity
(hatched) Low to Medium Levels of Subsistence Activity
(dark) High Levels of Subsistence Activity

Sources: IAI (1990), RFSUNY (1984)
As interpreted by Stephen R. Braund & Associates

Table 2.15-3
Nuiqsut Subsistence Harvests and Subsistence Activities for 1985, 1992, and 1993

Study Year	Resource	Percentage of Households					Estimated Harvest				
		Use	Try to Harvest	Harvest	Receive	Give	Total Number	Total Pounds	Mean HH Pounds	Per Capita Pounds	% of Total Harvest
1985	All Resources	100	98	98	100	95		160,036	160,035	399	100.0%
	Fish	100	93	93	78	83	68,153	68,153	70,609	176	44.1%
	Salmon	60	43	40	23	23	441	441	1,366	3	0.9%
	Non-Salmon	100	93	93	75	83	67,712	67,712	69,243	173	43.3%
	Land Mammals	100	95	93	70	85	1,224	1,224	67,866	169	42.4%
	Large Land	98	90	90	70	80	536	536	67,621	169	42.3%
	Small Land	65	63	58	13	23	688	688	245	1	0.2%
	Marine Mammals	100	48	23	100	30	59	59	13,355	33	8.3%
	Birds & Eggs	98	95	95	60	80	3,952	3,952	8,035	20	5.0%
	Vegetation	38	50	18	20	10		169	169	0	0.1%
1992	All Resources							150,196	1,430	359	100.0%
	Fish							51,955	495	124	35.0%
	Land Mammals							41,503	395	99	28.0%
	Marine Mammals							52,749	502	126	35.0%
	Birds and Eggs							3,924	37	9	3.0%
	Vegetation							65	1	0	0.0%
1993	All Resources	100	94	90	98	92		267,818	267,818	742	100.0%
	Fish	100	81	81	94	90	71,897	71,897	90,490	251	33.8%
	Salmon	71	45	36	47	39	272	272	1,009	3	0.4%
	Non-Salmon	97	79	79	90	87	71,626	71,626	89,481	248	33.4%
	Land Mammals	98	77	76	94	82	1,290	1,290	87,390	242	32.6%
	Large Land	98	76	74	92	82	691	691	87,306	242	32.6%
	Small Land	53	45	42	18	27	599	599	84	0	0.0%
	Marine Mammals	97	58	37	97	79	113	113	85,216	236	31.8%
	Birds & Eggs	90	77	76	69	73	3,558	3,558	4,325	12	1.6%
	Vegetation	79	71	71	40	27		396	396	1	0.1%
1994-95	All Resources										100.0%
	Fish						14,650				30.0%
	Land Mammals						254				63.0%
	Marine Mammals						24				2.0%
	Birds & Eggs						605				5.0%
	Vegetation										<1%

Source: ADF&G, Division of Subsistence CPBD, Version 3.12, July 2001 (for 1985 and 1993).
Fuller and George, 1999 (for 1992).
Brower and Opie, 1997 (for 1994-1995).
As interpreted by Stephen R. Braund & Associates

Table 2.15-4
Selected Nuiqsut Subsistence Harvests for 1985, 1992, 1993, and 1994-1995

Study Year	Resource	Estimated Harvest				
		Total Number	Total Pounds	Mean HH Pounds	Per Capita Pounds	% of Total Harvest
1985	Caribou	513	513	60,021	150	37.5%
	Cisco	46,478	46,478	29,354	73	18.3%
	Broad Whitefish	7,900	7,900	26,861	67	16.8%
	Bowhead	0	0	7,458	19	4.7%
	Moose	13	13	6,650	17	4.2%
	Geese	1,345	1,345	6,045	15	3.8%
	Grayling	4,055	4,055	3,650	9	2.3%
	Humpback Whitefish	4,345	4,345	3,476	9	2.2%
	Arctic Char	1,060	1,060	2,969	7	1.9%
	Burbot	669	669	2,675	7	1.7%
1992	Bowhead	2	48,715	464	117	32.0%
	Caribou	278	32,551	310	78	22.0%
	Arctic cisco	22,391	22,391	213	54	15.0%
	Broad Whitefish	6,248	15,621	149	37	10.0%
	Moose	18	8,835	84	21	6.0%
1993	Caribou	672	672	82,169	228	30.7%
	Bowhead	3	3	76,906	213	28.7%
	Broad Whitefish	12,193	12,193	41,455	115	15.5%
	Cisco	51,791	51,791	34,943	97	13.0%
	Ringed Seal	98	98	7,277	20	2.7%
	Burbot	1,416	1,416	5,949	16	2.2%
	Moose	9	9	4,403	12	1.6%
	Grayling	4,515	4,515	4,063	11	1.5%
	Geese	1,459	1,459	2,314	6	0.9%
	Arctic Char	603	603	1,689	5	0.6%
1994-95	Caribou	258				
	Whitefish	14,532				
	Seals	24				
	Grayling	462				
	Moose	5				
	Burbot	91				
	Char	8				
	Wolf	19				
	Geese	457				
	Berries	14				

Source: ADF&G, Division of Subsistence CPBD, Version 3.12, July 2001 (for 1985 and 1993).
Fuller and George, 1999 (for 1992).
Brower and Opie, 1997 (for 1994-1995).
As interpreted by Stephen R. Braund & Associates

Table 2.15-5
Recent Harvest of Bowhead Whales near Cross Island

Year	Whales			Notes
	Quota	Landed	Struck and Lost	
1973	NA	1	0	First "Nuiqsut" whale, no quota in effect
1982	1	1	0	
1986		1	0	
1987		1	0	
1989		2	2	Oil industry vessel disturbance noted
1990		0	1	Oil industry disturbance, also rough seas
1991	3	1	2	Poor weather, bad ice conditions
1992	3	2	1	
1993	3	3	0	Very favorable conditions
1995	4	4	0	
1996	4	2	0	
1997	4	3	1	
1998	4	4	1	
1999	4	3	0	
2000	4	4	0	Very favorable conditions
2001	4	3	0	Saw few whales, relatively far from Cross Island
2002	4	4	1	Saw more whales closer in than in 2001
2003	4	4	0	Poor weather for whaling
2004	4	3	0	Poor weather for whaling

Notes: Years of no harvest and no "struck and lost" are not listed. This does not imply that no whaling effort was made that year. "Quota" was not applicable in 1973.

Source: Compiled from AWC and NSB Wildlife Management records

Table 2.15-6
Selected Characteristics of Nuiqsut Whaling Seasons, 2001-2004

Year	Crews	Boats	Season Dates	Season Days	Scouting Days	Whales Taken	Struck and Lost
2001	4	7	9/03-9/26	24	11	3	0
2002	3	9	8/30-9/20	23	11	4	1
2003	4	9[1]	8/23-9/10[2]	19	7	4	0
2004	4	7[1]	8/15-9/19[2]	36	12	3	0

Notes:
1. Plus two boats used primarily for support and logistics
2. One crew went out earlier than all other crews – see text
Source: Galginaitis and Funk (2003a,b, 2004, 2005) Galginaitis (2005b)

Table 3.1-1
Predicted Travel Distance for Suspended Sediment to Settle to Seafloor

Particle Size (microns)	ASTM Soil Classification	Travel Distance (meters)
1	Clay (lower range)	142,400
5	Clay (upper range) / Silt (lower range)	5,700
15	Silt	630
25	Silt	230
50	Silt	60
75	Silt (upper range) / Fine Sand (lower range)	25
100	Fine Sand	14

Table 3.5-1
* (See Note Below) - **Effects of Liberty Development Alternatives on Boulder Patch and Benthic Communities**

Project Component		Alternatives: Point Brower	Alternatives: Kadleroshilik River	Alternatives: Liberty Island	Alternatives: SDI Expansion
Development Pads	Description	New pad 45 acres, onshore	New pad 40 acres, onshore	New island 22.4 acres, offshore	Pad expansion 20 acres, nearshore
	Effect	None	None	Insignificant loss of Boulder Patch and marine benthic habitat, minor and insignificant effect of small refined-oil spills and activity disturbances	Insignificant loss of nearshore benthic habitat, minor and insignificant effect of small refined-oil spills and activity disturbances (marine access)
Access Roads	Description	New 7.3 miles (62 acres), 3 bridges	New 15.2 miles (129 acres), 7 bridges	None	None
	Effect	None	None	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	None	None	Oil spills, temporary and minor alteration of marine habitat from turbidity during construction, insignificant effect of small refined-oil spills	None
Gravel Placement	Description	1,040,000 yd^3	1,570,000 yd^3	797,600 yd^3	860,000 yd^3
	Effect	None	None	None	None
Operations	Description	Production	Production	Production	Production
	Effect	Large oil spill not a major threat to Boulder Patch, marine and nearshore benthic habitat	Large oil spill not a major threat to Boulder Patch, marine and nearshore benthic habitat	Large oil spill not a major threat to Boulder Patch, marine and nearshore benthic habitat	Large oil spill not a major threat to Boulder Patch, marine and nearshore benthic habitat

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that “significant” findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-2
* (See Note Below) - **Effects of Liberty Development Alternatives on Fish and Fish Habitat**

Project Component		Alternatives: Point Brower	Alternatives: Kadleroshilik River	Alternatives: Liberty Island	Alternatives: SDI Expansion
Development Pads	Description	New pad 45 acres	New pad 40 acres	New island 22.4 acres	Pad expansion 20 acres
	Effect	Insignificant loss of freshwater habitat, insignificant effect of small refined-oil spills and activity disturbances	Insignificant loss of freshwater habitat, insignificant effect of small refined-oil spills and activity disturbances	Insignificant loss of marine habitat, insignificant effect of small refined-oil spills and activity disturbances	Insignificant loss of nearshore brackish habitat, insignificant effect of small refined-oil spills and activity disturbances
Access Roads	Description	New 7.3 miles (62 acres), 3 bridges	New 15.2 miles (129 acres), 7 bridges	None	None
	Effect	Pond and stream fish habitat loss, altered drainage (movement routes), possible disturbance to overwintering sites at river crossings during construction, insignificant effect of small refined-oil spills	Pond and stream fish habitat loss, altered drainage (movement routes), possible disturbance to overwintering sites at river crossings during construction, insignificant effect of small refined-oil spills	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Oil spills, possible disturbance to overwintering sites at river crossings during construction, insignificant effect of small refined-oil spills	Oil spills, possible disturbance to overwintering sites at river crossings during construction, insignificant effect of small refined-oil spills	Oil spills, temporary and minor alteration of marine habitat from turbidity during construction, insignificant effect of small refined-oil spills	Oil spills from existing lines, possible disturbance to overwintering site on lagoon side of causeway, insignificant effect of small refined-oil spills
Gravel Placement	Description	1,040,000 yd^3	1,570,000 yd^3	797,600 yd^3	860,000 yd^3
	Effect	Insignificant loss of freshwater habitat, insignificant effect of small refined-oil spills, reclamation enhance summer and winter habitat	Insignificant loss of freshwater habitat, insignificant effect of small refined-oil spills, reclamation enhance summer and winter habitat	Insignificant loss of freshwater habitat, insignificant effect of small refined-oil spills, reclamation enhance summer and winter habitat	Insignificant loss of freshwater habitat, insignificant effect of small refined-oil spills, reclamation enhance summer and winter habitat
Operations	Description	Production	Production	Production	Production
	Effect	Large oil spill threat to anadromous fish nearshore migratory corridor, selected feeding grounds. Major threat to critical fish habitat in the Sag Delta.	Large oil spill threat to anadromous fish nearshore migratory corridor, selected feeding grounds. Moderate threat to critical fish habitat in the Sag Delta.	Minor, unless in the unlikely event of a large oil spill then threat to anadromous fish nearshore migratory corridor, selected feeding grounds. Moderate threat to critical fish habitat in the Sag Delta	Minor, unless in the unlikely event of a large oil spill then threat to anadromous fish nearshore migratory corridor, selected feeding grounds. Major threat to critical fish habitat in the Sag Delta.

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that “significant” findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-3

* (See Note Below) - **Effects of Liberty Development Alternatives on Marine Mammals**

Project Component		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
		Alternatives			
Development Pads	Description	New pad 45 acres	New pad 40 acres	New island 22.4 acres	Pad expansion 20 acres
	Effect	Minor noise and activity disturbances	Minor noise and activity disturbances	Moderate noise and activity disturbances, insignificant loss of marine habit	Minor noise and activity disturbances, insignificant loss of marine habitat
Access Roads	Description	New 7.3 miles (62 acres), 3 bridges	New 15.2 miles (129 acres), 7 bridges	None	None
	Effect	None	None	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Minor unless large oil spill in marine environment	Minor unless large oil spill in marine environment	Large oil spill in marine environment, temporary and minor alteration of marine habitat from turbidity during construction, moderate noise and activity disturbances during construction	Oil spill in marine environment from existing lines, minor noise and activity disturbances during construction
Gravel Placement	Description	1,040,000 yd^3	1,570,000 yd^3	797,600 yd^3	860,000 yd^3
	Effect	None	None	None	None
Operations	Description	Production	Production	Production	Production
	Effect	Minor unless large oil spill in marine environment, minor noise and activity disturbances	Minor unless in the unlikely event a large oil spill reaches the marine environment, minor noise and activity disturbances	Minor unless in the unlikely event a large oil spill reaches the marine environment, moderate noise and activity disturbances including annual ice roads	Minor unless in the unlikely event a large oil spill reaches the marine environment, impacts would depend upon numerous factors, minor noise and activity disturbances

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-4
* (See Note Below) - **Effects of Liberty Development Alternatives on Marine and Coastal Birds**

Project Component		Alternatives			
		Point Brower	**Kadleroshilik River**	**Liberty Island**	**SDI Expansion**
Development Pads	Description	New Pad 45 acres, onshore	New Pad 40 acres, onshore	New Island 22.4 acres, offshore	Pad expansion 20 acres, nearshore
	Effect	Minor coastal nesting, foraging, brood rearing, staging habitat loss (shorebirds, brant, tundra swan)	Minor coastal nesting, foraging, brood rearing, staging habitat loss (shorebirds, snow geese, brant)	Insignificant loss of marine seabird foraging habitat, insignificant addition of molting habitat (long-tailed ducks, loons, gulls)	Insignificant loss of marine seabird foraging and molting habitats (long-tailed ducks, loons, gulls)
Communication Towers	Description	New tower	New tower	New tower	Existing tower
	Effect	Minor collision mortality - coastal island (migrant seabirds, raven and gull perch)	Minor collision mortality - coastal shoreline (migrant seabirds and shorebirds, raven and gull perch)	Minor collision mortality - offshore (migrant seabirds - offshore location may lead to increased seabird mortality compared to coastal locations, raven and gull perch)	No additional mortality or perch habitat
Access	Description	New Road 7.3 miles (62 acres), 3 bridges	New Road 15.2 miles (129 acres), 7 bridges	Air and Boat Traffic	Existing road
	Effect	62 acres coastal, riparian tundra habitat loss in Sag Delta (snow goose and tundra swan brood rearing, tundra swan nesting, shorebird nesting and staging). Traffic disturbance to nesting and brood rearing birds, increased depredation.	129 acres coastal, riparian tundra habitat loss in Sag Delta and across Kadleroshilik (snow goose and tundra swan brood rearing, tundra swan nesting, shorebird nesting and foraging). Traffic disturbance to nesting and brood rearing birds, increased depredation.	Air traffic disturbance to nesting, brood rearing, molting, staging birds. Boat traffic disturbance to brood rearing, molting birds (snow geese, tundra swans, long-tailed ducks, common eiders, shorebirds)	Existing effects.
Power Lines	Description	Buried in road	Buried in road	None	Buried in road
	Effect	7.3 miles construction disturbance to nesting and brood rearing birds during summer installation.	15.2 miles construction disturbance to nesting and brood rearing birds during summer installation.	None	None

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-4 (Cont'd)
Effects of Liberty Development Alternatives on Marine and Coastal Birds

Project Component		Alternatives			
		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Oil spills - Sag Delta, Foggy Island; nesting, brood rearing, staging (snow geese, tundra swan, brant, sea ducks, loons, shorebirds), predator perches.	Oil spills - Kadleroshilik, Shaviovik; nesting, brood rearing, staging (snow geese, tundra swan, brant), predator perches	Oil spills - Foggy Island Bay, Sag Delta, Kadleroshilik Delta, Shaviovik Delta; molting, brood rearing, staging (snow geese, tundra swan, brant, sea ducks, loons, shorebirds), predator perches	Oil spills from existing lines - Sag Delta; nesting, molting, brood rearing, staging (snow geese, tundra swan, brant, sea ducks, loons, shorebirds), predator perches - existing pipelines
Construction	Description	Primary construction in winter - following summer grade and smooth road/pads	Primary construction in winter - following summer grade and smooth road/pads	Primary construction in winter - following summer grade and smooth island	Primary construction in winter - following summer grade and smooth island
	Effect	Summer smoothing/compaction - disturbance to tundra nesting birds, facilitation of predation	Summer smoothing/compaction - disturbance to tundra nesting birds, facilitation of predation	Summer smoothing/compaction disturbance to foraging, molting seabirds	Summer smoothing/compaction disturbance to foraging, molting seabirds
Gravel Source	Description	Sagavanirktok Pit - 1,040,000 yd^3 (63 acres)	Sagavanirktok and Kadleroshilik Pits - 1,570,000 yd^3 (89 acres)	Kadleroshilik Pit - 797,600 yd^3 (31 acres)	Sagavanirktok Pit - 860,000 yd^3 (50 acres)
	Effect	63-acre coastal tundra habitat loss or alteration - nesting, foraging, brood rearing, staging	89-acre coastal tundra and riparian habitat loss or alteration - nesting, foraging, brood rearing, staging	31-acre riparian habitat loss or alteration - nesting, foraging, brood rearing	50-acre coastal habitat loss or alteration - nesting, foraging, brood rearing, staging
Operations	Description	Production	Production	Production	Production
	Effect	Large oil spill threat to Sag Delta, nearshore waterfowl brood rearing, seabird foraging, shorebird staging habitats	Large oil spill threat to Kadleroshilik and Sagavanirktok river deltas, nearshore waterfowl brood rearing, seabird foraging, shorebird staging habitats	Large oil spill threat to Kadleroshilik and Sagavanirktok river deltas, nearshore waterfowl brood rearing, seabird foraging, sea duck molting, shorebird staging habitats	Minor, because of low likelihood of a large oil spill occurrence. However, would be major in the event that this occurred. Effects to Sag Delta, nearshore waterfowl brood rearing, seabird foraging, shorebird staging habitats

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-5
* (See Note Below) - **Effects of Liberty Development Alternatives on Terrestrial Mammals**

Project Component		Alternatives: Point Brower	Alternatives: Kadleroshilik River	Alternatives: Liberty Island	Alternatives: SDI Expansion
Development Pads	Description	New Pad 45 acres, onshore	New Pad 40 acres, onshore	New Island 22.4 acres, offshore	Pad expansion 20 acres, nearshore
	Effect	Minor coastal insect relief and foraging, habitat loss disturbance displacement (caribou, arctic fox, arctic ground squirrel)	Minor coastal insect relief and foraging, habitat loss disturbance displacement (caribou, arctic fox, arctic ground squirrel)	None	None
Access	Description	New Road 7.3 miles (62 acres), 3 bridges	New Road 15.2 miles (129 acres), 7 bridges	Air and Boat Traffic	Existing road
	Effect	62 acres coastal, riparian tundra habitat loss in Sag Delta, displacement from coastal mudflat and spit insect relief habitats, displacement from potential bear denning habitat (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel). Traffic disturbance and collision mortality.	129 acres coastal, riparian tundra habitat loss in Sag Delta and across Kadleroshilik, displacement from coastal and riparian insect relief habitats, displacement from potential bear denning habitat (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel). Traffic disturbance and collision mortality.	Air traffic disturbance from Deadhorse to Liberty Island to caribou calving and coastal and riparian insect relief habitats.	Existing effects
Power lines	Description	Buried in road	Buried in road	None	Buried in road
	Effect	7.3 miles construction disturbance during summer installation (caribou, muskoxen, grizzly bear, arctic fox).	15.2 miles construction disturbance during summer installation (caribou, muskoxen, grizzly bear, arctic fox).	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Oil spills - Sag Delta, Foggy Island; insect relief, foraging, denning habitats (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel)	Oil spills - Kadleroshilik, Shaviovik; insect relief, foraging, denning habitats (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel)	Oil spills - Foggy Island Bay, Sag Delta, Kadleroshilik Delta, Shaviovik Delta; insect relief, foraging habitats (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel)	Oil spills from existing lines - Sag Delta - existing pipeline; foraging, insect relief, denning habitats (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel)

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-5 (Cont'd)
Effects of Liberty Development Alternatives on Terrestrial Mammals

Project Component		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
		Alternatives			
Construction	Description	Primary construction in winter - following summer grade and smooth road/pads	Primary construction in winter - following summer grade and smooth road/pads	Primary construction in winter - following summer grade and smooth island	Primary construction in winter - following summer grade and smooth island
	Effect	Winter - disturbance of bear dens; Summer smoothing/compaction - disturbance to insect relief, foraging habitats (caribou, muskoxen, grizzly bears, arctic foxes)	Winter - disturbance of bear dens; Summer smoothing/compaction - disturbance to insect relief, foraging habitats (caribou, muskoxen, grizzly bears, arctic foxes)	None	None
Gravel Source	Description	Sagavanirktok Pit - 1,040,000 yd^3 (63 acres)	Sagavanirktok and Kadleroshilik Pits - 1,570,000 yd^3 (89 acres)	Kadleroshilik Pit - 797,600 yd^3 (31 acres)	Sagavanirktok Pit - 860,000 yd^3 (50 acres)
	Effect	63-acre coastal tundra habitat loss or alteration - foraging, denning habitats (caribou, grizzly bear, arctic fox, arctic ground squirrel)	89-acre coastal tundra and riparian habitat loss or alteration - foraging, migration, denning (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel)	31-acre riparian habitat loss or alteration - foraging, insect relief, migration, denning (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel)	50-acre coastal habitat loss or alteration - foraging, denning habitats (caribou, grizzly bear, arctic fox, arctic ground squirrel)
Operations	Description	Production	Production	Production	Production
	Effect	Minor, because of low likelihood of a large oil spill occurrence. In the event of a large spill, areas for inspect relief, and foraging in Sag Delta may be unavailable (caribou, muskoxen, grizzly bear, arctic fox)	Minor, because of low likelihood of a large oil spill occurrence. In the event of a large spill, areas for inspect relief, and foraging in Kadleroshilik and Sagavanirktok river deltas may be unavailable (caribou, muskoxen, grizzly bear, arctic fox)	Minor, because of low likelihood of a large oil spill occurrence. In the event of a large spill, areas for inspect relief, and foraging in Kadleroshilik and Sagavanirktok river deltas may be unavailable (caribou, muskoxen, grizzly bear, arctic fox)	Minor, because of low likelihood of a large oil spill occurrence. In the event of a large spill, areas for inspect relief, and foraging in Sag Delta may be unavailable (caribou, muskoxen, grizzly bear, arctic fox)

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-6

* (See Note Below) - **Effects of Liberty Development Alternatives on Terrestrial and Wetland Vegetation**

Project Component		Alternatives			
		Point Brower	**Kadleroshilik River**	**Liberty Island**	**SDI Expansion**
Development Pads	Description	New pad 45 acres	New pad 40 acres	New island 22.4 acres	Pad expansion 20 acres
	Effect	Burial of vegetation, possible changes to drainage patterns altering community types and species composition of surrounding tundra	Burial of vegetation, possible changes to drainage patterns altering community types and species composition of surrounding tundra	None	None
Access Roads	Description	New 7.3 miles (62 acres), 3 bridges	New 15.2 miles (129 acres), 7 bridges	None	None
	Effect	Burial of vegetation, potential changes to drainage patterns altering community types and species composition of surrounding tundra, dust from road travel possibly thinning vegetation, altering species composition and soil properties	Burial of vegetation, potential changes to drainage patterns altering community types and species composition of surrounding tundra, dust from road travel possibly thinning vegetation, altering species composition and soil properties	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Oil spills, possible disturbance to organic mat during construction (ice roads), insignificant effect of small refined-oil spills	Oil spills, possible disturbance to organic mat during construction (ice roads), insignificant effect of small refined-oil spills	Oil spills, possible disturbance to organic mat during construction (ice roads), insignificant effect of small refined-oil spills	None
Gravel Placement	Description	1,040,000 yd^3	1,570,000 yd^3	797,600 yd^3	860,000 yd^3
	Effect	Loss of terrestrial and wetland vegetation at roads, pads and mine site	Loss of terrestrial and wetland vegetation at roads, pads and mine site	Loss of terrestrial and wetland vegetation at mine sire only	Loss of terrestrial and wetland vegetation at mine site only
Operations	Description	Production	Production	Production	Production
	Effect	Large oil spill threat to terrestrial and wetland vegetation communities	Large oil spill threat to terrestrial and wetland vegetation communities	Large oil spill threat to coastal vegetation communities	Minor, unless in the unlikely event of a large oil spill then threat to coastal vegetation communities

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-7
* (See Note Below) - **Effects of Liberty Development Alternatives on Bowhead Whales**

Project Component		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
		Alternatives			
Development Pads	Description	New pad 45 acres	New pad 40 acres	New island 22.4 acres	Pad expansion 20 acres
	Effect	Negligible noise and activity disturbances from construction during fall migration.	Negligible noise and activity disturbances from construction during fall migration	Moderate noise and activity disturbances from construction during fall migration, potential for offshore displacement during fall migration, insignificant loss of marine habitat	Negligible noise and activity disturbances from construction during fall migration
Access Roads	Description	New 7.3 miles (62 acres), 3 bridges	New 15.2 miles (129 acres), 7 bridges	None	None
	Effect	None	None	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Minor unless large oil spill in marine environment	Minor unless large oil spill in marine environment	Minor unless large oil spill in marine environment	Minor unless oil spills from existing lines
Gravel Placement	Description	1,040,000 yd^3	1,570,000 yd^3	797,600 yd^3	860,000 yd^3
	Effect	None	None	None	None
Operations	Description	Production	Production	Production	Production
	Effect	Reduced risk of large oil spill in marine environment	Reduced risk of large oil spill in marine environment	Minor, because of low likelihood of a large oil spill occurrence. Moderate noise and activity disturbances, potential for offshore displacement of fall migration	Minor, because of low likelihood of a large oil spill occurrence. Negligible noise and activity disturbances, unlikely potential for offshore displacement during fall migration

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-8
* (See Note Below) - **Effects of Liberty Development Alternatives on Spectacled and Steller's Eiders**

Project Component		Alternatives: Point Brower	Alternatives: Kadleroshilik River	Alternatives: Liberty Island	Alternatives: SDI Expansion
Communication Towers	Description	New tower	New tower	New tower	No new tower
	Effect	Minor of collision mortality, avian-predator perch sites	Minor of collision mortality, avian-predator perch sites	Elevated of collision mortality, avian-predator perch sites	None
Development Pads	Description	New pad 45 acres	New pad 40 acres	New island 22.4 acres	Pad expansion 20 acres
	Effect	Potential loss of tundra nesting habitat, moderate noise and activity disturbances during nesting season, low risk of collision mortality, potential for predator denning/nesting habitat	Potential loss of tundra nesting habitat, moderate noise and activity disturbances during nesting season, low risk of collision mortality, potential for predator denning/nesting habitat	Insignificant loss of marine habitat, negligible noise and activity disturbances during nesting season, elevated risk of collision mortality, minimal potential for predator denning/nesting habitat	Insignificant loss of marine habitat, negligible noise and activity disturbances during nesting season, elevated risk of collision mortality, potential for predator denning/nesting habitat
Access Roads	Description	New 7.3 miles (62 acres), 3 bridges	New 15.2 miles (129 acres), 7 bridges	None	None
	Effect	Potential loss or alteration of tundra nesting habitat, moderate noise and activity disturbances, risk of vehicular collision mortality	Potential loss or alteration of tundra nesting habitat, moderate noise and activity disturbances, risk of vehicular collision mortality	None	None
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect	Large oil spills, avian-predator perch sites	Large oil spills, avian-predator perch sites	Large oil spills, avian-predator perch sites	Large oil spills from existing lines, minimal noise and activity disturbances if constructed during open-water season, no new avian perch sites (new gas and water pipelines will parallel existing pipelines)
Gravel Placement	Description	1,040,000 yd^3	1,570,000 yd^3	797,600 yd^3	860,000 yd^3
	Effect	Potential loss or alteration of tundra nesting habitat	Potential loss or alteration of tundra nesting habitat	Potential loss or alteration of tundra nesting habitat	Potential loss or alteration of tundra nesting habitat

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that “significant” findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-8 (Cont'd)
Effects of Liberty Development Alternatives on Spectacled and Steller's Eiders

Project Component		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
		Alternatives			
Operations	Description	Production	Production	Production	Production
	Effect	Minor, because of low likelihood of a large oil spill occurrence. Moderate noise and activity disturbances during nesting season	Minor, because of low likelihood of a large oil spill occurrence. Moderate noise and activity disturbances during nesting season	Minor, because of low likelihood of a large oil spill occurrence. Negligible noise and activity disturbances during nesting season	Minor, because of low likelihood of a large oil spill occurrence. Negligible noise and activity disturbances during nesting season

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-9

* (See Note Below) - **Effects of Liberty Development Alternatives on Subsistence, Sociocultural, and Environmental Justice**[1]

Project Component		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
		Alternatives			
Development Pads	Description	New pad 45 acres, onshore	New pad 40 acres, onshore	New island 22.4 acres, offshore	Pad expansion 20 acres, nearshore
	Effect	Subsistence: Insignificant; negligible habitat loss, minor effects of small refined oil spills and activity disturbances. Sociocultural: Insignificant; no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant	Subsistence: Insignificant; negligible habitat loss, minor effects of small refined oil spills and activity disturbances. Sociocultural: Insignificant; no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant	Subsistence: Insignificant; negligible habitat loss, minor effects of small refined oil spills and activity disturbances. Sociocultural: Insignificant; no material impacts on subsistence; more, but still few FTEs, compared to other alternatives. Environmental Justice: Insignificant	Subsistence: Insignificant; negligible habitat loss, minor effects of small refined oil spills and activity disturbances. Sociocultural: Insignificant; no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant
Access Roads	Description	New road 7.3 miles (62 acres), 3 bridges	New road 15.2 miles (110 acres), 2 bridges	No roads, but air and boat traffic	Existing road
	Effect	Subsistence: Insignificant; negligible habitat loss, minor effects of small refined oil spills and activity disturbances. No effects on bowhead whales. Sociocultural: Insignificant, no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant	Subsistence: Insignificant; negligible habitat loss, minor effects of small refined oil spills and activity disturbances. No effects on bowhead whales. Sociocultural: Insignificant, no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant	Subsistence: Insignificant; no habitat loss, air traffic disturbance from Deadhorse to Liberty Island to caribou calving and coastal and riparian insect relief habitats. No effects on bowhead whales. Sociocultural: Insignificant, no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant	Subsistence: Insignificant; no incremental habitat loss, minor effects of small refined oil spills and activity disturbances. No effects on bowhead whales. Sociocultural: Insignificant, no material impacts on subsistence; relatively few incremental FTEs. Environmental Justice: Insignificant

[1] All alternatives have similar (and generally positive) economic impacts. Qualitative assessments of significance of impacts assume that mitigating measures identified in this document are implemented.

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-9 (Cont'd)
Effects of Liberty Development Alternatives on Subsistence, Sociocultural, and Environmental Justice

Project Component		Alternatives			
		Point Brower	Kadleroshilik River	Liberty Island	SDI Expansion
Pipelines	Description	New 15.2 miles onshore, 3 bridges	New 11.5 miles onshore, 2 bridges	New 1.5 miles onshore, 6.1 miles offshore	No new oil pipeline; new gas and water lines on existing 3-mile-long Endicott causeway
	Effect[2]	Subsistence: Insignificant; possible disturbance to fish overwintering sites at river crossings during construction, insignificant effect of small refined-oil spills. Sociocultural: Insignificant Environmental Justice: Insignificant	Subsistence: Insignificant; possible disturbance to fish overwintering sites at river crossings during construction, insignificant effect of small refined-oil spills. Sociocultural: Insignificant Environmental Justice: Insignificant	Subsistence: Insignificant; oil spills, temporary and minor alteration of marine habitat from turbidity during construction, insignificant effect of small refined-oil spills Sociocultural: Insignificant Environmental Justice: Insignificant	Subsistence: Insignificant; maximizes utilization of existing infrastructure, possible disturbance to fish overwintering site on lagoon side of causeway, insignificant effect of small refined-oil spills. Sociocultural: Insignificant Environmental Justice: Insignificant
Gravel Source	Description	Sagavanirktok Pit - 1,040,000 yd^3 (63 acres)	Sagavanirktok and Kadleroshilik Pits - 1,570,000 yd^3 (89 acres)	Kadleroshilik Pit - 797,600 yd^3 (31 acres)	Sagavanirktok Pit - 860,000 yd^3 (35 acres)
	Effect	Subsistence: Insignificant. No risk to bowhead whales. 63 acre coastal tundra habitat loss or alteration - foraging, denning habitats (caribou, grizzly bear, arctic fox, arctic ground squirrel). Sociocultural: Insignificant; effects on cultural resources mitigated by survey and consultation process. Environmental Justice: Insignificant	Subsistence: Insignificant. No risk to bowhead whales. 89 acre coastal tundra and riparian habitat loss or alteration - foraging, migration, denning (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel). Sociocultural: Insignificant; effects on cultural resources mitigated by survey and consultation process. Environmental Justice: Insignificant	Subsistence: Insignificant. No risk to bowhead whales. 31 acre riparian habitat loss or alteration - foraging, insect relief, migration, denning (caribou, muskoxen, grizzly bear, arctic fox, arctic ground squirrel). Sociocultural: Insignificant; effects on cultural resources mitigated by survey and consultation process. Environmental Justice: Insignificant	Subsistence: Insignificant. No risk to bowhead whales. alteration - foraging, denning habitats (caribou, grizzly bear, arctic fox, arctic ground squirrel). Sociocultural: Insignificant; effects on cultural resources mitigated by survey and consultation process. Environmental Justice: Insignificant

[2] Infrastructure effects discussed in this table, such as pipelines, refer to effects during construction. Impacts during operation of these facilities are included under the heading of "operations." Thus, for example, impacts of oil spills from pipelines are included under "operations."

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.5-9 (Cont'd)
Effects of Liberty Development Alternatives on Subsistence, Sociocultural, and Environmental Justice

Project Component		Alternatives			
		Point Brower	**Kadleroshilik River**	**Liberty Island**	**SDI Expansion**
Operations	Description	Production	Production	Production	Production
	Effect	Subsistence: Minor, because of low likelihood of a large oil spill that would impact subsistence resources. Negligible noise and activity disturbances, unlikely potential for offshore displacement during fall bowhead migration. Oil spill threat to Sagavanirktok Delta; insect relief, foraging (caribou, muskoxen, grizzly bear, arctic fox). Sociocultural: Probably minor unless subsistence resource impacts resulted from large oil spill. Environmental Justice: Probably minor unless subsistence resource impacts resulted from large oil spill.	Subsistence: Minor, because of low likelihood of a large oil spill that would impact subsistence resources. Negligible noise and activity disturbances, unlikely potential for offshore displacement during fall bowhead migration. Oil spill threat to Kadleroshilik and Sagavanirktok river deltas; insect relief, foraging (caribou, muskoxen, grizzly bear, arctic fox). Sociocultural: Probably minor unless subsistence resource impacts resulted from large oil spill. Environmental Justice: Probably minor unless subsistence resource impacts resulted from large oil spill.	Subsistence: Minor, because of low likelihood of a large oil spill that would impact subsistence resources. Likelihood of an offshore spill impacting bowhead whales, although low, is probably greater than any of the other alternatives considered. Moderate noise and activity disturbances, potential for offshore displacement of fall bowhead migration. Oil spill threat to Kadleroshilik and Sagavanirktok river deltas; insect relief, foraging (caribou, muskoxen, grizzly bear, arctic fox). Sociocultural: Probably minor unless subsistence resource impacts resulted from large oil spill. Environmental Justice: Probably minor unless subsistence resource impacts resulted from large oil spill.	Subsistence: Minor, because of low likelihood of a large oil spill that would impact subsistence resources. Negligible noise and activity disturbances, unlikely potential for offshore displacement during fall bowhead migration. Oil spill threat to Sagavanirktok Delta; insect relief, foraging (caribou, muskoxen, grizzly bear, arctic fox). Sociocultural: Probably minor unless subsistence resource impacts resulted from large oil spill. Environmental Justice: Probably minor unless subsistence resource impacts resulted from large oil spill.

* Note: Reviewers of both the Environmental Impact Analysis (EIA) submitted with the DPP and this EA will note that "significant" findings discussed in the EIA have been modified to reflect: (1) MMS analysis of potential impact; (2) MMS significance thresholds; and (3) additional mitigation measures identified subsequent to submittal of the DPP, which have been incorporated in the proposed action or become requirements for the proposed action.

Table 3.6-1
Some Perspectives on Possible Cumulative Effects

Expected oil and gas activities are likely to have fewer impacts on the environment than those activities conducted in the early years of the region's development. More rigorous environmental standards and more environmentally prudent industry practices now exist, which include smaller facility "footprints," fewer roads, directional drilling from onshore, elimination of most discharges into the water, practices that avoid damage to the tundra, and better working relations with the local residents.
Current industry practices and the environmental state of the North Slope/Beaufort Sea region frequently are observed and assessed, and much of this information is available to the public. This information and the ongoing dialogue about environmental issues among Federal, State, and local government agencies; Iñupiat regional and village corporations; industry; interest groups; and the public should continue to increase environmental awareness and encourage environmentally sound practices that, in turn, should help reduce the potential for environmental damage.
A key element of the transportation system for development of North Slope/Beaufort Sea oil is the Trans-Alaska Pipeline System pipeline. The pipeline is 800 miles long, stretching from Pump Station 1 at Prudhoe Bay to the Valdez Marine Terminal and, if we choose a corridor width of about 100 feet, it represents an area of about 16 square miles. This pipeline is expected to continue to serve as existing infrastructure for all foreseeable future oil production, eliminating the need for the construction of new oil pipelines other than feeder pipelines.
Following the Exxon Valdez oil spill, substantive improvements have been made in tanker safety to reduce the potential for oil spills from tanker accidents. These include a mandatory phase-in of double-hulled tankers, better navigational systems, and tanker escorts. In addition, oil-spill response capabilities for tanker-related oil spills in Prince William Sound have been increased substantially through additional equipment, personnel, training, and exercises. These initiatives were developed specifically to reduce the potential for future tanker accidents and to lessen effects, should spills occur.
If a major spill occurred, there likely would be a great slowdown in new development during which additional safeguards certainly would be put in place and new ideas of pipeline placement and design would be researched. Just as the additional safeguards resulting from the Exxon Valdez oil spill, the likelihood of an additional oil spill from the same causative factors and to the same resources would be reduced. This emphasis on preventing a similar incident further would ensure the full recovery of those resources from the initial spill.
The actual size and location of future oil and gas developments on the North Slope and in the Beaufort Sea are uncertain. The actual effects on natural resources and the human environment that may result from such developments also are uncertain. Nevertheless, we have developed our best estimate of what those activities and effects might be. However, it is likely that projected actions or effects may not happen in a way that fits neatly into the scenarios we have established for this EIS.
The recommended alternative in the original EIS has been changed. The new proposal involves the use of ultra-extended reach drilling (uERD) from an onshore location. This design eliminates the offshore impacts of island and pipeline construction and significantly mitigated the potential offshore environmental impacts related to the Boulder Patch, marine mammals, and concerns of the North Slope Iñupiat communities related to the bowhead whale and subsistence whaling.

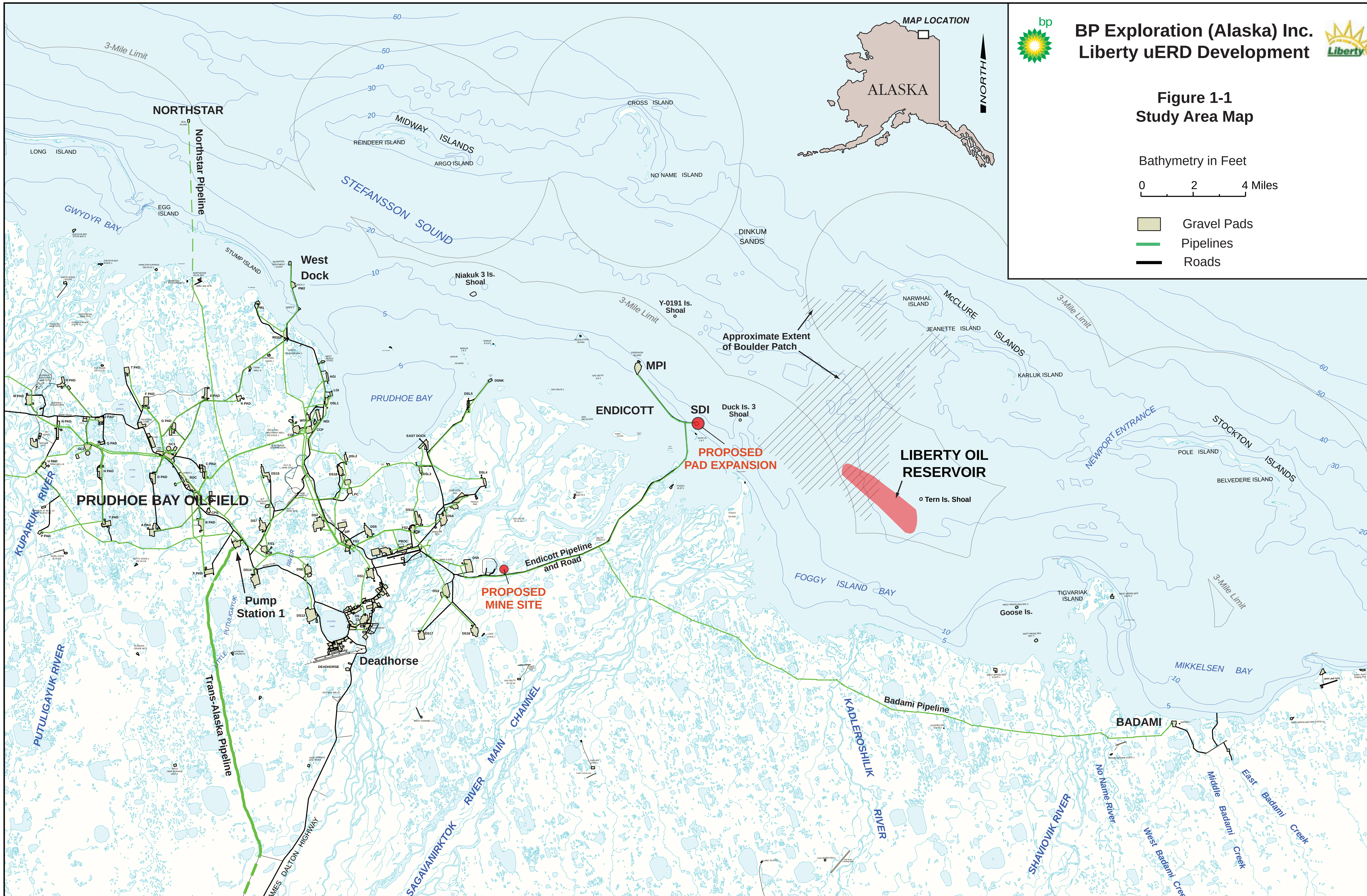
Source: The first six points are included in the Liberty FEIS (USDOI, MMS, 2002).

Table 4-1
Avoidance and Minimization of Environmental Impact during Design

Action	Benefit
Developed the oil reservoir from an existing oil and gas facility.	Avoid potential impacts in marine environment. Eliminates need for offshore pipeline with related concerns about spills and construction near Boulder Patch. Minimize the project footprint – no new roads or pads in undeveloped areas of the Sagavanirktok River delta and adjacent to Foggy Island Bay. Minimize air emissions (versus standalone facility with full processing). Provides year-round access to the drilling site and eliminates the need for a new road. Endicott facility has been studied extensively over the past 20 years with respect to fish and wildlife, water quality and other issues. This has benefited the design, environmental mitigation and assessment of potential impacts.
Site gravel mine outside active river floodplain. Mine gravel during winter according to approved mining plan. Use ice roads for gravel haul.	Minimize impacts to fish overwintering areas; Minimize bird impacts, including eiders; reduce or eliminate impacts due to increased dust from mining and gravel haul.
Designed facility for zero surface discharge of drilling wastes; no reserve pits.	Reduce drilling pad size and impacts to benthos; eliminate potential for contaminant release from reserve pits.
Use sheetpile for slope protection.	Reduces the seabed footprint (versus other slope protection systems). Reduces TSS concentrations in the water column from erosion of side slopes.
Meet with Federal, State, and local agencies early and frequently in project development to reaffirm critical issues and develop familiarity with project.	Verify critical issues early in project design; establish agency involvement in design and environmental mitigation early in process.
Reviewed and summarized existing data on oceanographic conditions and potential alterations due to expansion of Endicott SDI.	Identify potential project and cumulative impacts; minimize impacts within project design and operational constraints.
Reviewed and summarized existing data on use of Sagavanirktok Delta by anadromous and freshwater fish, marine mammals and birds.	Identify potential project and cumulative impacts; minimize impacts within project design and operational constraints.
Drilling rig to be powered by natural gas.	Reduce air emissions as a result of cleaner burning fuel.
Drilling engineers to meet with USFWS to discuss rig design and mitigation of raven reproduction.	Reduce potential increase in bird-predator populations.
Drilling engineers to meet with USFWS to discuss rig design and mitigation of light attraction by birds to newly constructed facilities.	Minimize bird strikes, including threatened eiders.
Conduct archeological survey of construction areas (mine site, etc.).	Avoid or minimize impacts to archeological and cultural resources.

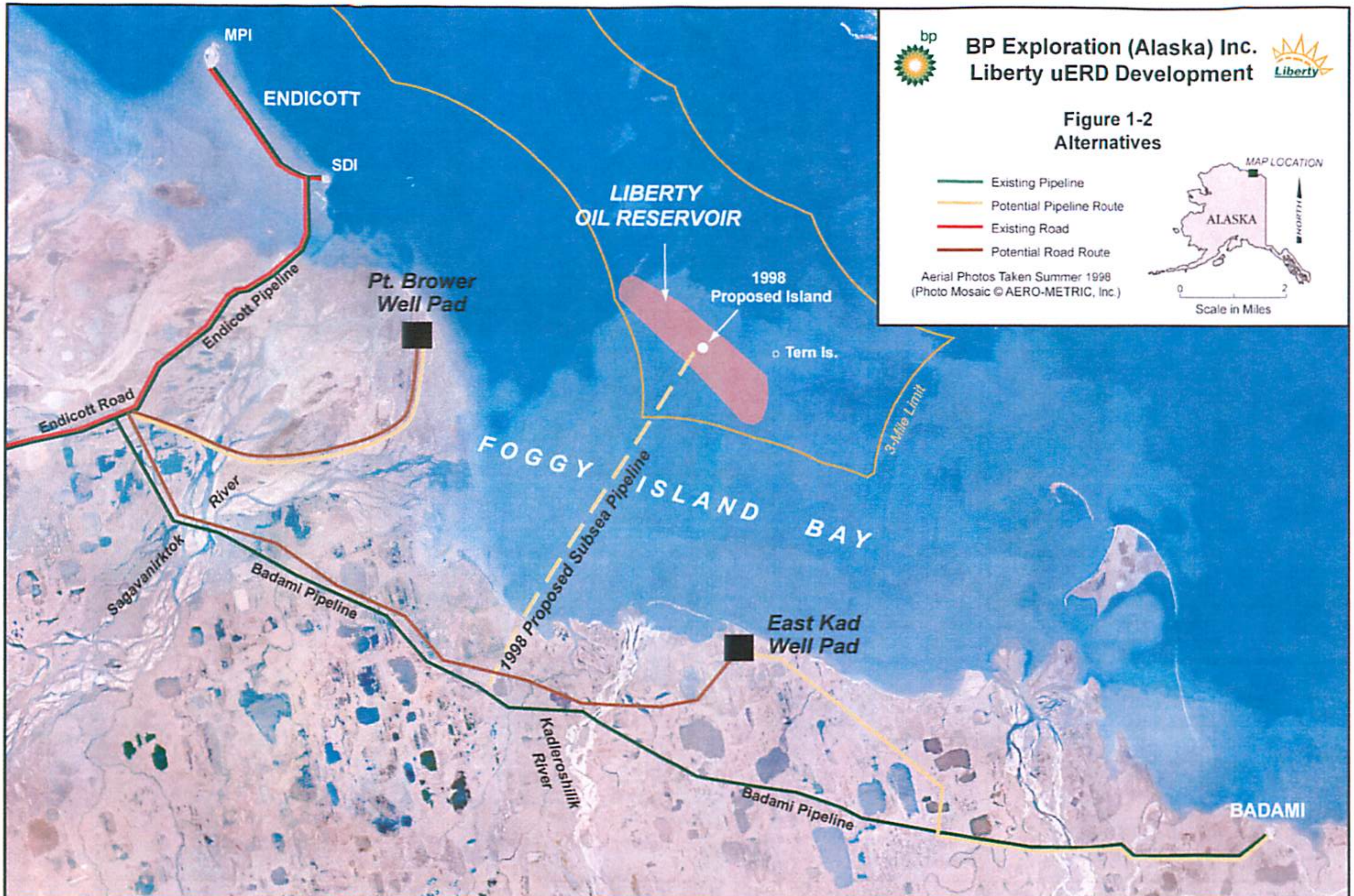
Table 4-2
Avoidance and Minimization of Environmental Impact during Construction and Operation

Action	Benefit
Use ice roads to construct Liberty Project and access temporary water sources; construct during winter.	Minimize impacts to tundra and disturbance to wildlife from permanent roads; minimize generation of dust.
House construction and drilling workers in existing facilities to the extent feasible.	Reduce temporary facilities on site; eliminate impacts of placement of new camps. Reduce potential for wildlife disturbance or attraction. Allow use of existing sewage treatment and other sanitation facilities.
Enforce speed limits along Endicott Road and other project areas.	Reduce wildlife impacts; reduce potential for accidents and spills both on road surface and onto tundra and sea ice; reduce generation of dust.
Coordinate with Alaska Department of Fish and Game. Identify and avoid grizzly bear den locations and avoid fish overwintering areas.	Avoid impacting bear dens and important fish resources in project area.
Coordinate with U.S. Fish and Wildlife Service on locations of polar bear den sites; perform surveys using FLIR/dogs along ice road route.	Avoid actions that would disturb denning polar bears.
Store food and dispose of solid wastes in wildlife-resistant facilities.	Minimize waste storage at project sites; reduce potential for wildlife population increase; avoid negative wildlife encounters.
Zero surface discharge of drilling wastes (disposal through grind and in injection well).	Avoid water quality impacts.
Drilling rig powered by natural gas.	Reduce air emissions and risks of fuel spills.
Route vessel traffic inshore and time sealift to occur outside of whaling season.	Minimize disturbance to marine mammals and subsistence whaling activities.
Maintain continual on-site environmental presence during construction and operation to ensure compliance with permit requirements.	Assure compliance with permits and environmental regulations and high level of environmental performance.
Remove bird-predator nests on facility structures; remove new fox dens constructed in facility structures.	Reduce the potential for increasing the abundance and distribution of bird predators.
Monitor for bird mortality from collision with facilities and vehicles.	Determine level of incidental take of protected species; assess potential effectiveness of mitigation measures.
Consult with Alaska Eskimo Whaling Commission on any marine activities (e.g., sealift). Develop Conflict Avoidance Agreement or similar mechanism with AEWC and local whalers, if necessary.	Minimize disturbance to migrating bowhead whales and conflicts with subsistence whaling activities.
If public access is restricted, prohibit hunting and fishing by project personnel within or via controlled access areas..	Provide equal access to fish and wildlife resources.
Train personnel in interactions with wildlife. Establish an environmental awareness program.	Increase awareness of risks and means to reduce impacts on wildlife.
Train personnel to recognize and avoid cultural resources.	Ensure that cultural resources are protected.



BP Exploration (Alaska) Inc.
Liberty uERD Development

Figure 1-1
Study Area Map



BP Exploration (Alaska) Inc.
Liberty uERD Development
Figure 1-2
Alternatives
Existing Pipeline
Potential Pipeline Route
Existing Road
Potential Road Route
Aerial Photos Taken Summer 1998
(Photo Mosaic © AERO-METRIC, Inc.)
MAP LOCATION
ALASKA
NORTH
0
2
Scale in Miles
MPI
ENDICOTT
SDI
LIBERTY
OIL RESERVOIR
1998
Proposed Island
Tern Is.
Pt. Brower
Well Pad
Endicott Pipeline
Endicott Road
FOGGY ISLAND BAY
3-Mile Limit
1998 Proposed Subsea Pipeline
River
Sagavanirktok
Badami Pipeline
East Kad
Well Pad
Kadleroshilik
River
Badami Pipeline
BADAMI

Figure 2.1-1
Location of the Meteorological Stations on the North Slope
Source: NCDC (2005)

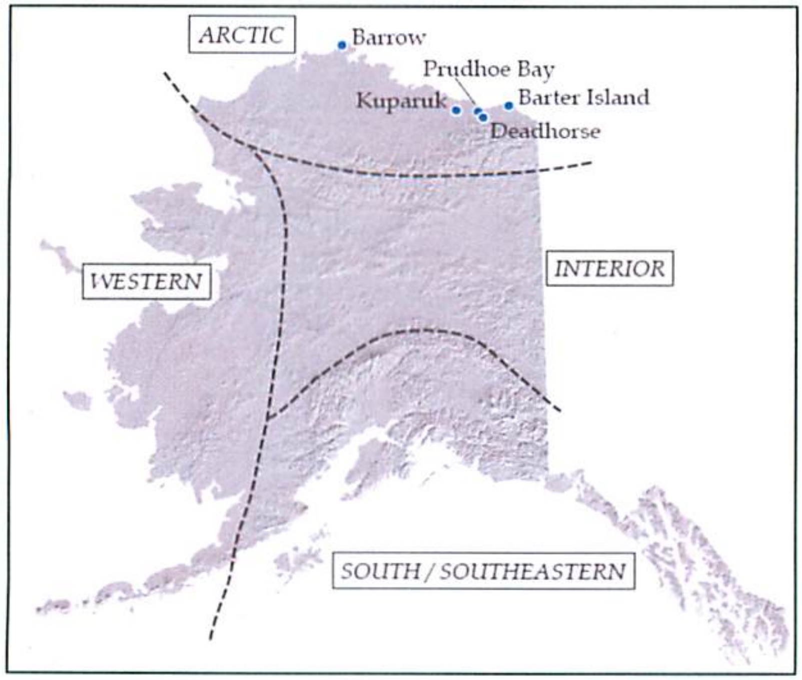


Figure 2.1-2
Annual Course of Temperature for Barrow (Mean High and Low, and Record Maximum and Record Minimum Based on the 30-Year Time Period 1975-2004)
Source: NCDC (2005)

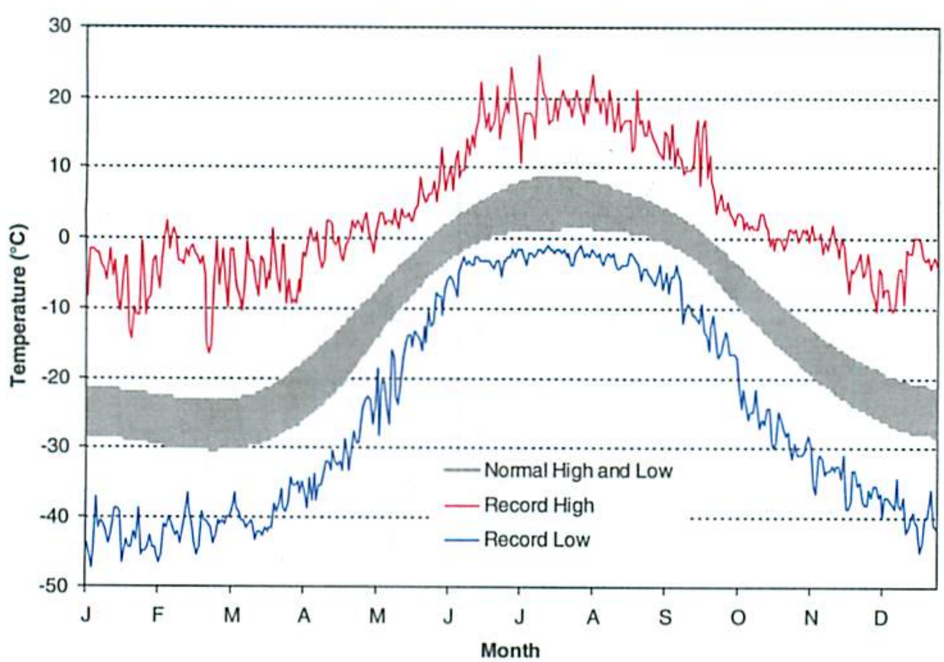


Figure 2.1-3
Mean Daily Snow Depth at Barrow and Barter Island
Source: NCDC (2005)

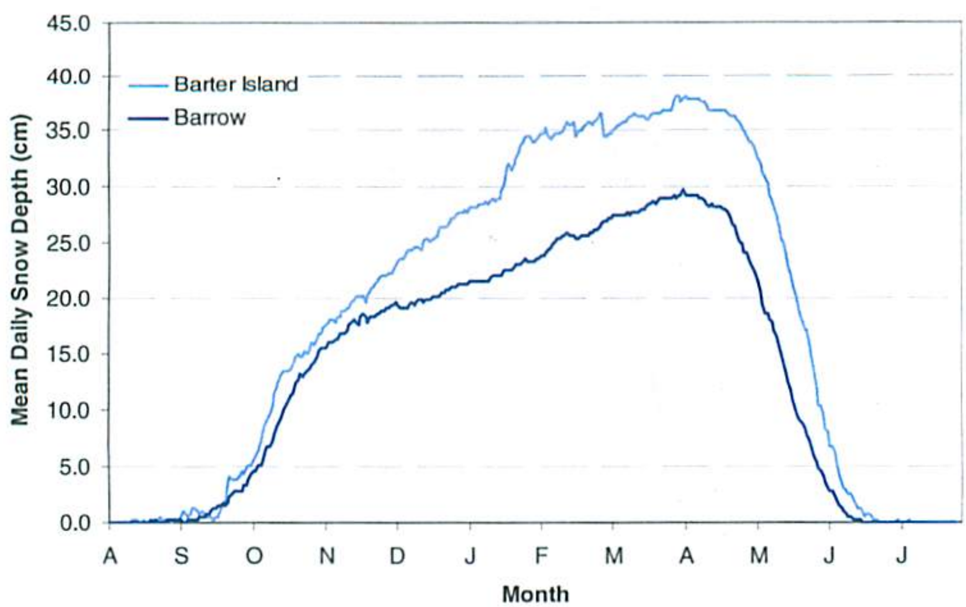


Figure 2.1-4
Wind Rose for Barrow
Source: NCDC (2005)

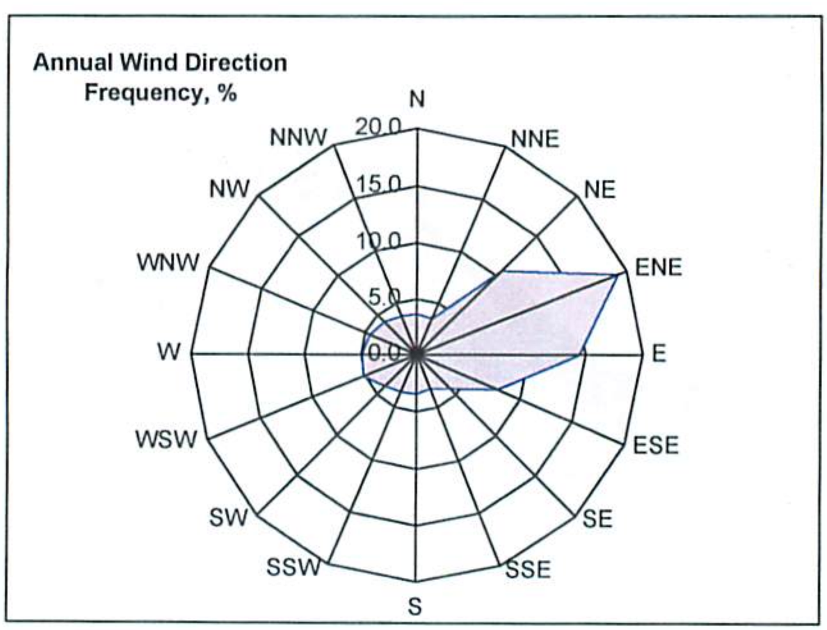


Figure 2.1-5
Number of Days per Year with Wind Speed in Excess of 30 kt at Barrow (1987-2003)
Source: NCDC (2005)

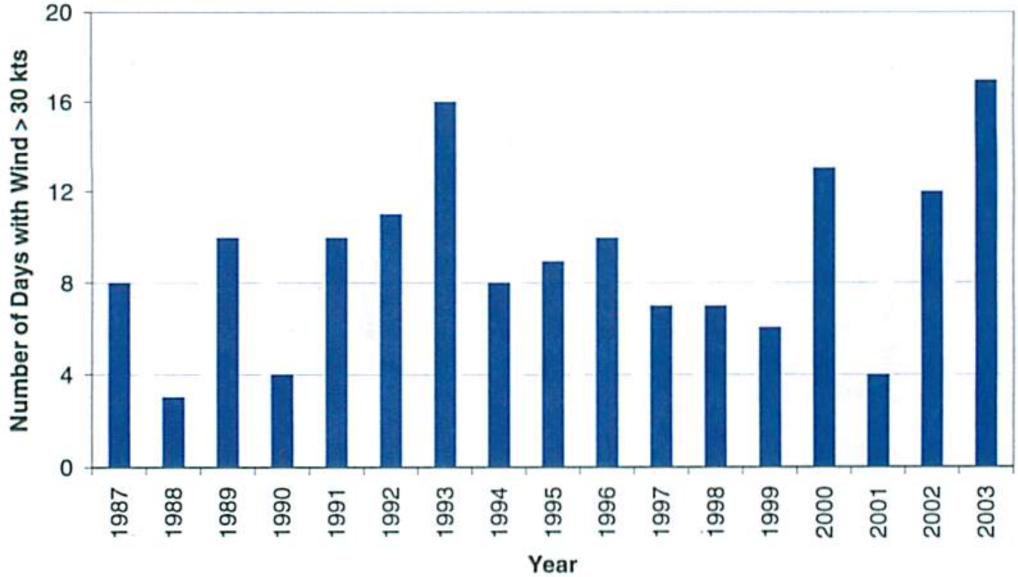


Figure 2.1-6
Mean Annual Temperatures for North Slope Climatological Stations
Source: NCDC (2005)

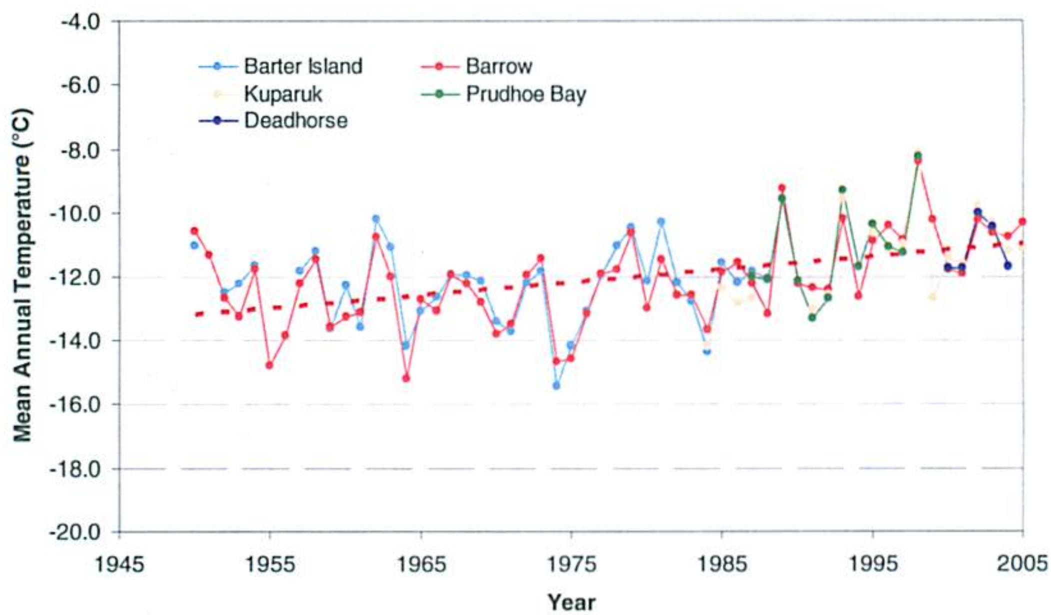


Figure 2.1-7
Mean Annual Ice Concentration in the Beaufort Sea for a 50-Km-Wide Strip off the Coast of Northern Alaska

Source: Wendler et al. (2003)

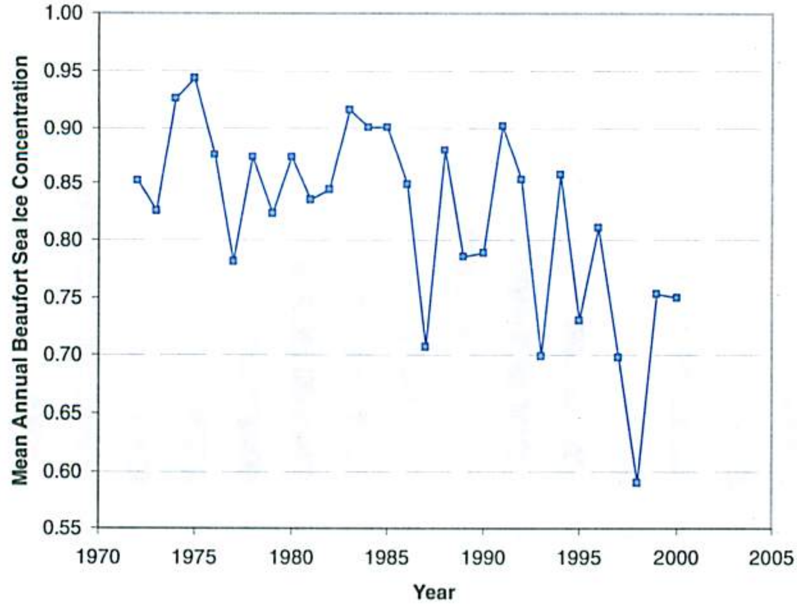


Figure 2.1-8
Number of Days per Year with a Daily Minimum Temperature Below -18°C and -34°C for Barrow (1949–2004)

Source: NCDC (2005)

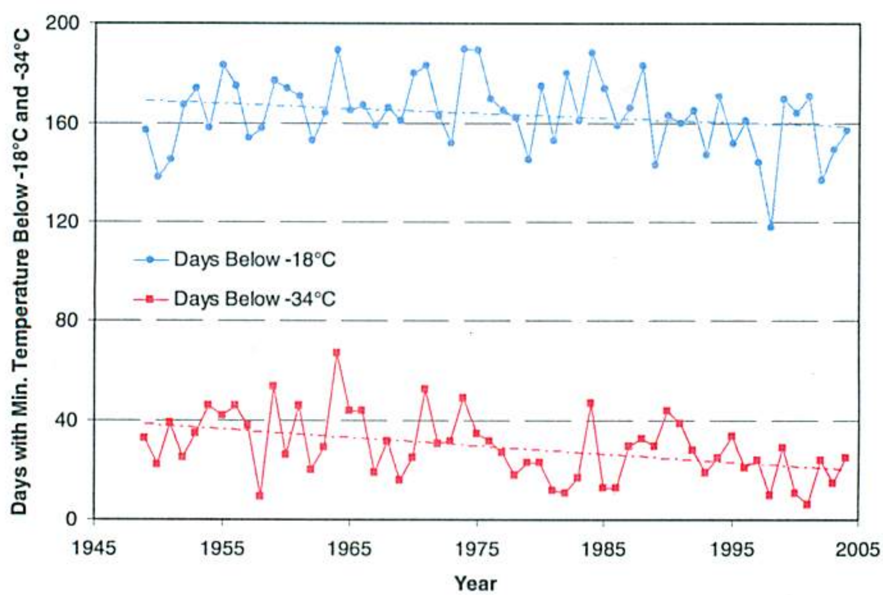


Figure 2.1-9
Number of Days per Year with a Daily Maximum Temperature Above 0°C and 10°C for Barrow (1949-2004)
Source: NCDC (2005)

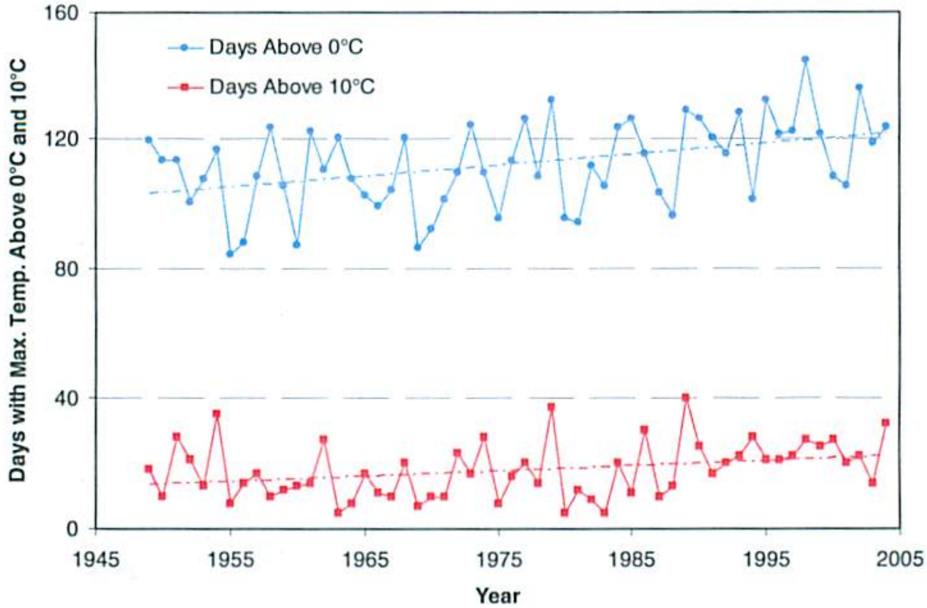


Figure 2.3-1
Foggy Island Bay and Sites of Bluff Erosion Studies
Source: NCDC (2005)

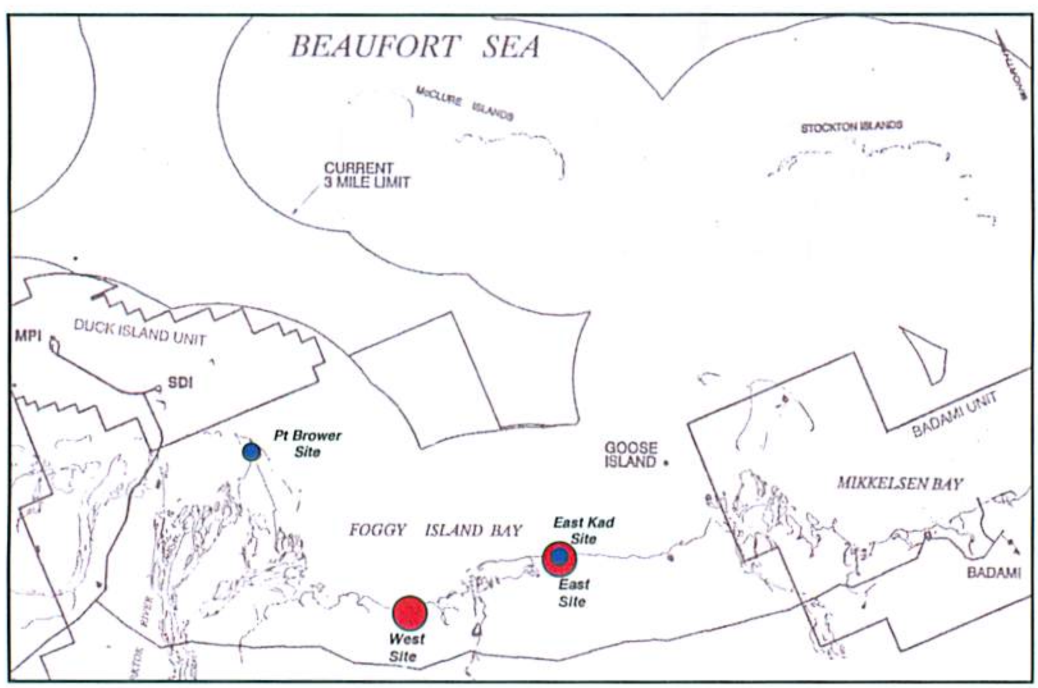


Figure 2.4-1
Wave Prediction Stations Near Endicott SDI
Source: Resio and Coastal Frontiers (2007)

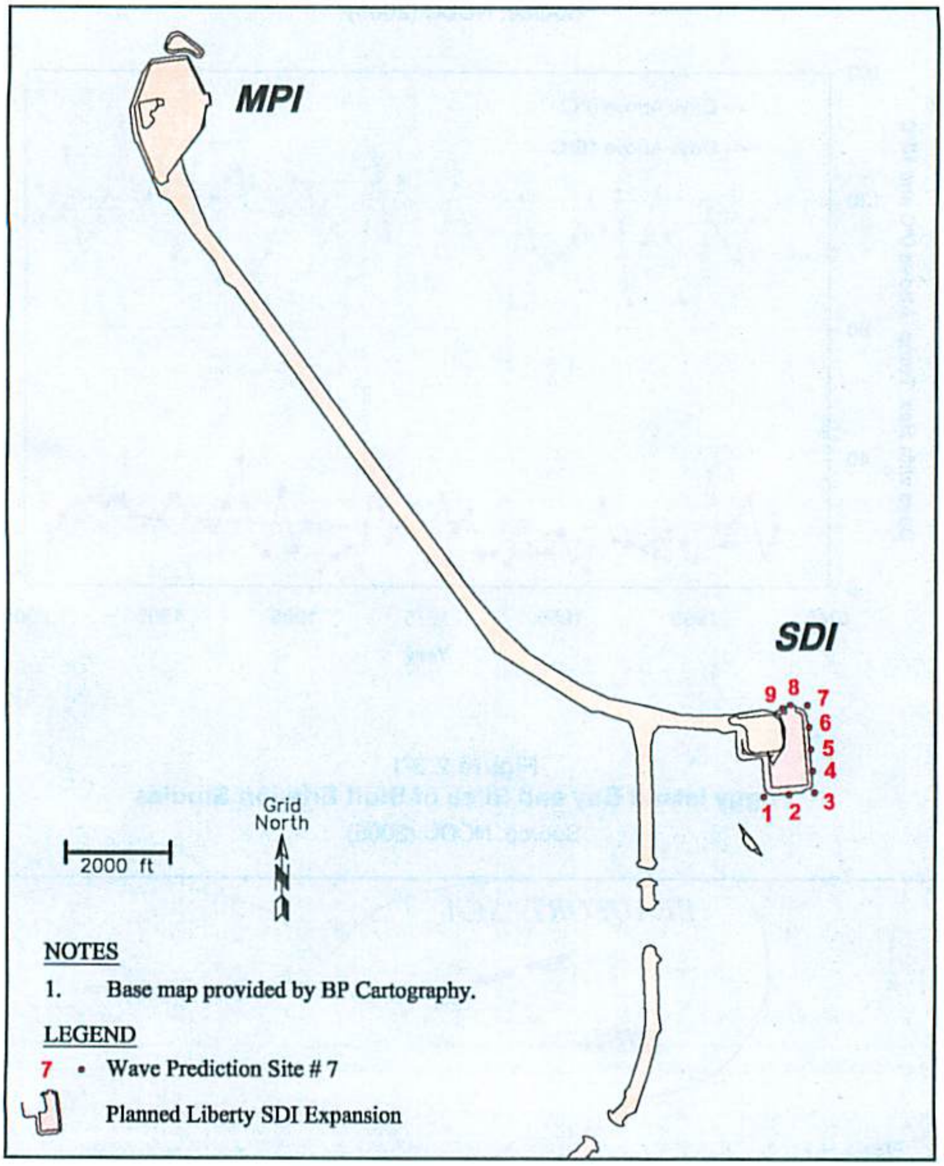


Figure 2.4-2
Mean Monthly Discharge in Sagavanirktok River, 1983-2005
(USGS Stream Gauge 15908000)
Source: USGS (2007)

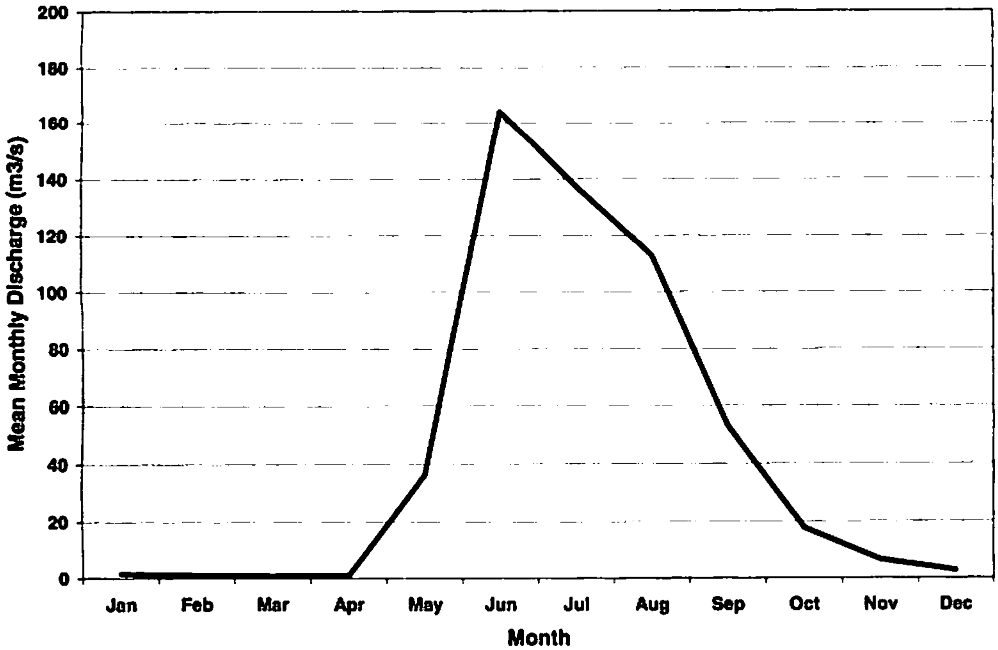


Figure 2.4-3
Average Daily Discharge in the Sagavanirktok River
(USGS Stream Gauge 15908000)
Source: USGS (2007)

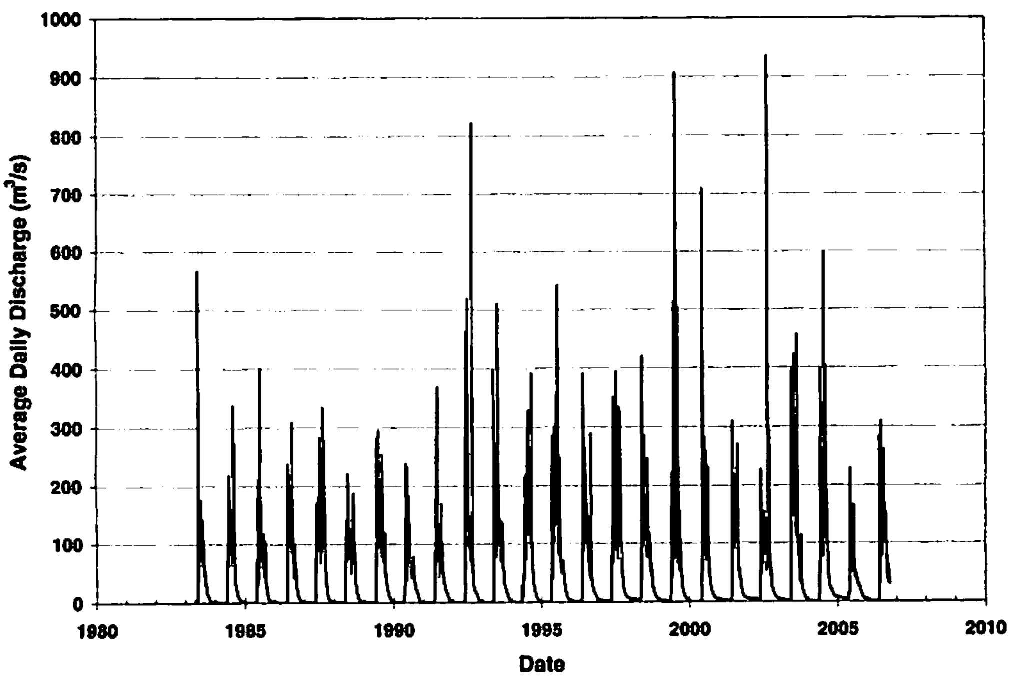


Figure 2.4-4
Historical River-Overflood Limits in Foggy Island Bay
Source: D.F. Dickins (1999) and Coastal Frontiers (2000, 2003a)

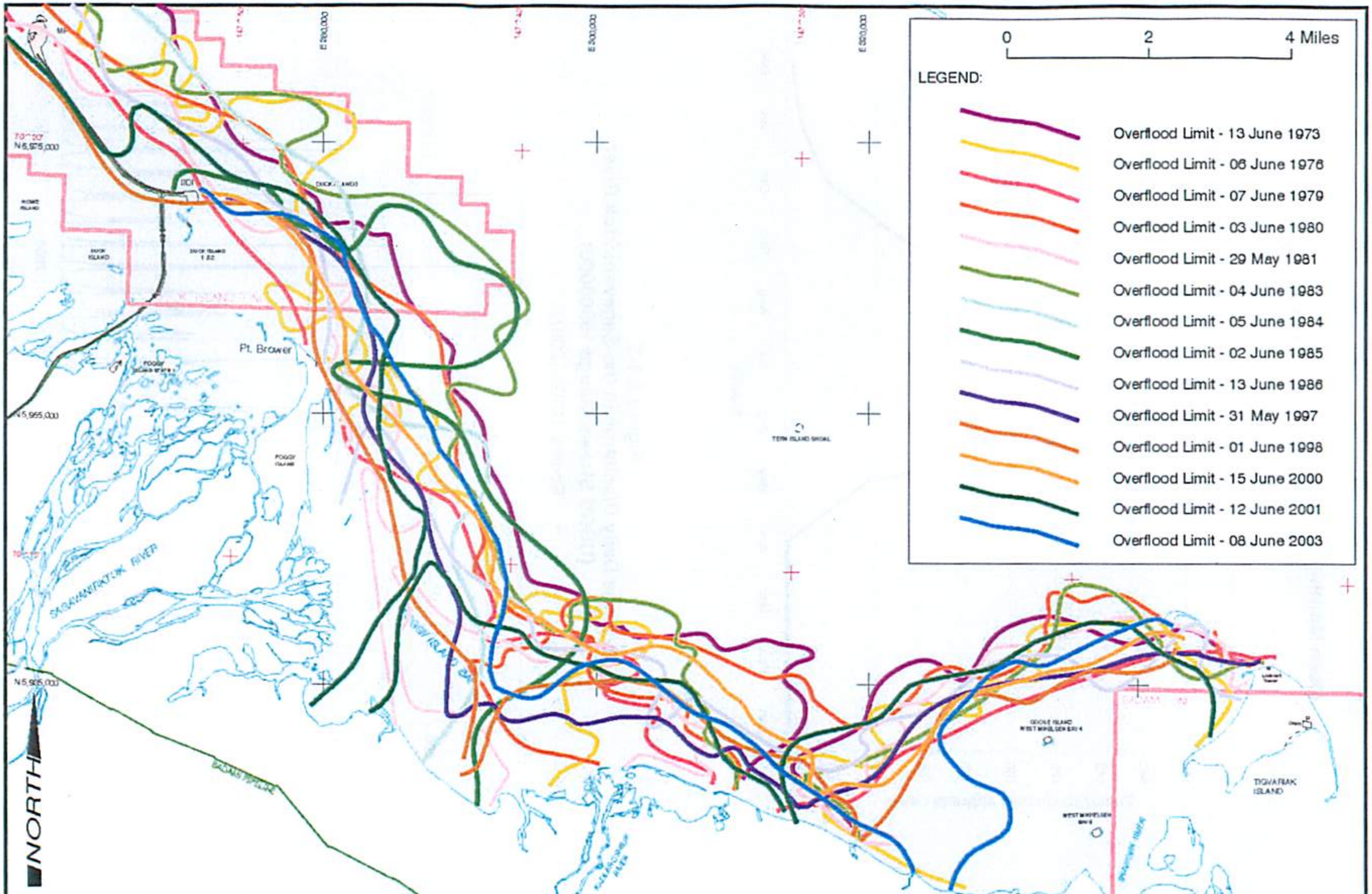


Figure 2.4-5
Ice Pile-up (7.5 m High) Encroached 40 ft onto the Slope of Tern Island during a 25-kt Southwesterly Storm on July 7, 1984

Source: K. Vaudry

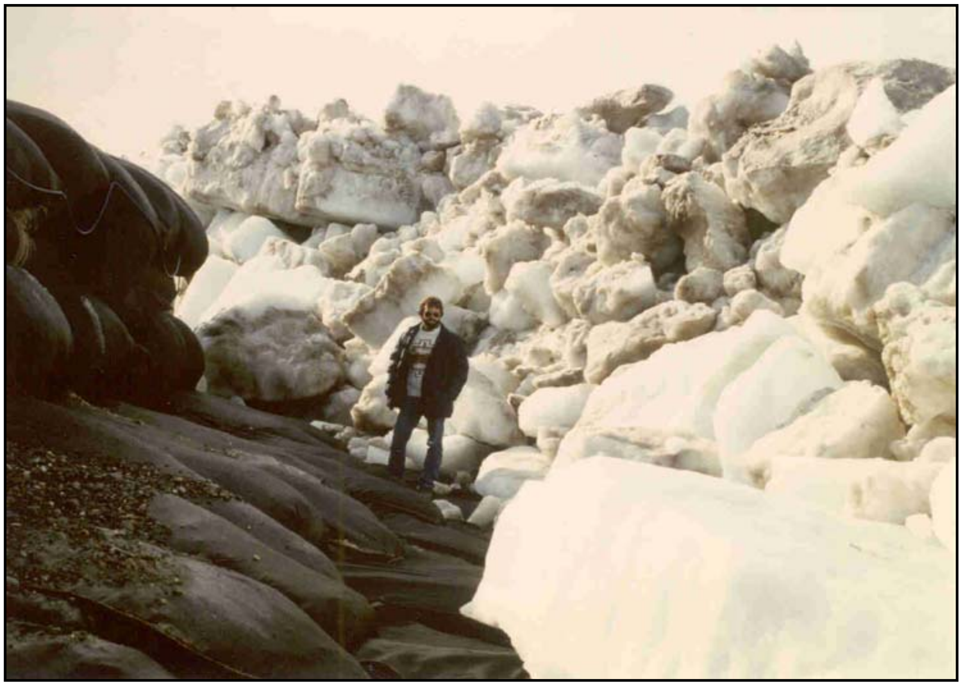


Figure 2.4-6
Ice Rubble Pile 6 m High Formed on West Side of the Duck Island 3 Manmade Gravel Island during a 20-kt Westerly Storm on 15-17 October 1984

Source: K. Vaudry

Figure 2.5-1
Interpolated Concentrations of TSS in Foggy Island Bay
Source: Dunton et al. (2005)

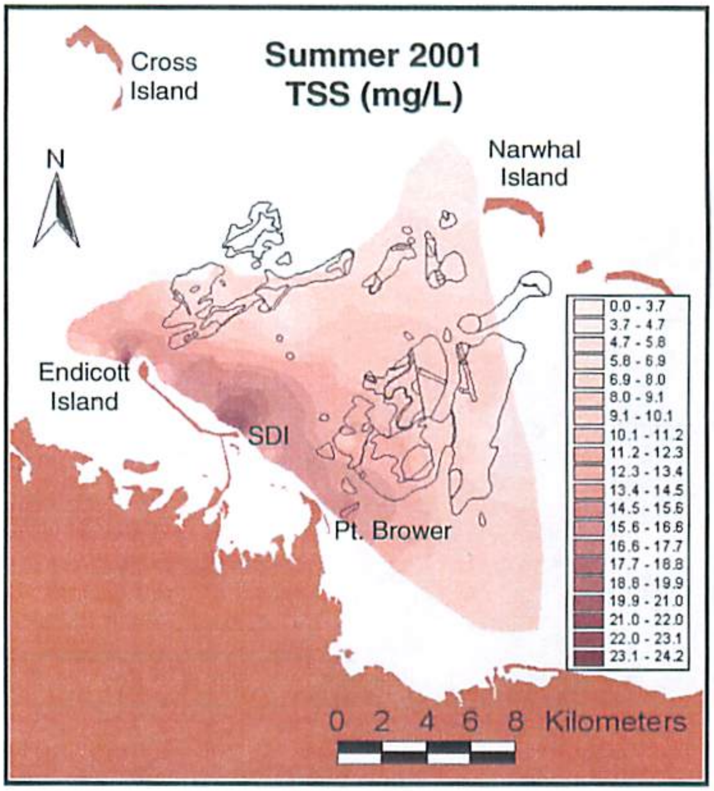


Figure 2.5-2
Concentrations of TSS and River Discharge for the Sagavanirktok River During Spring 2001
Source: Trefry et al. (2004a)

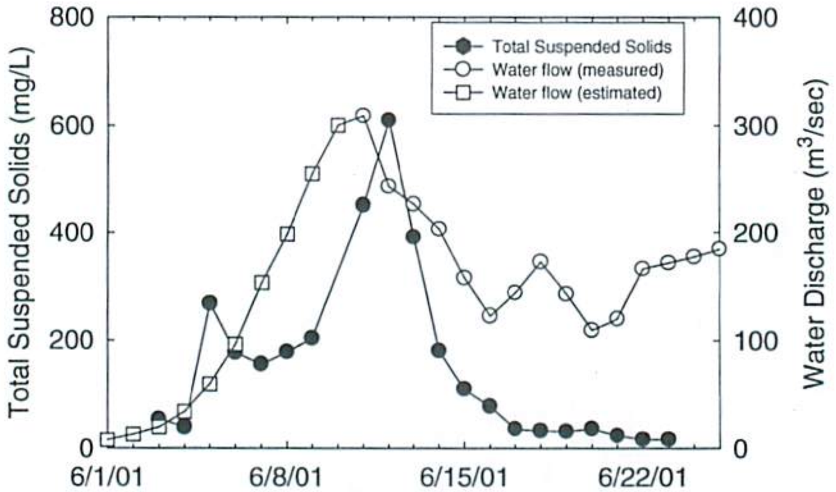


Figure 2.5-3
Concentrations in Sediment from the Coastal Beaufort Sea, Including Foggy Island Bay, for Al Versus (a) Cu, (b) Pb, (c) Hg and (d) Ba

Source: Trefry et al. (2003)

Equations are from linear regression calculations, r is the correlation coefficient and n is the total number of data points. Dashed lines above and below the regression line show the 99% prediction intervals. Points marked with large letters on selected graphs are for suspended sediment from the Sagavanirktok (S), Kuparuk (K) and Colville (C) rivers. Data for sites identified on the graph were not included in the regression calculations.

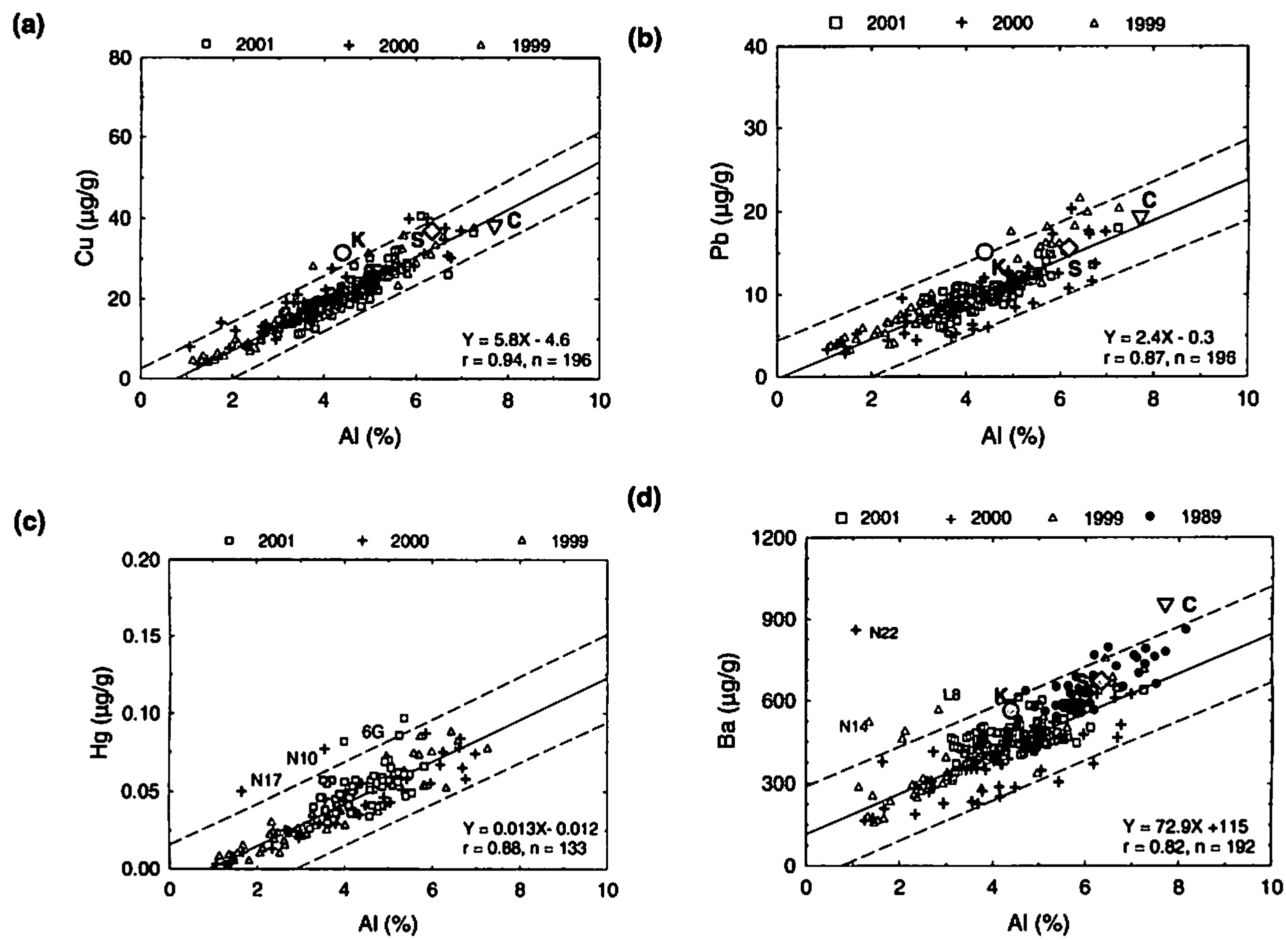


Figure 2.5-4
Trace Metal Concentrations in Clams (Astarte) from the Coastal Beaufort Sea, Including Foggy Island Bay

Source: Brown et al. (2004)

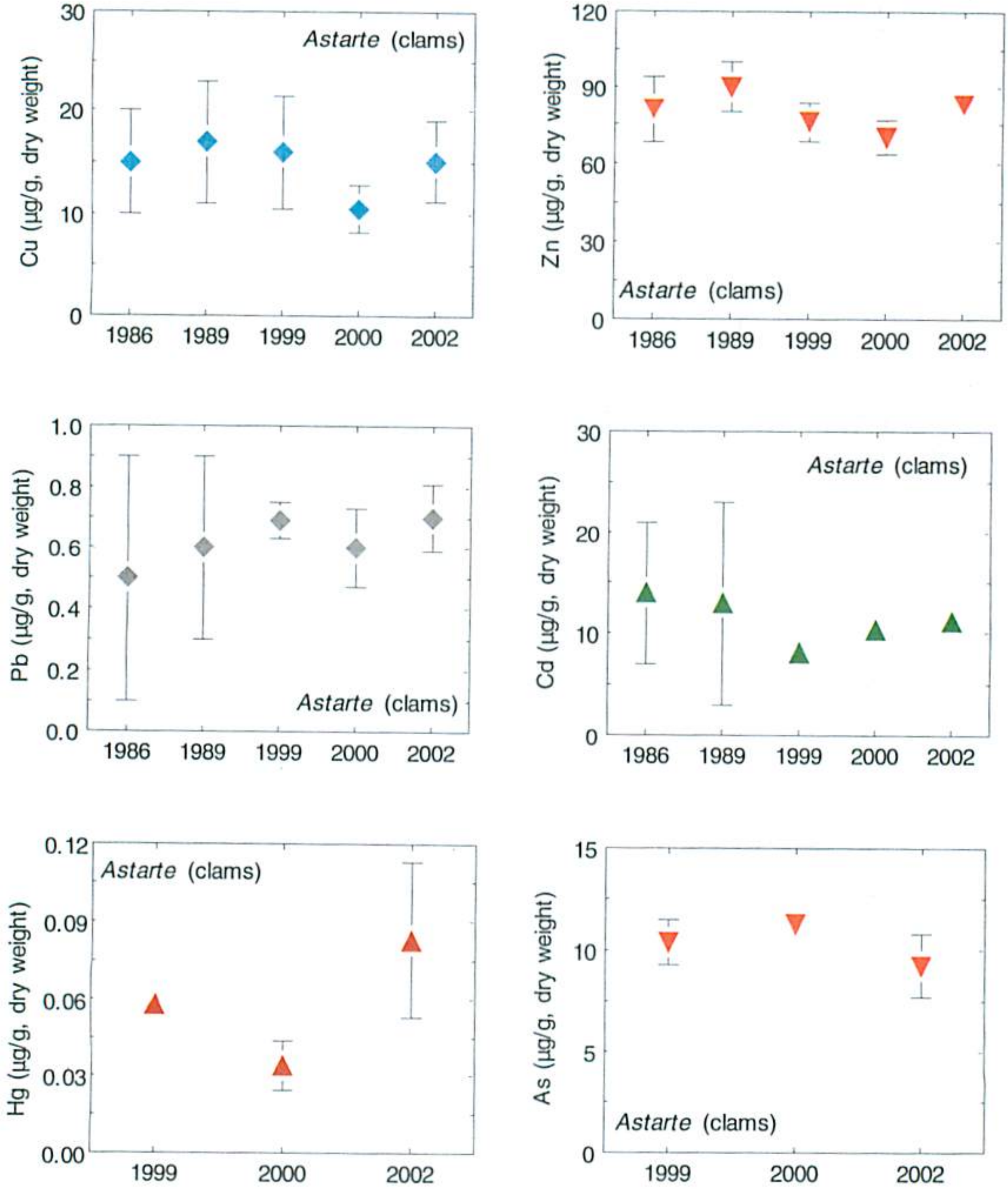
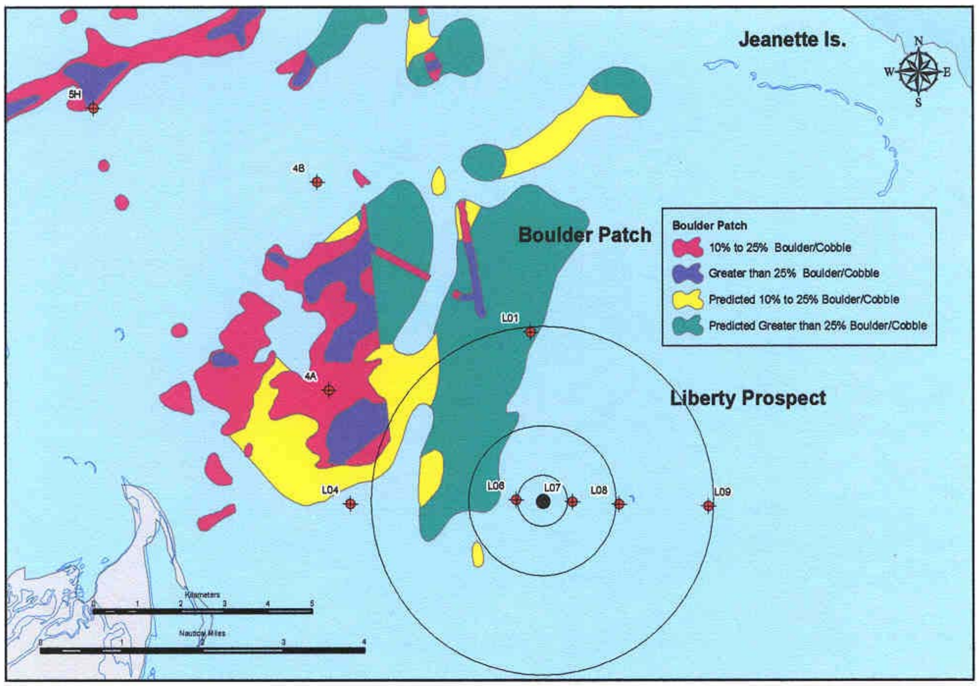


Figure 2.5-5
Map Showing Foggy Island Bay Sampling Stations and Table of Concentrations for Selected Organic Parameters and Grain Size in Sediment Samples

PAH = polynuclear aromatic hydrocarbons; PHC = petroleum hydrocarbons; S = steranes; T = triterpanes; TOC = total organic carbon

Source: Brown et al. (2004)



Station	Total PAH (μg/kg)	Total PHC (mg/kg)	Total S/T (μg/kg)	TOC (%)	Silt+Clay (%)
Foggy Island Bay- 2000					
L01	610	12	62	1.0	66
L04	400	7.7	51	0.47	60
L06	400	11	51	0.90	94
L07	220	6.9	20	1.5	36
L081	280 (70)	12 (1.7)	41 (10)	0.24 (0.06)	31 (7.4)
L09	99	1.9	11	0.49	5.3
Mean (SD)	340 (180)	8.6 (3.9)	39 (20)	0.76 (0.45)	49 (31)

Station	Total PAH (μg/kg)	Total PHC (mg/kg)	Total S/T (μg/kg)	TOC (%)	Silt+Clay (%)
Foggy Island Bay- 2002					
L01	150	2.9	15	0.59	11
L04	400	7.1	34	0.71	53
L06	420	6.5	32	1.2	58
L07	340	5.9	28	0.88	49
L08	340	10	52	0.67	6.4
L09	84	3.4	11	0.18	9.7
Mean (SD)	290 (140)	6.0 (2.6)	29 (15)	0.70 (0.33)	31 (24)

Note[1] – Field triplicates were collected at this station. The average value of the triplicates is reported with the standard deviation in parentheses

Figure 2.5-6
Concentrations of (silt + clay) versus Total Polynuclear Aromatic Hydrocarbons (PAH) in Sediments from Foggy Island Bay, Northstar and the Coastal Beaufort Sea for 1999, 2000, 2002 and 2004

Source: Brown et al. (2006)

The central line, the 95% prediction intervals, and the r-squared are from linear regression calculations.

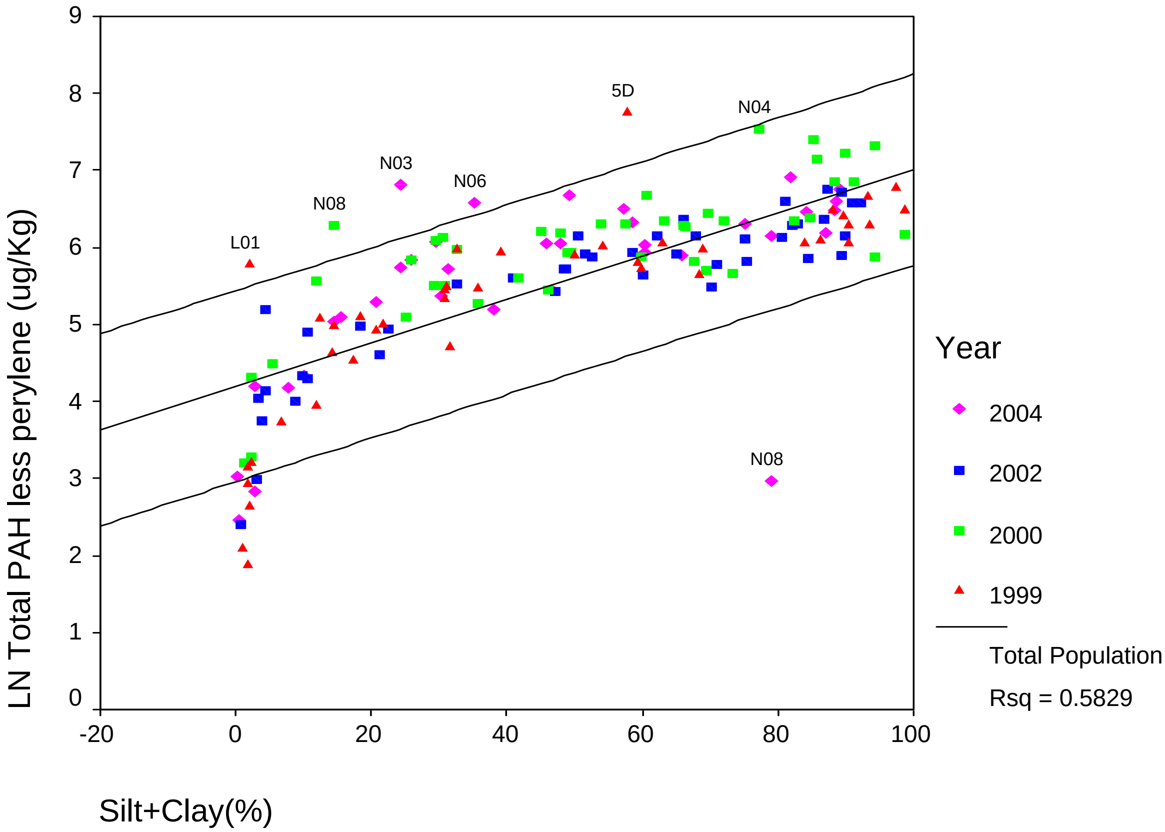


Figure 2.5-7

Concentrations of Total Polynuclear Aromatic Hydrocarbons (Total PAH) for Sediments from the Sites in the Beaufort Sea Monitoring Program — BSMP, Foggy Island Bay, and Northstar

Source: Long et al. (1995); Brown et al. (2006)

Horizontal lines show values for the Effects Range Low (ERL) and Effects Range Median (ERM)

Note: the y axis is a logarithmic scale

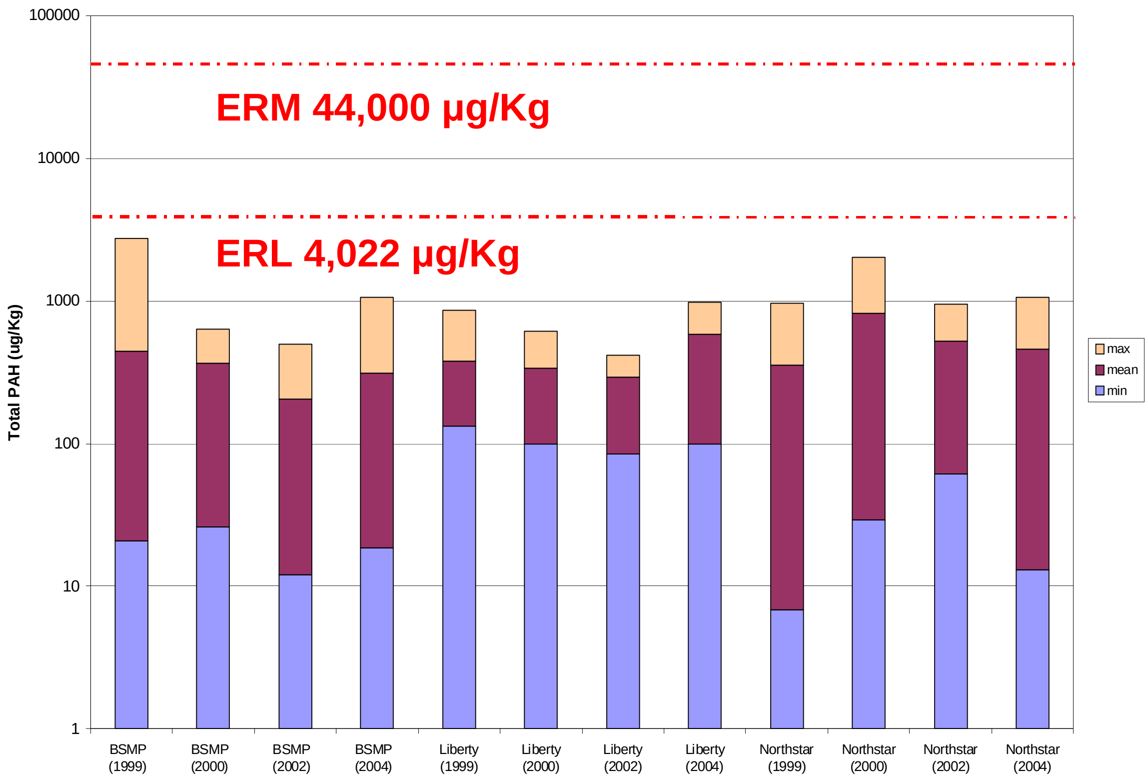
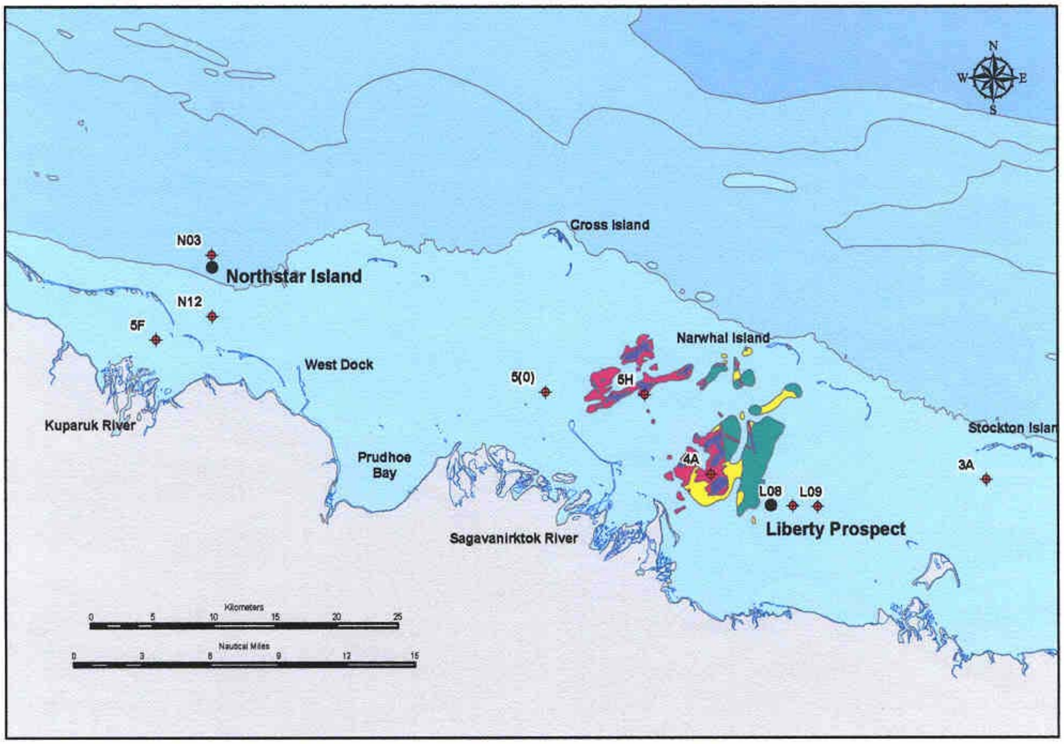


Figure 2.5-8
Map Showing Sampling Stations and Table Showing Concentrations for 2000 of Total Polynuclear Aromatic Hydrocarbons (PAH), Total Petroleum Hydrocarbons (PHC), and Steranes/Triterpanes (S/T) for Clams (*Astarte* and *Cyrtodaria*), Amphipods (*Anonyx*) for the Coastal Beaufort Sea, Including Foggy Island Bay

Source: Brown et al. (2004)



Station	Species	Total PAH (μg/kg wet weight)	Total PHC (mg/kg wet weight)	Total S/T (μg/kg wet weight)
Summer - 2000				
N03	*Anonyx*	23	12	8.1
N12	*Anonyx*	16	26	3.2
N13	*Anonyx*	14	14	4.1
N18	*Anonyx*	12	15	2.8
L08	*Astarte*	13	ND	2.7
L09	*Astarte*	16	ND	2.5
3A	*Astarte*	7.4	1.6	2.0
4A	*Anonyx*	18	ND	2.4
5(0)	*Anonyx*	20	ND	2.0
5F	*Cyrtodaria*	39	4.4	3.6
5H	*Astarte*	15	ND	4.0

Anonyx (an amphipod), *Astarte* (a clam), *Cyrtodaria* (a clam).
ND – Not detected.

Figure 2.6-1
Mean Daily Discharge, Sagavanirktok River near Pump Station 3, 1983-2005
Source: USGS 15908000 SAGAVANIRKTOK R NR PUMP STA 3 AK" found at http://waterdata.usgs.gov/ak/nwis/dv/?site_no=15908000

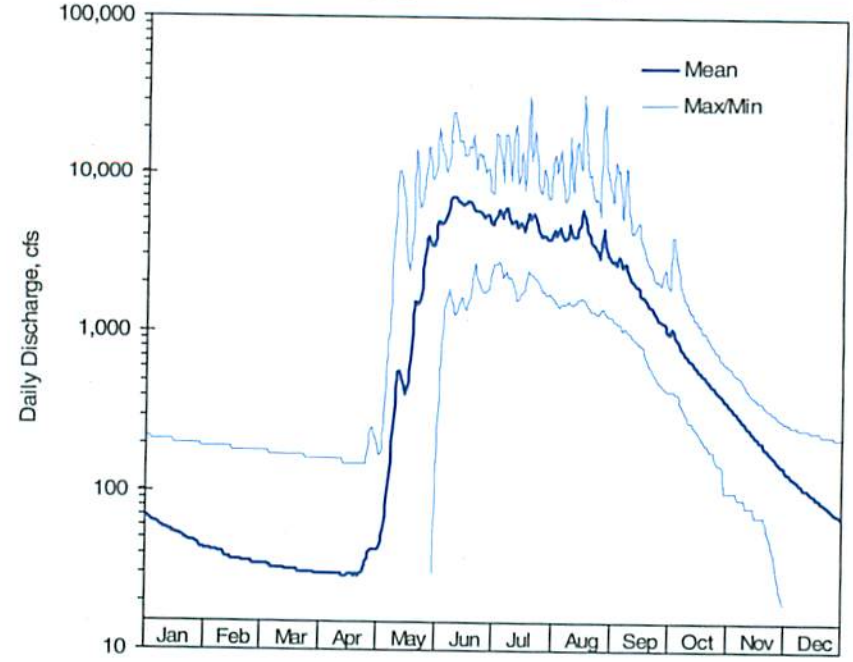


Figure 2.6-2
Flow Distribution in the Sagavanirktok River Delta, 1982 to 1990
Source: PND (2006b)

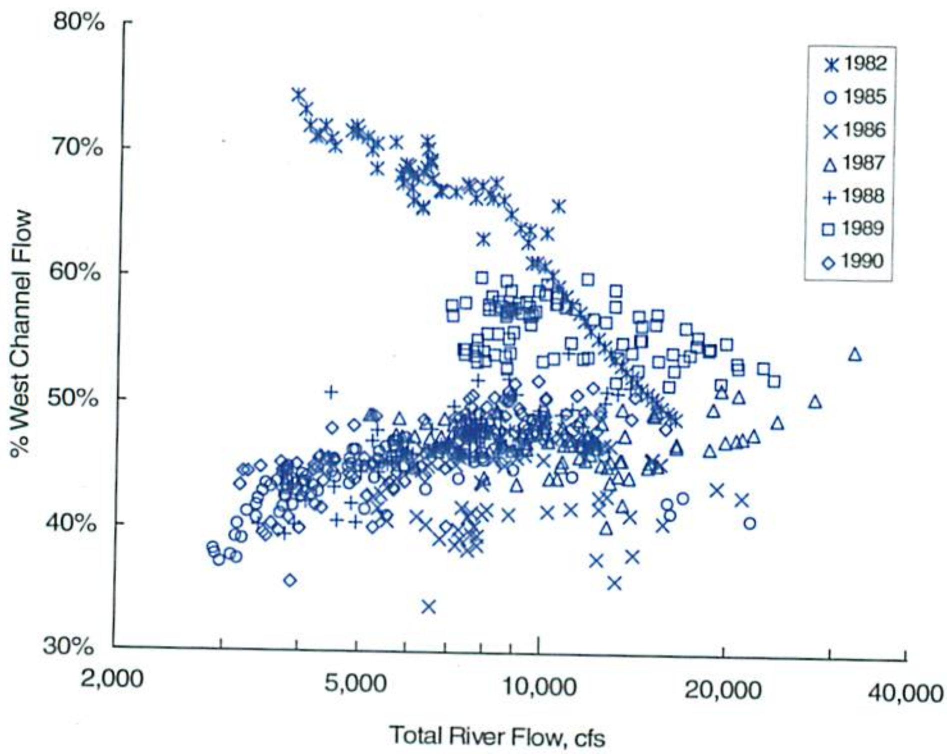


Figure 2.6-3
Flood Frequency at the Sagavanirktok River West Channel (Endicott Road) Bridge
Source: PND (2006b)

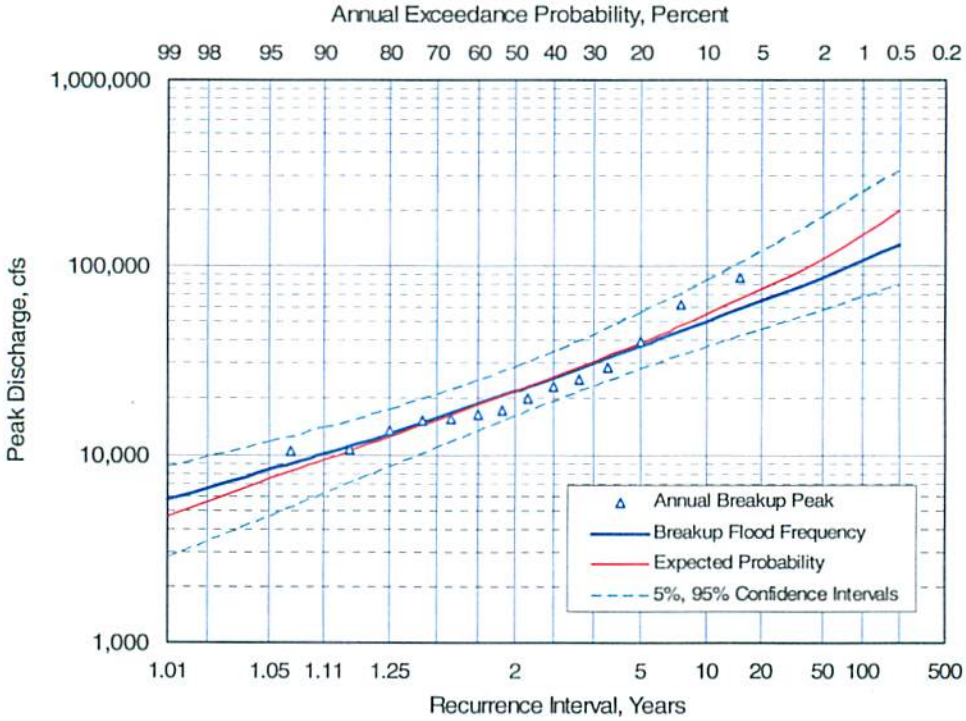
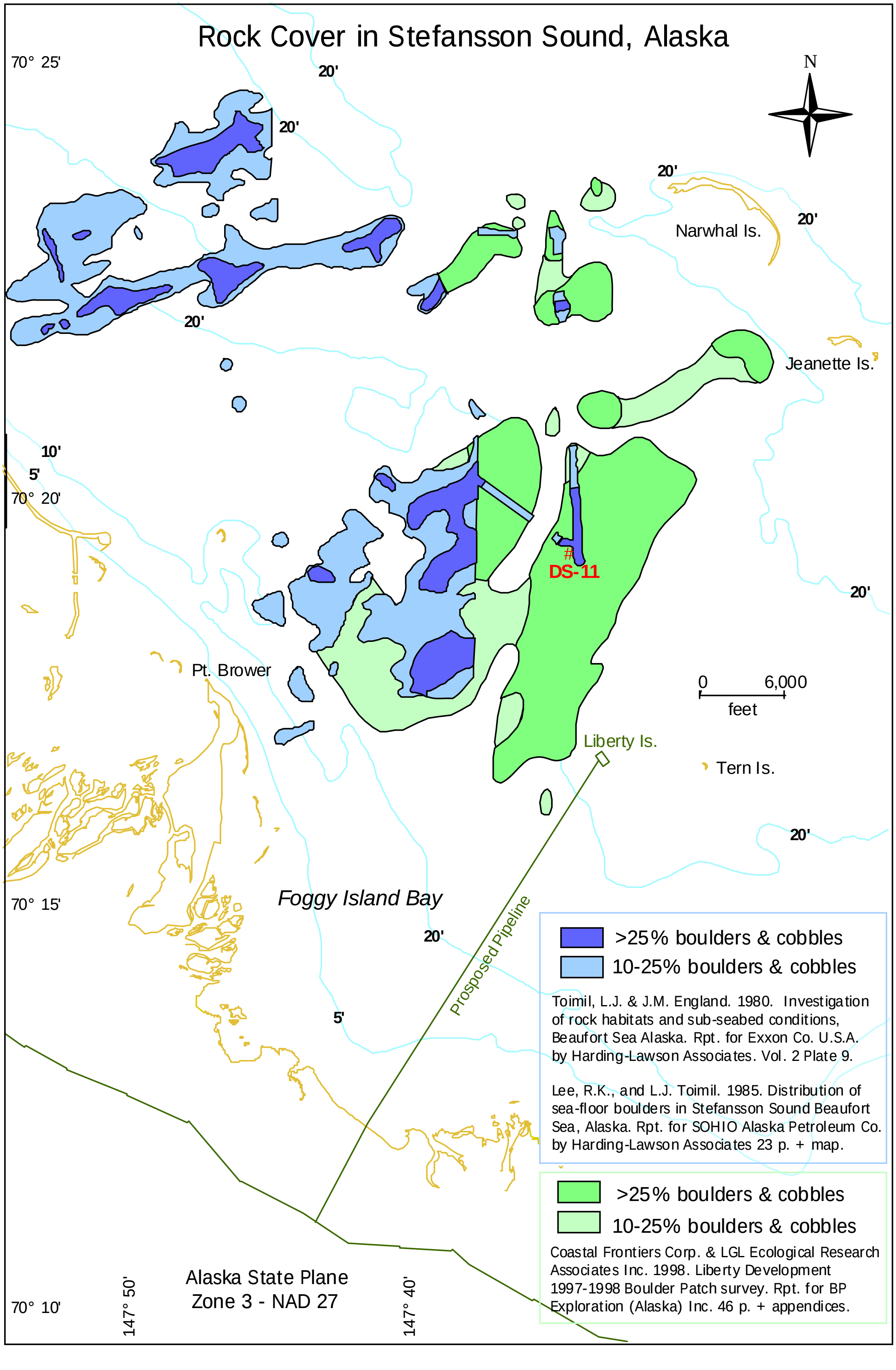


Figure 2.7-1
The Stefansson Sound Boulder Patch



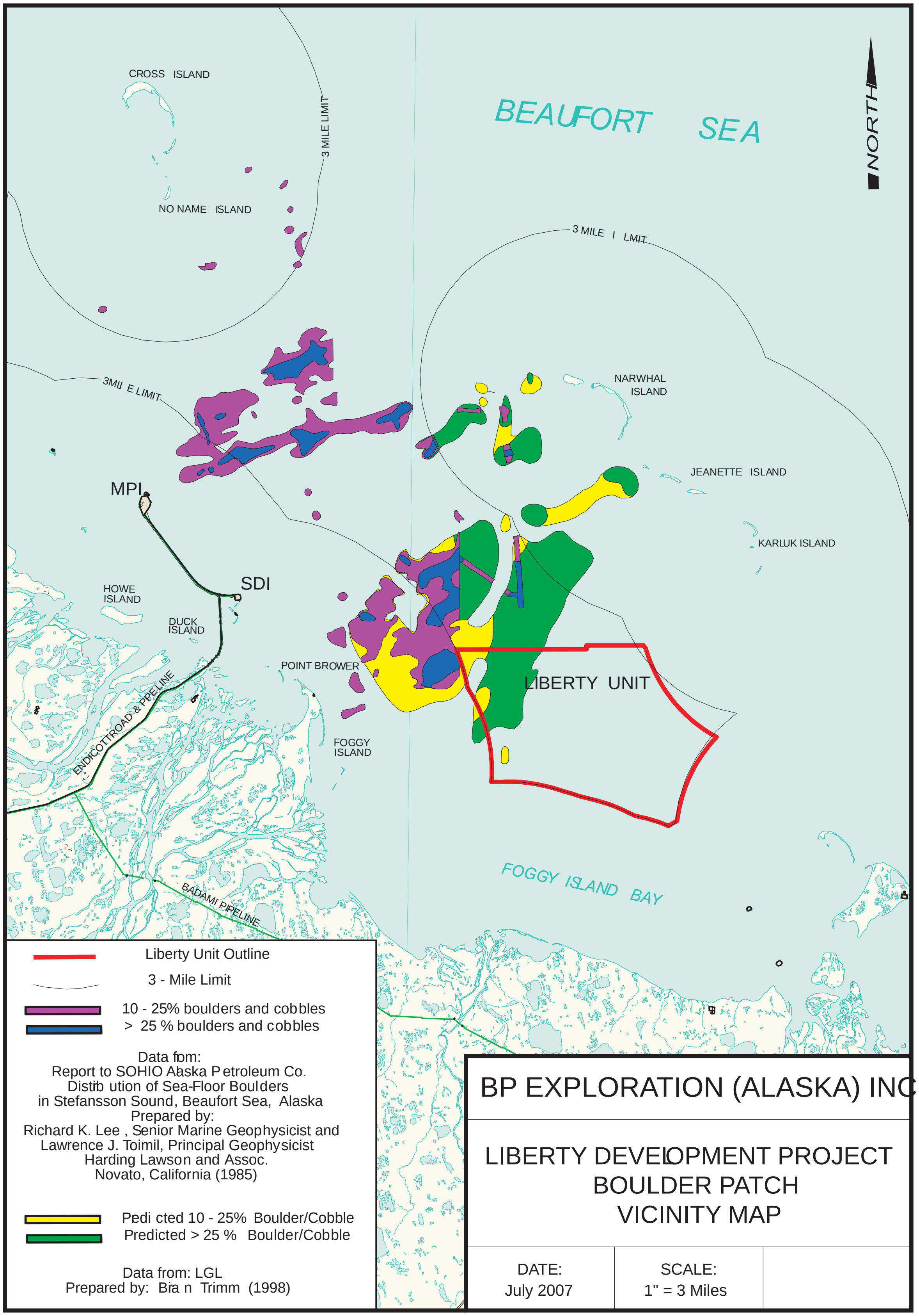


Figure 2.7-1a Liberty Development Project Boulder Patch Vicinity Map

ms15521b.dgn

Figure 2.7-2
Relative Contribution (% total biomass) of the Predominant Epilithic Flora and Fauna Collected in 0.05-m^2 Rock Scrapes in the Boulder Patch, Stefansson Sound, 1979-1980.

Source: Dunton and Schonberg (2000)

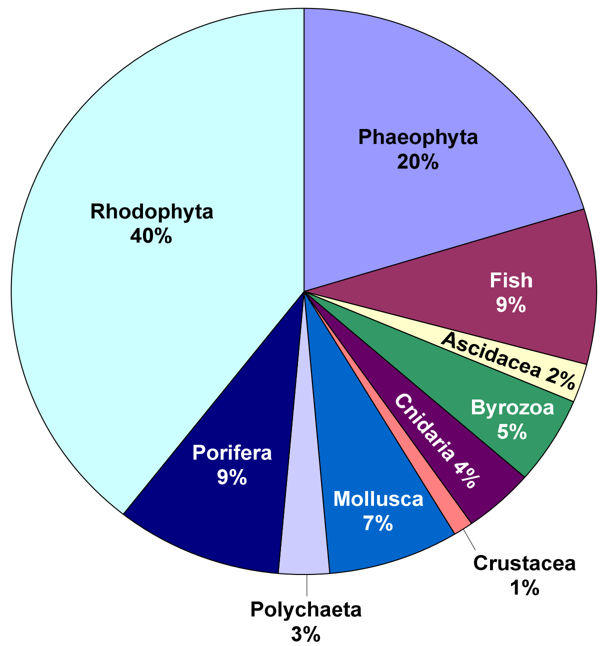


Figure 2.7-3
Annual Linear Growth of *Laminaria solidungula* Blades for 8 Years at 7 Sites in Stefansson Boulder Patch

Compiled from Aumack (2003)

Values are Mean ± SE (n=15 to 30)

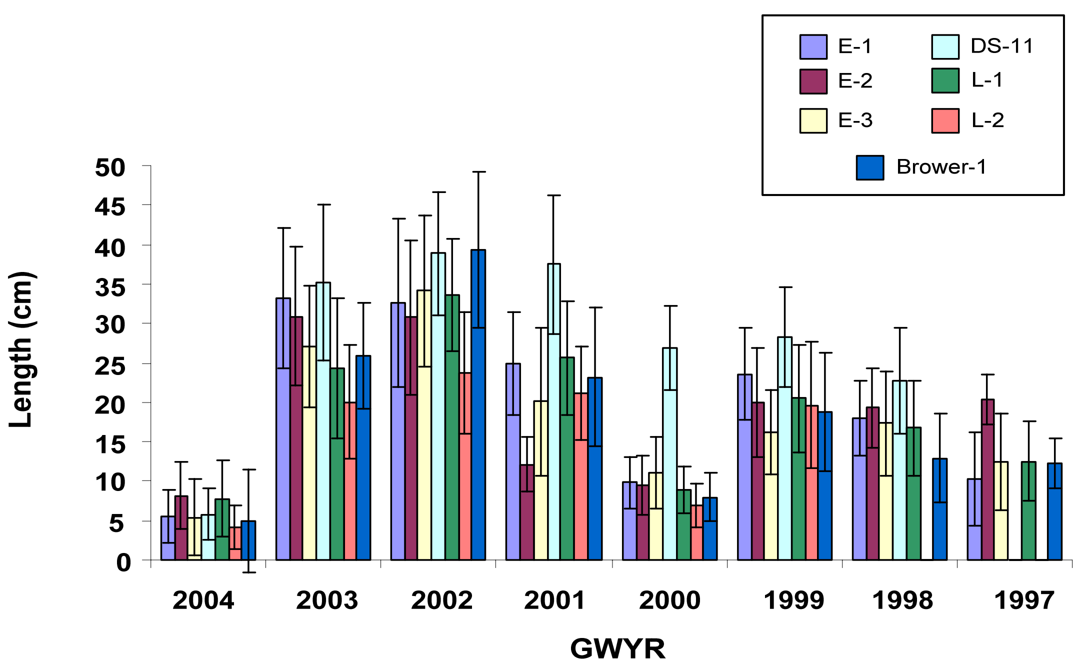


Figure 2.10-1
Snow Goose, Brant and Common Eider and Glaucous Gull Nesting Areas

Sources: Johnson (2000b); Sedinger and Stickney (2000); Noel et al. (2005); Rodrigues, McKendrick, and Reiser (2006)

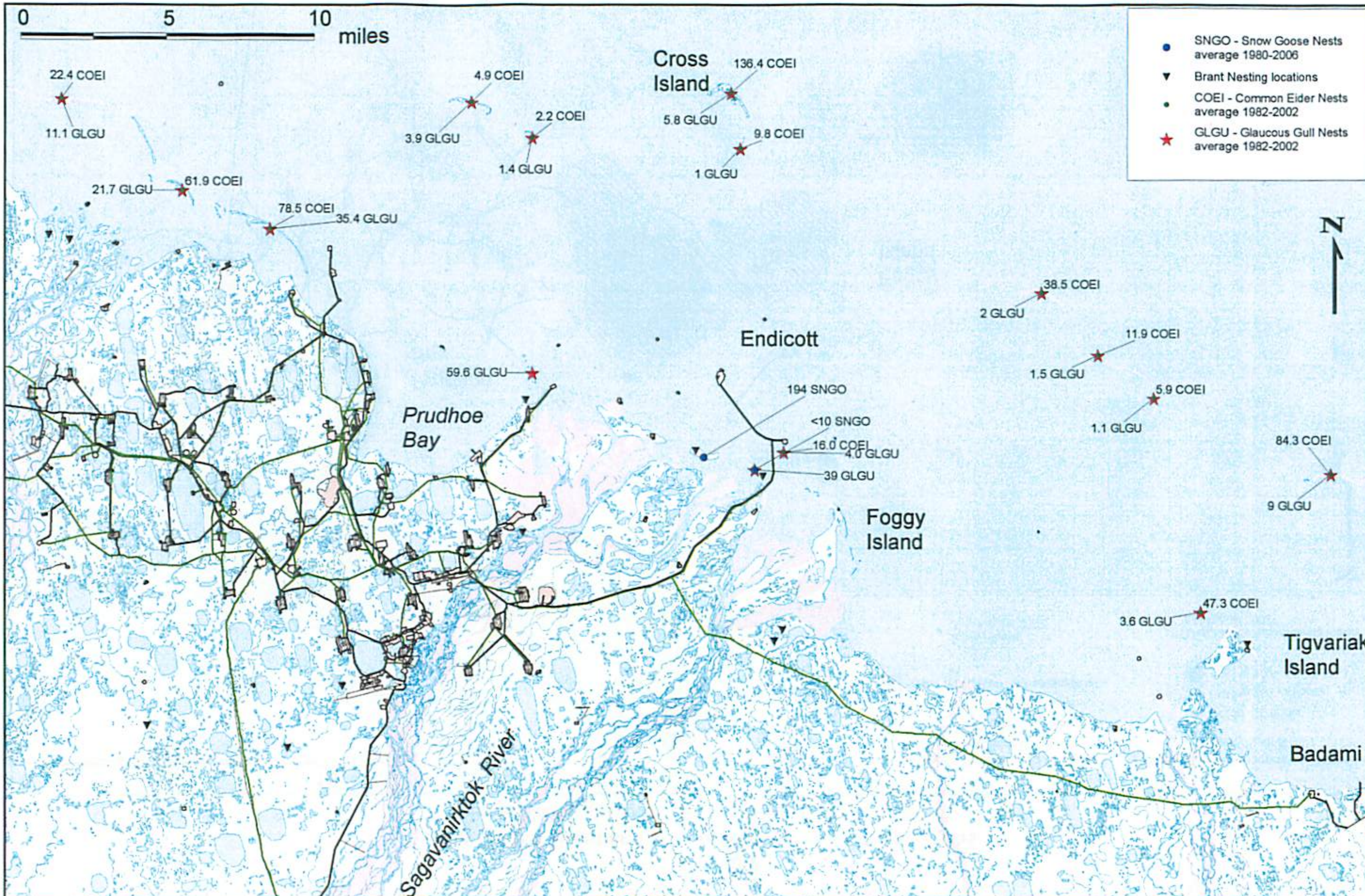


Figure 2.10-2
Snow Goose, Brant and Tundra Swan Brood-Rearing Areas
Sources: Noel et al. (2005), LGL unpublished data (2002, 2006)

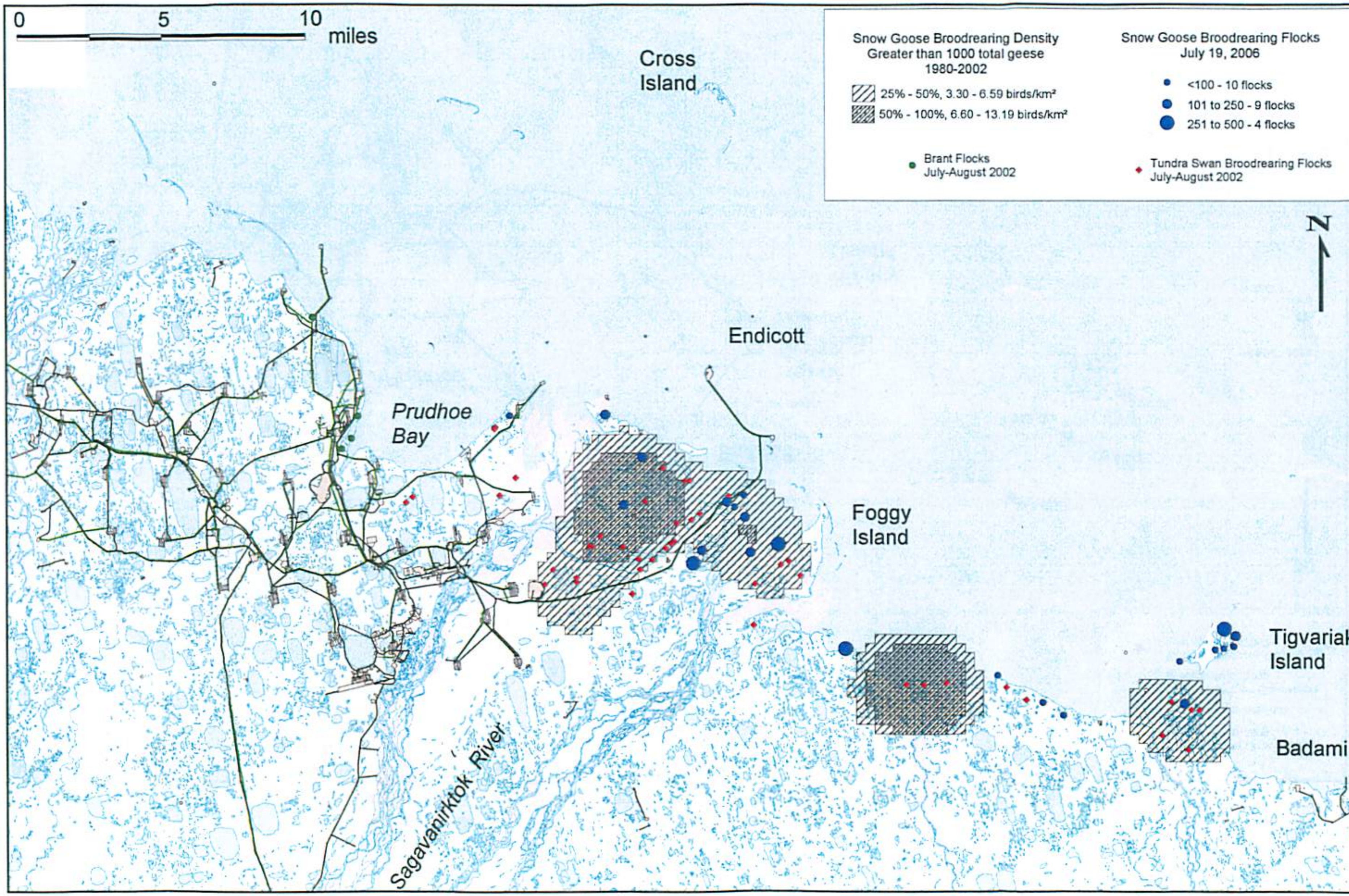


Figure 2.10-3
Long-tailed Duck, Eider and Scoter August Concentration Areas in Lagoons 1999-2002, and Offshore Distribution and Abundance June to September 1999-2001

Sources: Fischer and Larned (2004); Noel, Johnson, and O'Doherty (2005)

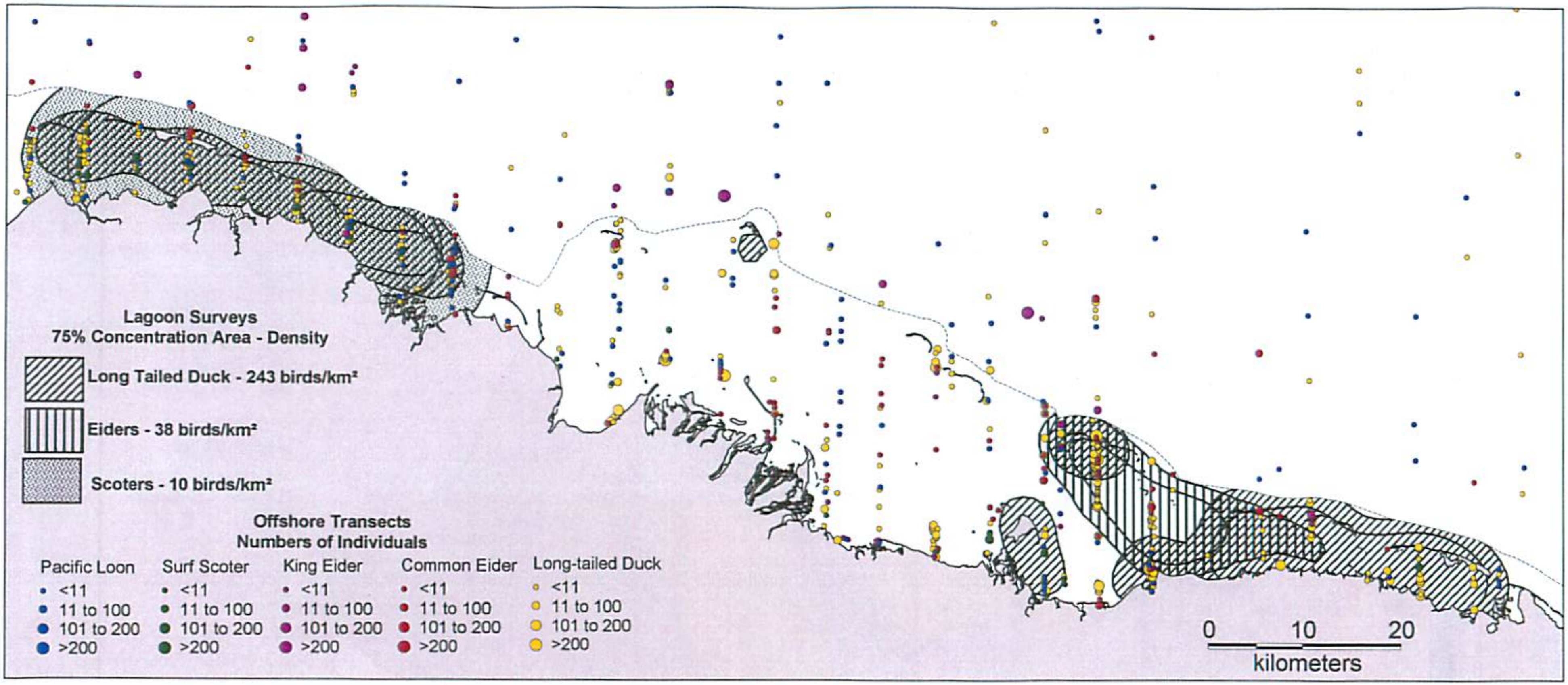


Figure 2.11-1
Seasonal Range of Central Arctic Caribou Herd
(Source: Arthur and Del Vecchio, 2004)

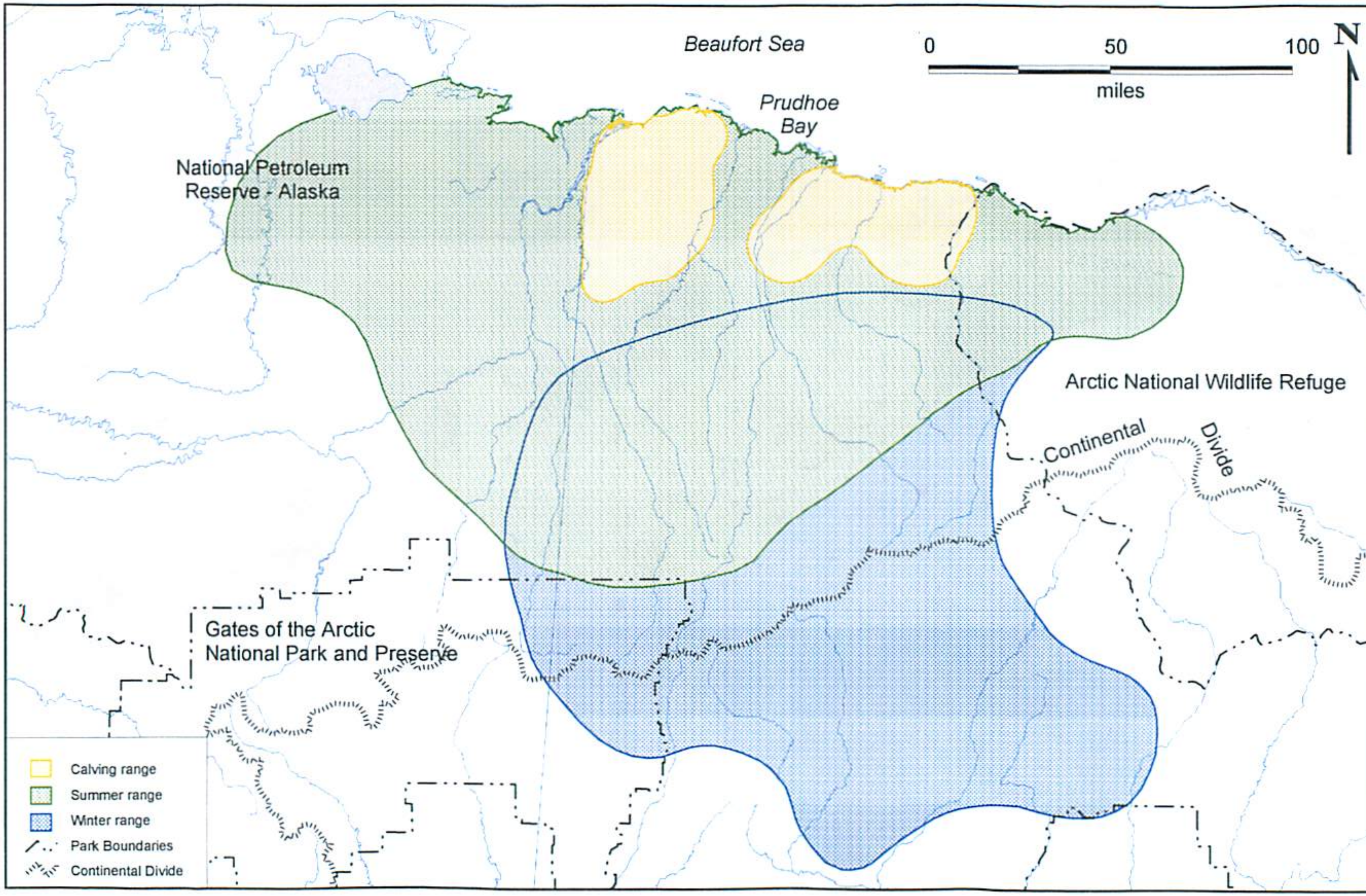


Figure 2.11-2
Caribou Calving Densities and Summer Large Group Distributions 1998-2003
Sources: LGL unpublished data (1998-2002); ENTRIX unpublished data (2003)

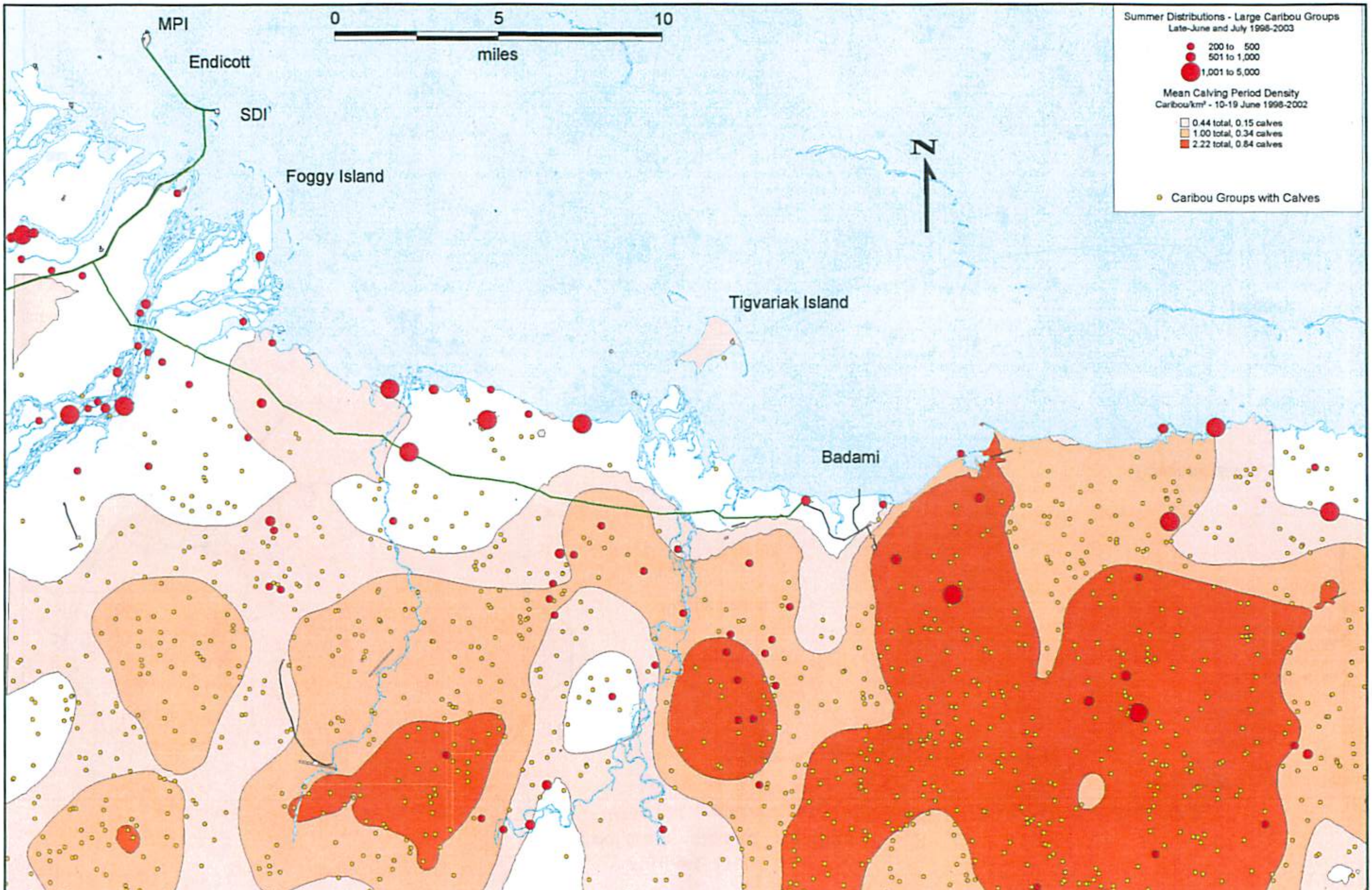


Figure 2.11-3
Terrestrial Mammals and Den Sites

Sources: Burgess and Banyas (1993); USDOI, MMS (1998); LGL unpublished data (1998-2002); ENTRIX unpublished data (2003)

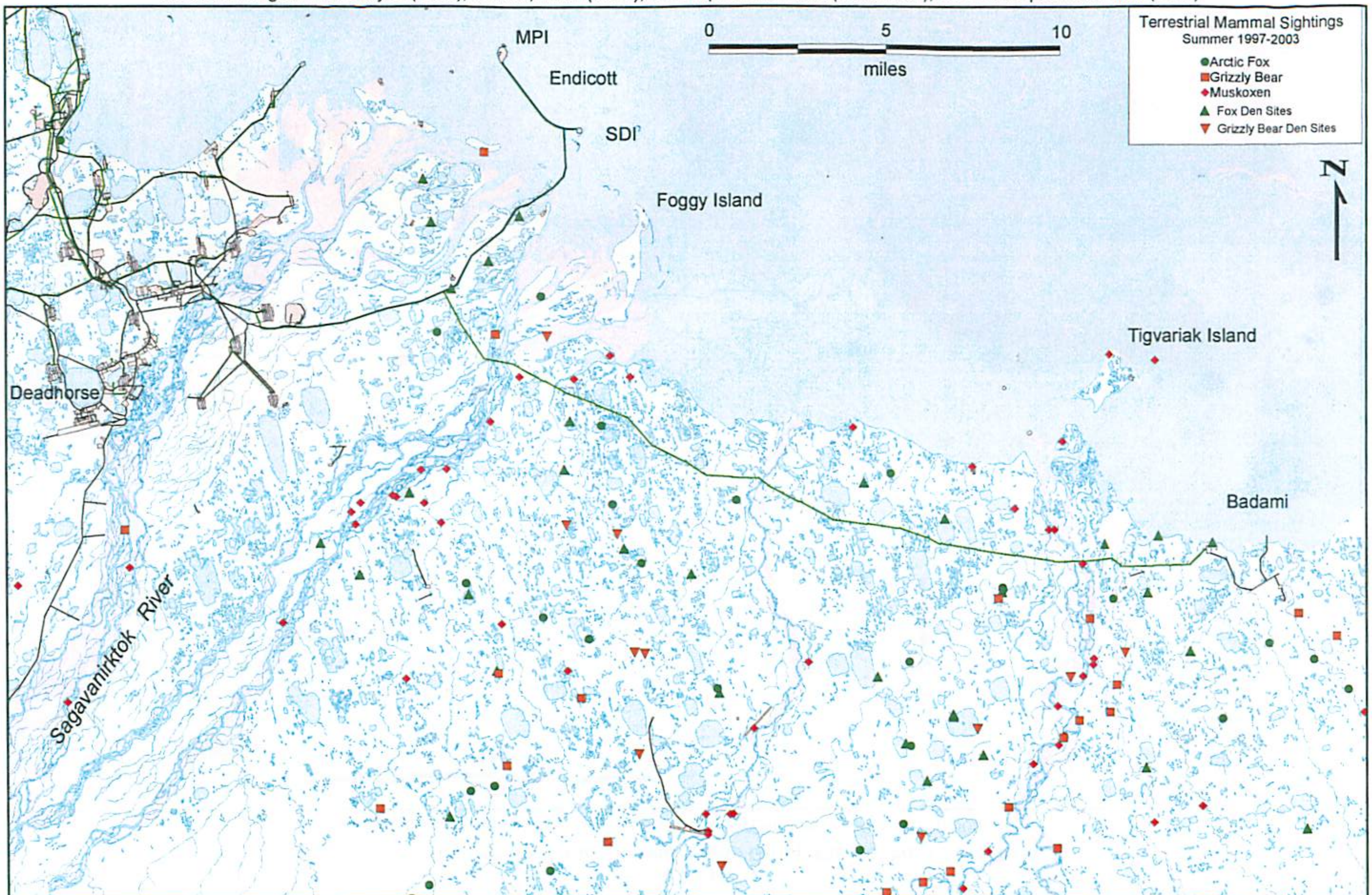
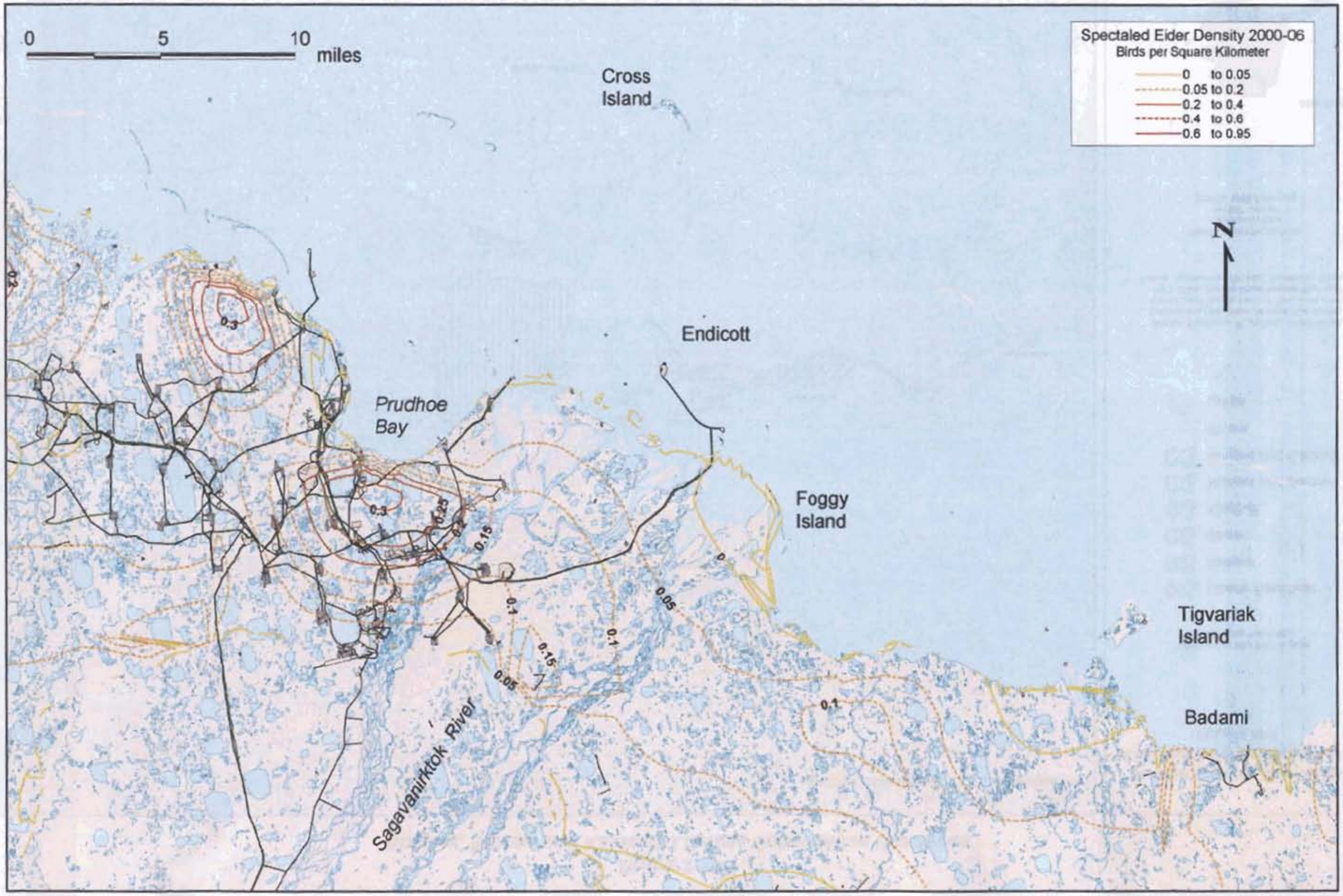
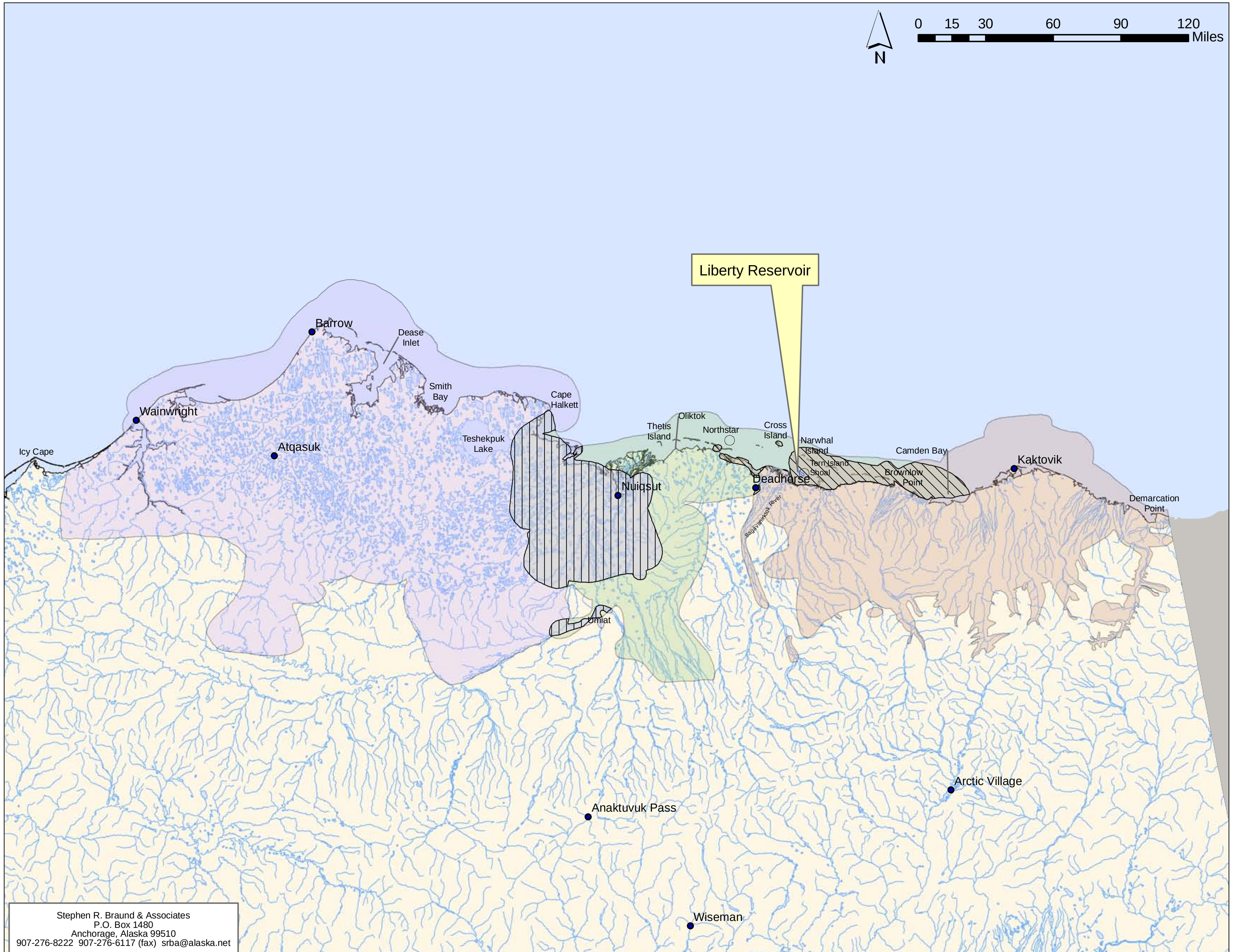


Figure 2.13-1
Relative Abundance of Spectacled Eiders in the Liberty Area
(Detail Based on Larned, Stehn, and Platte [2005])





Nuiqsut, Barrow and Kaktovik Lifetime Subsistence Use Areas

Figure 2.15-1

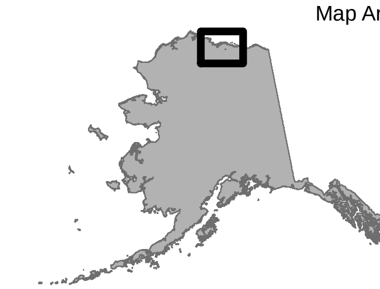
Other areas may also be used
for resource harvesting.

- Liberty Reservoir
- Nuiqsut
- Barrow
- Kaktovik
- Nuiqsut and Barrow
- Nuiqsut and Kaktovik
- Rivers
- Lakes

Source: Pederson, S. In Prep. North Slope Subsistence Data Atlas, Nuiqsut Map Series, Extent Land Use by Nuiqsut Residents circa 1973-1986. Alaska Department of Fish and Game, Subsistence Division, Fairbanks, Alaska.

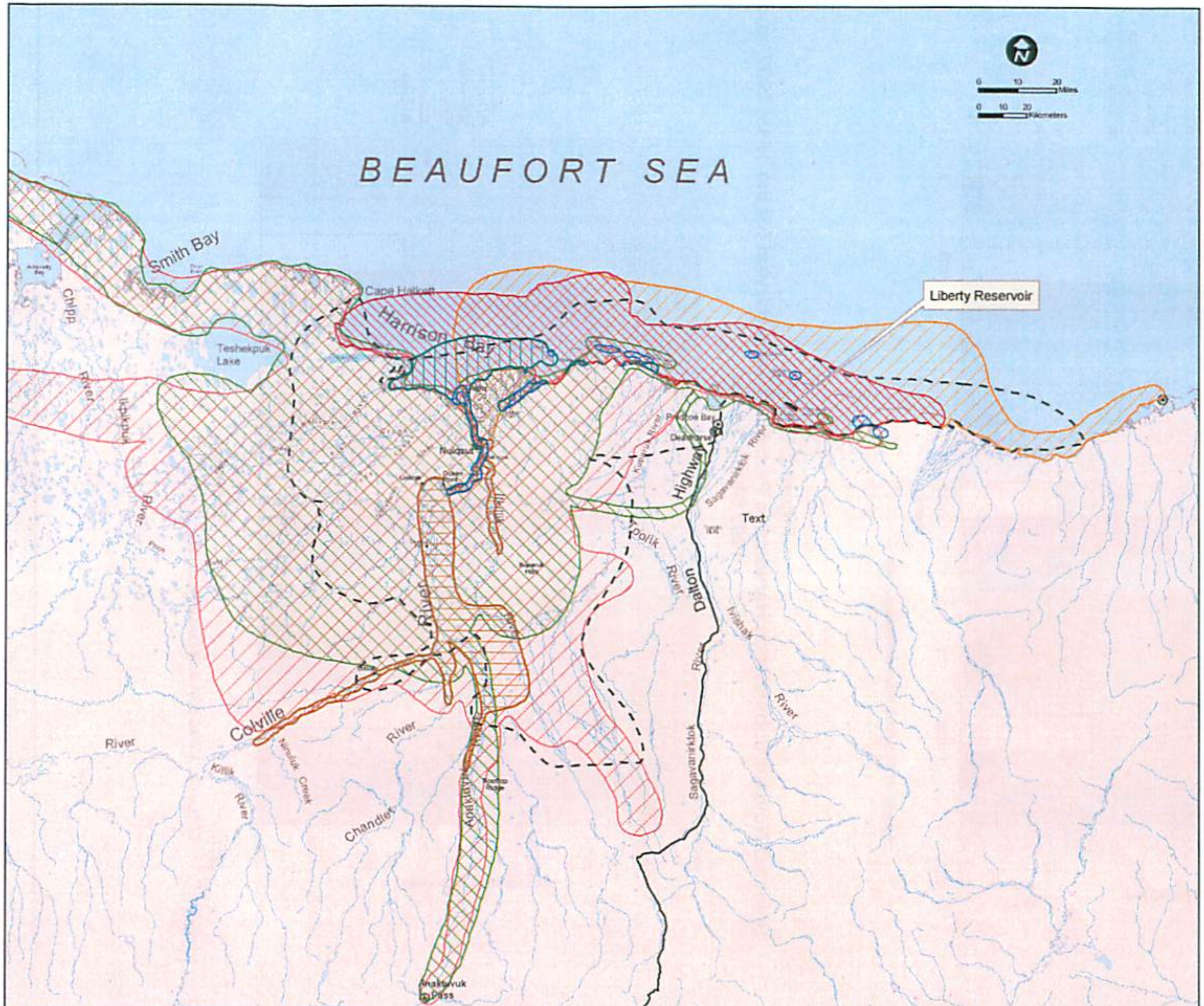
Alaska Albers Equal-Area
Conic projection
NAD27 Datum
(Clarke 1866 Spheroid)

Map Area



C:\gis\BP05\Maps\all_subsistence.pdf

Figure 2.15-2
Nuiqsut Subsistence Land Use, 1973-1986



Nuiqsut Subsistence Land Use 1973-1986

Figure 2.15-2

Legend

- Communities
- Wildfowl
- Whale
- Caribou
- Seal
- Moose
- Fish
- Furbearer Hunting
- Nuiqsut Lifetime Community Land Use Areas (Pederson 1979)

Source: Pederson, S. In Prep. North Slope Subsistence Data Atlas, Nuiqsut Map Series, Extent Land Use by Nuiqsut Residents circa 1973-1986. Alaska Department of Fish and Game, Subsistence Division, Fairbanks, Alaska.

Scale: 1:1,600,000

Alaska Albers Equal-Area Conic projection NAD27 Datum (Clarke 1866 Spheroid)

Map Area

Alpine Satellite Development Plan EIS
Prepared for BLM by

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Anchorage, Alaska 99510
907-276-8222 907-276-6117 (fax)
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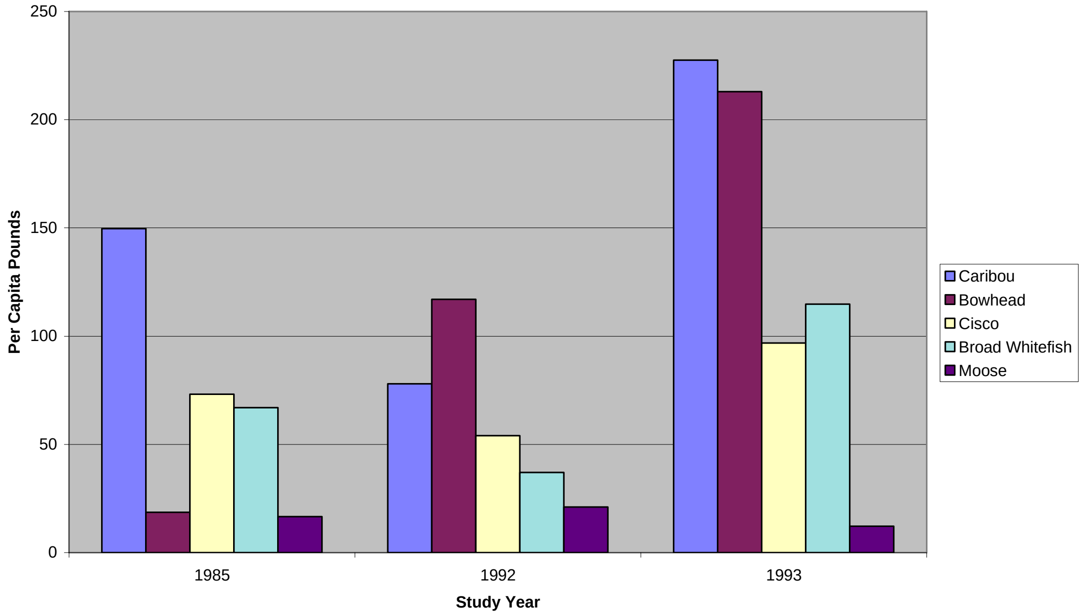
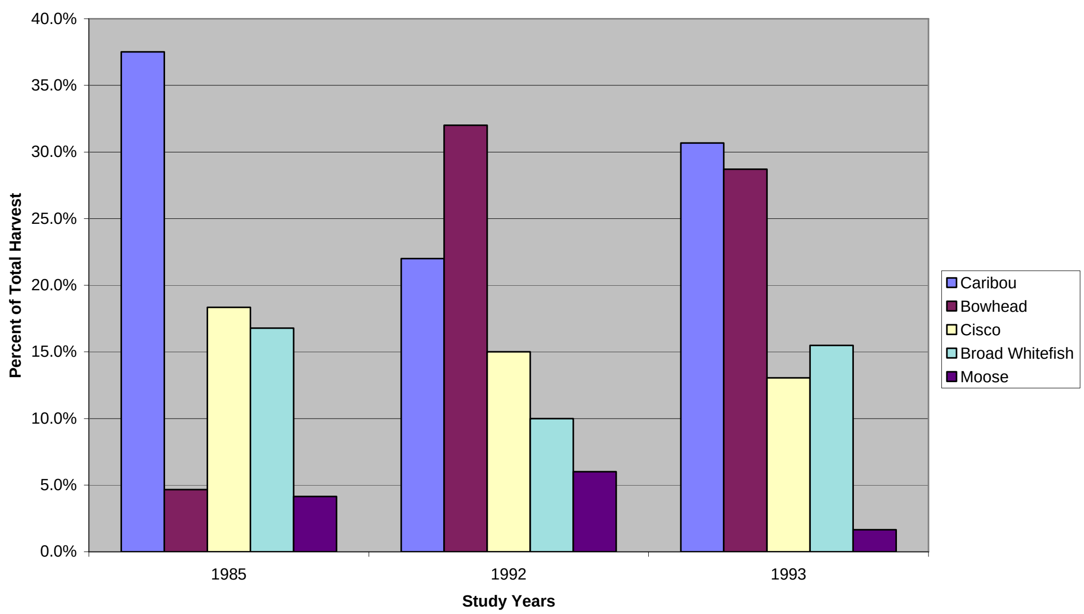
Figure 2.15-3
Selected Nuiqsut Subsistence Harvests in Per Capita Pounds for the 1985, 1992, and 1993 Study Years



Sources: ADF&G 2001; Fuller and George, 1999

Figure 2.15-4
Selected Nuiqsut Subsistence Harvests in Percent of Total Harvest for the 1985, 1992, and 1993 Study Years



Sources: ADF&G 2001; Fuller and George, 1999

Figure 2.15-5
Nuiqsut Subsistence Whaling Near Cross Island: 2001, 2002, 2003

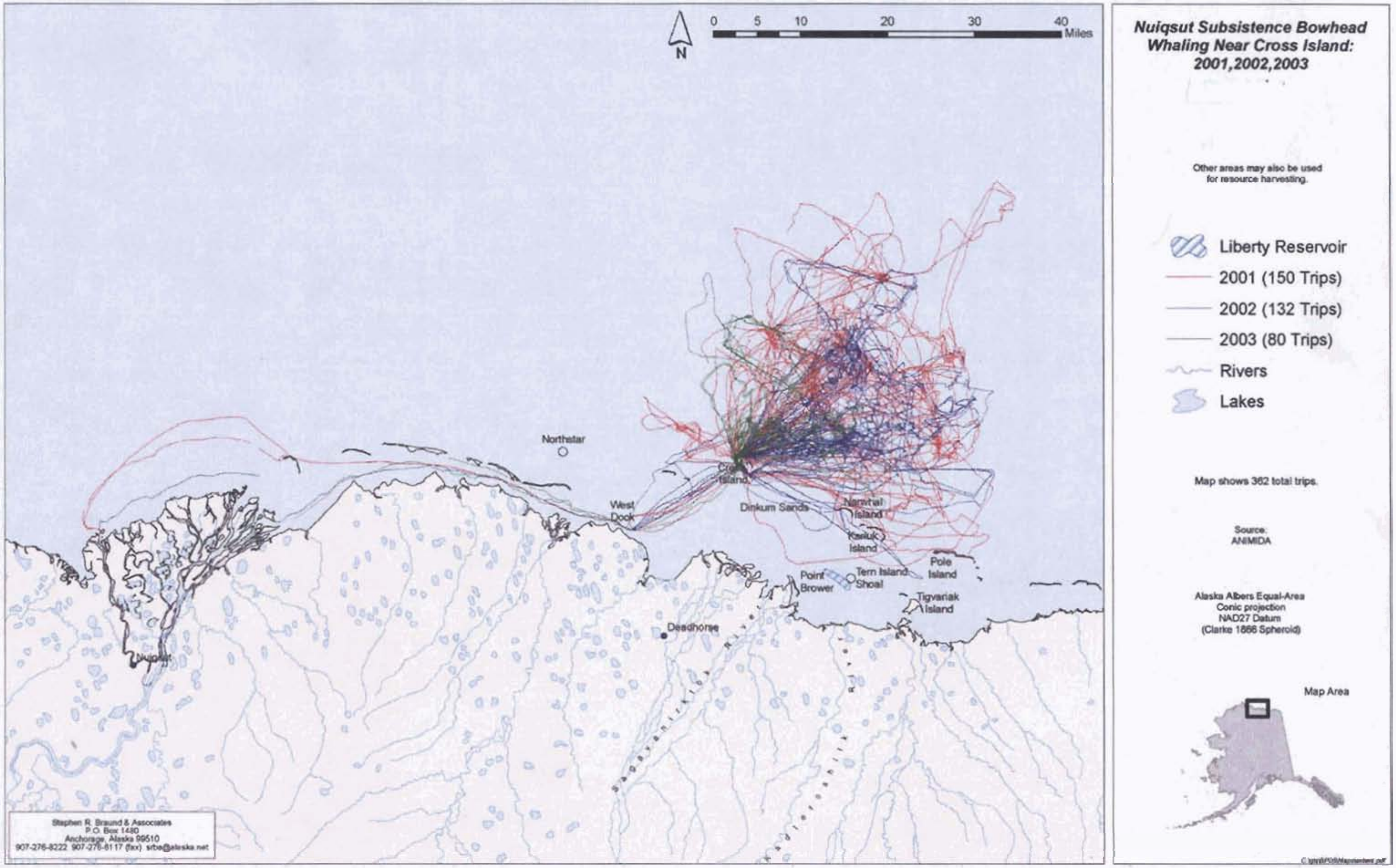
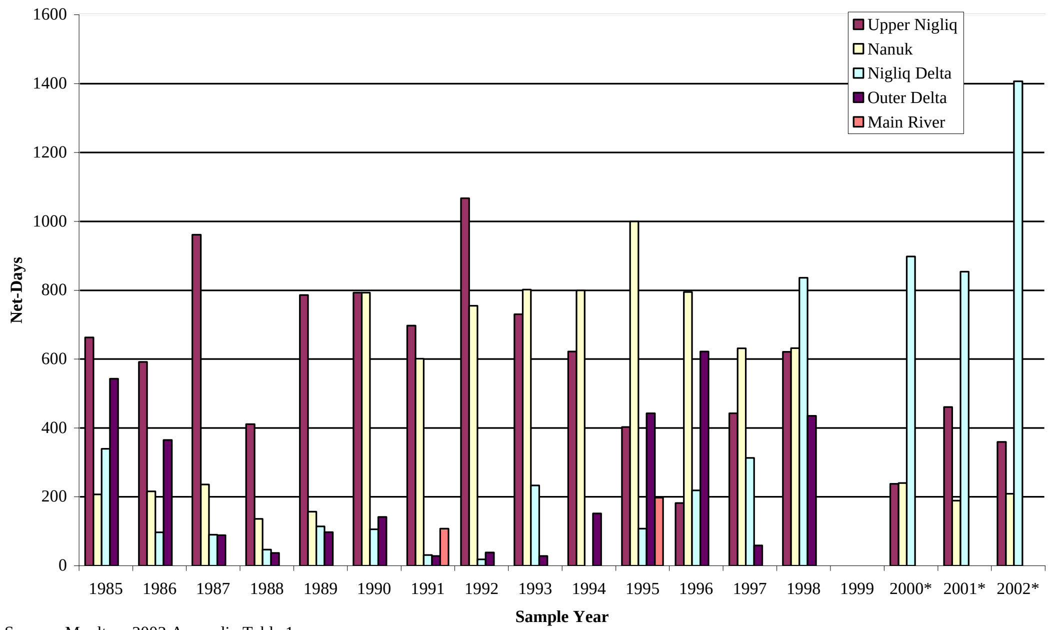


Figure 2.15-6
Estimated Fishing Effort in the Colville River Delta Fall Subsistence Fishery in Net-Days, 1985-2002

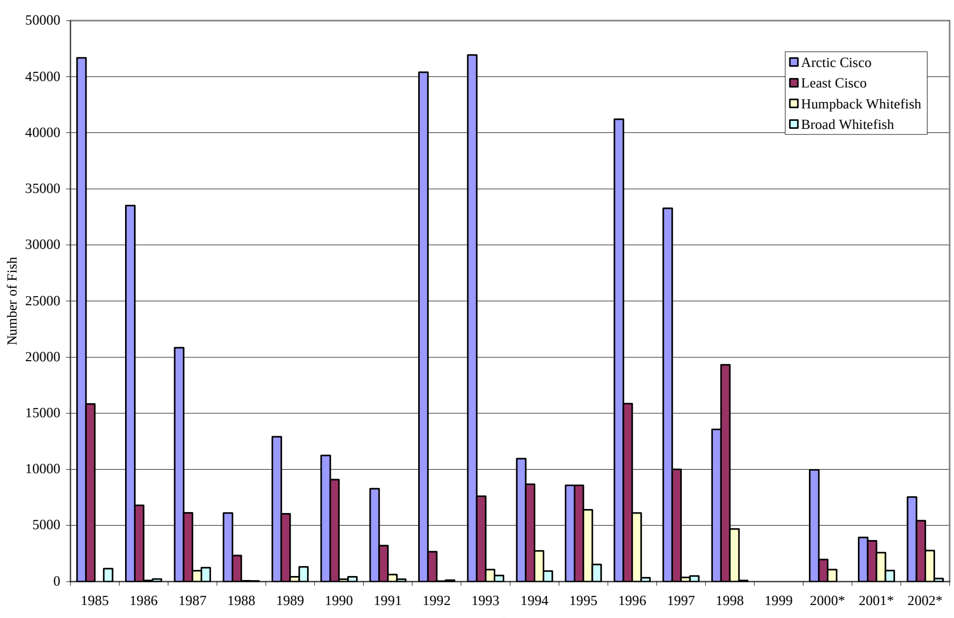


Source: Moulton, 2002:Appendix Table 1.

Stephen R. Braund & Associates, 2005.

* Harvest numbers represent only the Nigliq Channel harvest.

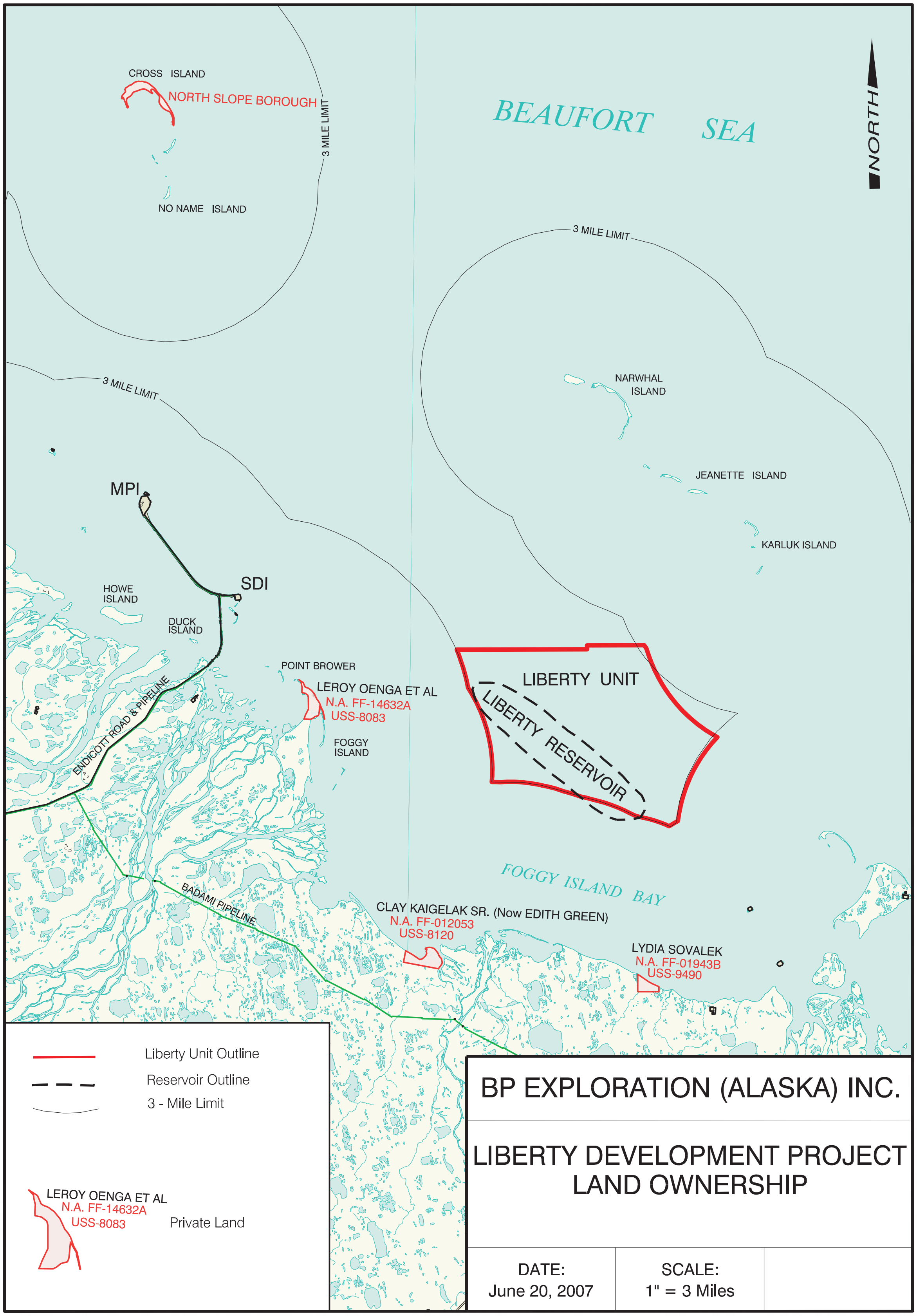
Figure 2.15-7
Estimated Whitefish Harvests for the Colville River Delta Fall Subsistence Fishery, 1985-2002



Source: Moulton, 2002:Table 6.

Stephen R. Braund & Associates, 2005.

* Harvest numbers represent only the Nigliq Channel harvest.



ms15521.dgn

Figure 2.15-8 Liberty Development Project Land Ownership

Figure 3.4-1
Process for Estimating the Risk of an Oil Spill Using Historical ANS Spill Data
See Appendix A for detailed methods and results.

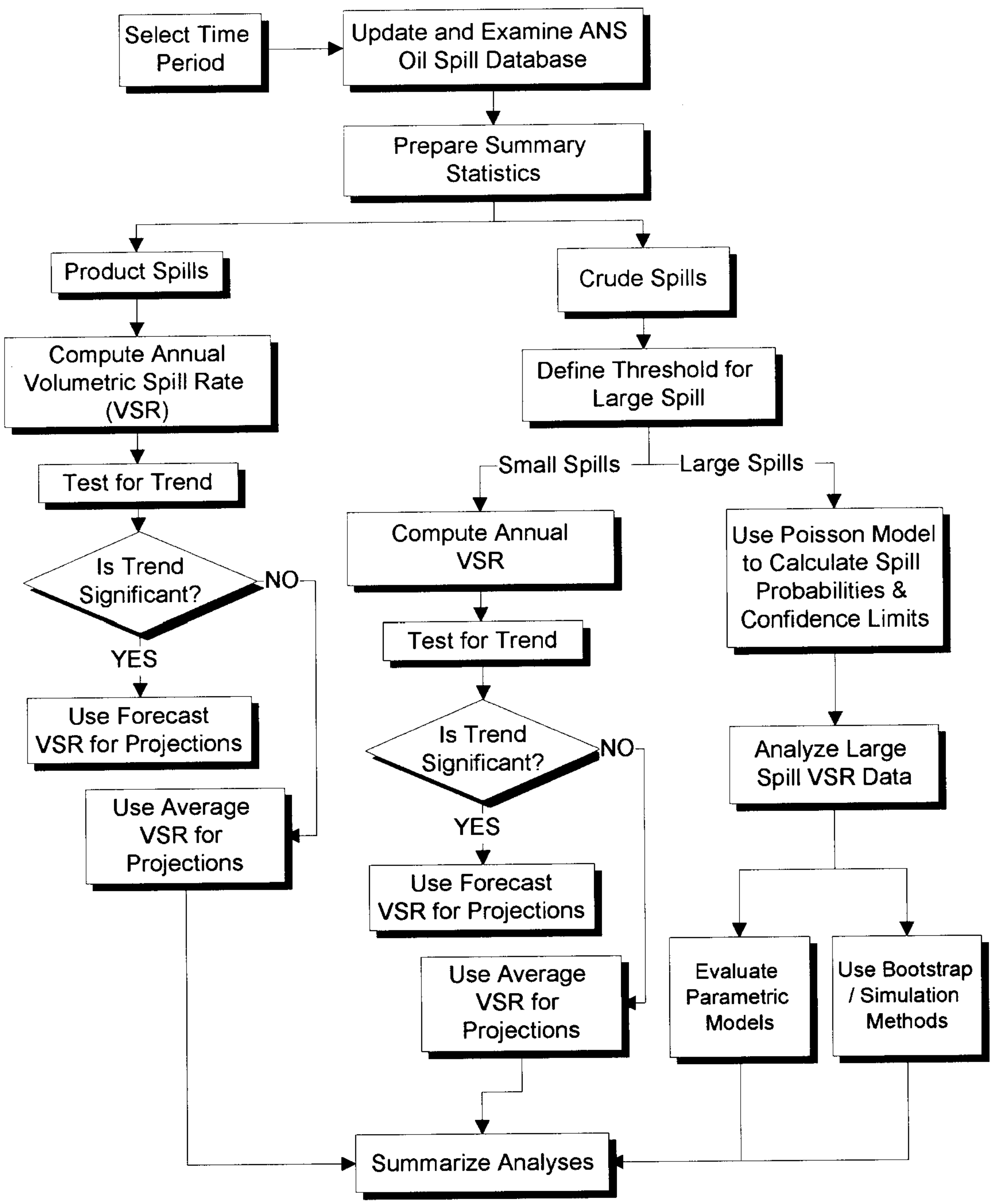
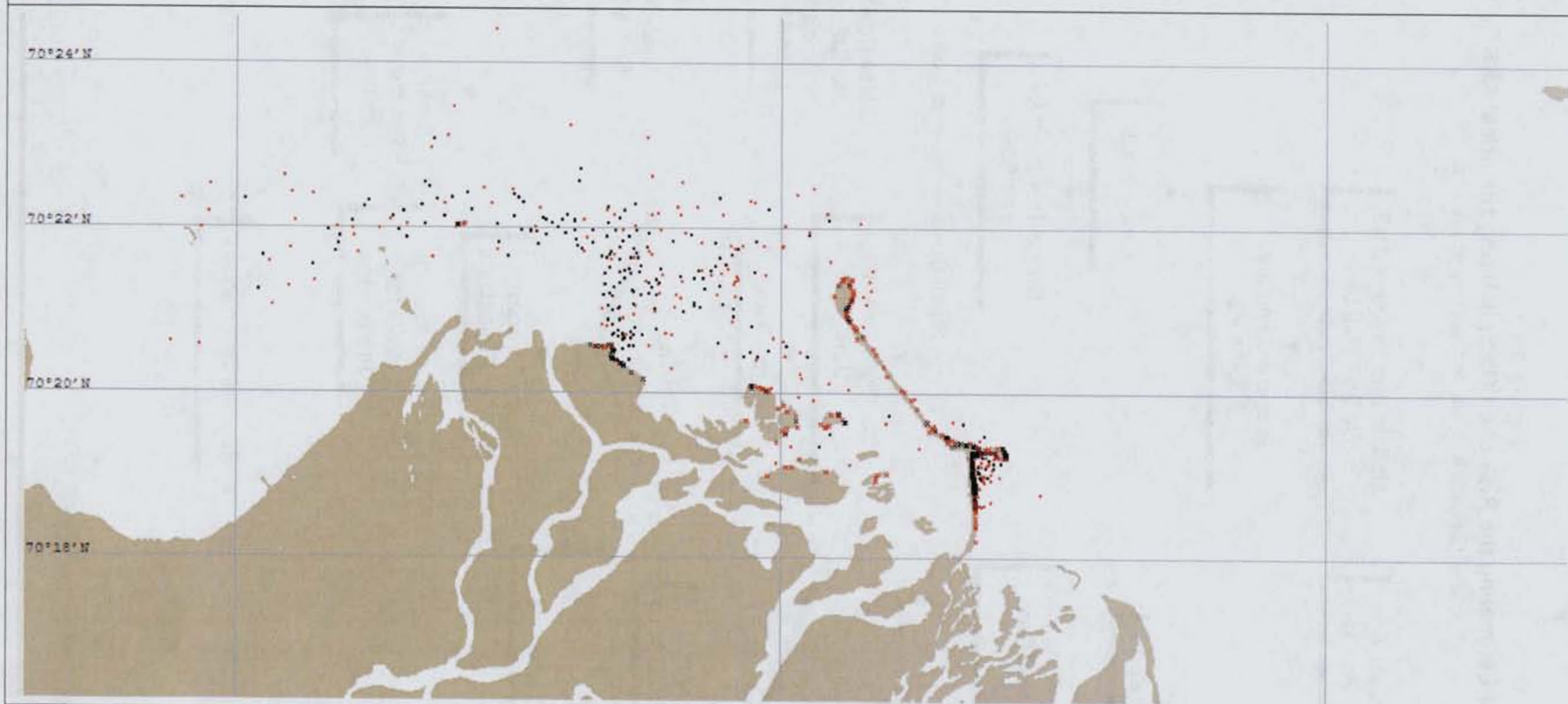


Figure 3.4-2
GNOME Model Oil Trajectory Plot for 24 Hours

Model Mode: Standard Estimate for: 08/01/06 24-hr Duration Prepared: 02/23/07	Model Name: Liberty

This trajectory was created using climatological currents from a GNOME Location File and is unlikely to represent conditions existing at any particular time at the depicted location.

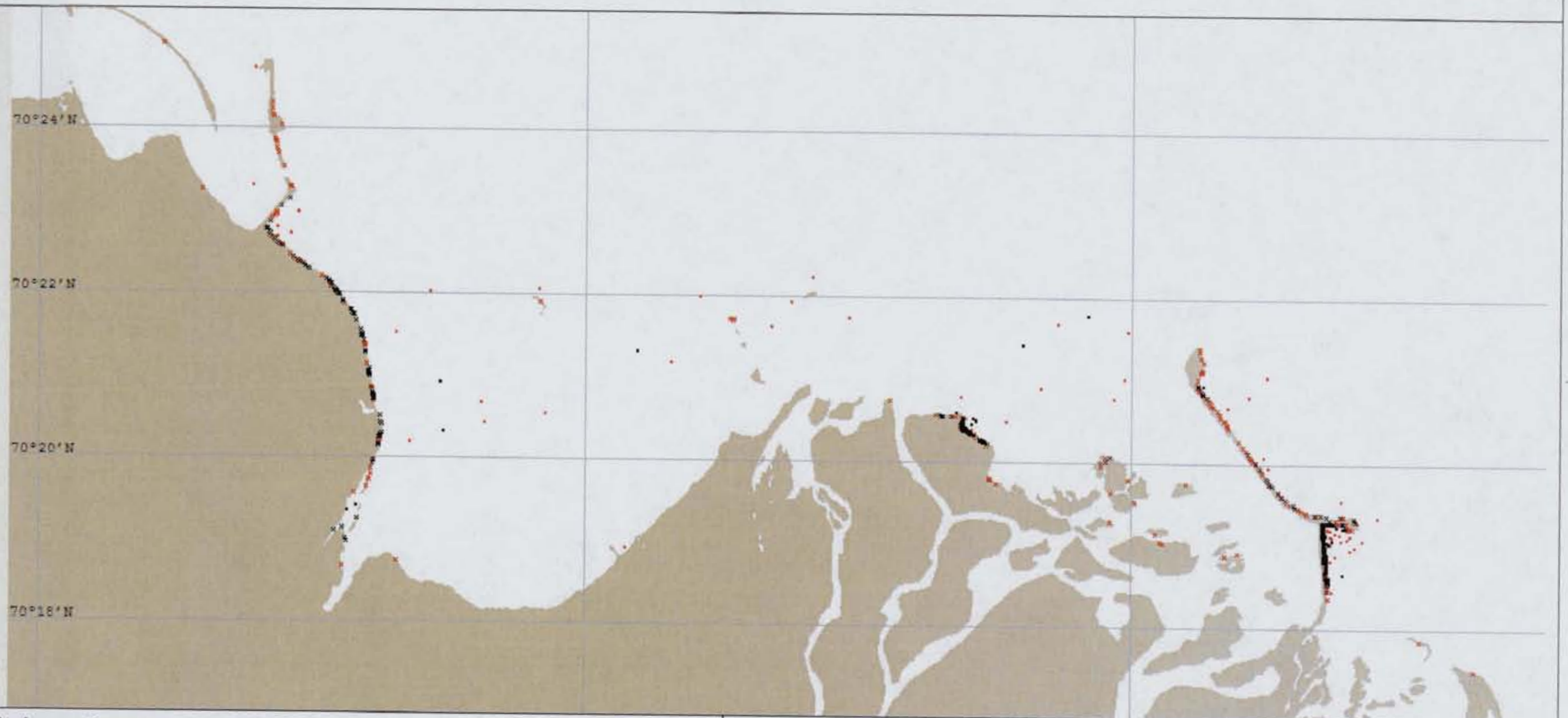


Stefanson Sound Sag River speed 0.5144 m/s Shaviovik River speed: 0.5144 m/s Canning R. West speed: 0.5144 m/s Canning R. East / Tamayariak R. speed: 0.5144 m/s Wind: Constant 10 knots from ENE Number of Spills: 1 Spill Location: Latitude 70°19.22'N Longitude 147°51.67'W	Black Splots: Best Guess, Red Splots: Uncertainty Splot Mass Balance Totals (Best guess): Released: 999 bbl Evaporated and Dispersed: 227 bbl Beached: 575 bbl Off Map: 0 bbl Floating: 197 bbl	

Figure 3.4-3
GNOME Model Oil Trajectory Plot for 72 Hours

Model Mode: Standard Estimate for: 08/01/06 72-hr Duration Prepared: 02/23/07	Model Name: Liberty

This trajectory was created using climatological currents from a GNOME Location File and is unlikely to represent conditions existing at any particular time at the depicted location.



Stefanson Sound Sag River speed 0.5144 m/s Shaviovik River speed: 0.5144 m/s Canning R. West speed: 0.5144 m/s Canning R. East / Tamayariak R. speed: 0.5144 m/s Wind: Constant 10 knots from ENE Number of Spills: 1 Spill Location: Latitude 70°19.22'N Longitude 147°51.67'W	Black Splots: Best Guess, Red Splots: Uncertainty Splot Mass Balance Totals (Best guess): Released: 999 bbl Evaporated and Dispersed: 383 bbl Beached: 587 bbl Off Map: 0 bbl Floating: 29 bbl	

APPENDICES

Appendix A

Analysis of Industry Crude and Product Oil Spills on the Alaska North Slope and Estimates of Potential Spills for the Liberty Development Project

Appendix A. Analysis of Industry Crude and Product Oil Spills on the Alaska North Slope and Estimates of Potential Spills for the Liberty Development Project

July 2, 2007

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Appendix A. Analysis of Industry Crude and Product Oil Spills on the Alaska North Slope and Estimates of Potential Spills for the Liberty Development Project

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Appendix A. Analysis of Industry Crude and Product Oil Spills on the Alaska North Slope and Estimates of Potential Spills for the Liberty Development Project

Summary

This appendix explains the data, methods, and results of an analysis of historical crude oil and refined product[1] ("product") spills for Alaska North Slope (ANS) facilities, including wells, facilities and other pipelines up to (but not including) Pump Station 1 (PS-1), which marks the beginning of the Trans Alaska Pipeline System (TAPS). The purpose of this analysis is to estimate the potential direct and indirect environmental impacts of the Liberty Development Project from potential crude oil and product spills. The projection method is based on statistical models used by the Minerals Management Service (MMS) for ANS and other oilfields. The data used for this analysis include historical ANS crude and product spills for the period 1985 – 2006; a time period believed most appropriate for this purpose.[2] The basic assumption is that the likelihood of future crude and product spills associated with the Liberty Development Project can be accurately estimated from prior ANS experience, i.e., that spill rates (per billion barrels produced) for this project will be similar to those at other ANS facilities. This basic assumption may overstate potential spills from the Liberty Development Project because this project makes efficient use of existing facilities and features few incremental facilities. The Liberty Development Project design and scope have evolved from an offshore stand-alone development in the outer continental shelf (OCS) (production/ drilling island and subsea pipeline) – as described in the 2002 Liberty Development and Production Plan Final Environmental Impact Statement – to make maximum use of the existing infrastructure involving an expansion of the Endicott Satellite Drilling Island (SDI). As a result, development of Liberty from Endicott significantly reduces potential environmental impacts, project footprint and does not require construction of new processing and transportation facilities.

Liberty will be developed with very few wells; up to six wells will be drilled from the expanded SDI using a purpose built drilling rig to reach the offshore Liberty reservoir located on the OCS. The drilling rig will be powered by natural gas so no handling and

[1] Two types of spills are considered in this analysis (1) spills of crude oil and (2) spills of refined products (e.g., aviation fuel, gasoline, diesel fuel, turbine fuel, motor oil, hydraulic oil, transformer oil, transmission oil, and engine lube oil, etc.). Produced water spills are not considered in this analysis. In cases where a "mixed spill" occurs the respective volumes of crude oil and product are calculated by multiplying the total spill volume by the respective percentages of crude or product. For simplicity, these are referred to as crude and product spills in the remainder of this appendix.

[2] It is believed that use of this spill reporting period is more accurate. First, the accuracy of oil spill data may have increased after 1985 and 1999 due to increased public awareness after certain large spills such as the Exxon Valdez, changes in the underlying reporting requirements in state and federal law, and a change from a paper format to an electronic format for records retention. Second, the reporting threshold for spills has substantially decreased since the early days of North Slope operations. This is supported by the finding that the average reported volumetric spill rate (see main text for definitions) from 1985 onwards was approximately 3 times greater than for the period 1977 – 1984. To avoid the possibility of under-estimating the number of spills the period from 1985 onwards was selected in this analysis.

storage of large quantities of diesel fuel is required for the project. Production from the Liberty wells will be tied into the existing Endicott flow line system with production sent from the SDI via the existing 28-inch CRA (Corrosion Resistant Alloy) three phase flow line to the Endicott Main Production Island (MPI) for processing. The Endicott plant internals are constructed of duplex stainless steel for production. After processing at the MPI facilities, Liberty oil will be transported through the existing 16-inch Endicott Sales oil pipeline (which is a DOT regulated pipeline) to Pump Station No. 1 of TAPS. This pipeline is internally inspected on a cycle of not less than once every five years (the last inspection was 2005) using a magnetic flux pig. The Liberty Project will be utilizing the Endicott facilities through a Facility Sharing Agreement (FSA) with the Duck Island Unit Owners which is currently being negotiated. No buried subsea pipelines (included in the alternatives considered in the original FEIS) are required.

As noted above, Liberty will maximize use of existing infrastructure; the analysis presented here conservatively assumes that the direct and indirect impacts of the Liberty Development Project can be estimated based on a statistical analysis of the historical crude and refined product oil spills that occurred on the North Slope.

Crude oil spills included in this analysis are subdivided into large spills (those greater than or equal [≥] to 200 barrels [bbls]) and small spills.[3] For large crude oil spills:

- The expected[4] number of large crude oil spills for the operating life of the Liberty Development Project is 0.09 based on the estimated production of 105 million bbls and the ANS experience that nine large crude oil spills occurred during the production of nearly 11 billion bbls of crude oil produced over the period from 1985 to 2006. We have high (95%) confidence that the expected number of future large crude oil spills associated with the Liberty Development Project ranges will be between 0.039 and 0.163.[5]

---

[3] MMS traditionally uses 1,000 bbls as the threshold for a large OCS oil spill. However, only one ANS spill > 1,000 bbls has occurred over the period from 1977 to the present. The original EIS for Liberty used 500 bbls as a threshold and more recent studies (Eschenbach and Harper, 2006) have considered thresholds as small as 50 bbls. The choice of 200 bbls provides an adequate sample of large spills for statistical purposes and lowers the likelihood that the estimates will be biased if the volume distribution of small spills differs from that for large spills.

[4] This is a statistical term of art and denotes the sum of the probabilities of 0, 1, 2, 3…spills times the number of spills, summed over all possible numbers of spills. Another word that might be chosen is the *estimated* number of spills. In this instance the expected or estimated number of large spills is 0.09—an impossibility because the number of large spills must be an integer (0, 1, 2, 3, etc). What this estimate tells us is that it is very likely that zero large spills will occur, a point amplified in the following paragraph.

[5] Technically this is known as a *confidence interval*. In statistics, a confidence interval (CI) for a population parameter (the large crude oil spill rate in this example) is an interval with an associated probability (95% in this instance) that is generated from a random sample of an underlying population such that if the sampling was repeated numerous times and the confidence interval recalculated from each sample according to the same method, a percentage (95%) of the confidence intervals would contain the true value of the population parameter in question. The use of confidence intervals was one of the specific recommendations of the NSBSAC. For additional information on confidence intervals, see http://www.cas.lancs.ac.uk/glossary_v1.1/confint.html.

- The estimated probability (in percentage terms) that no large crude oil spill will occur from the Liberty Development Project is approximately 92%[6] if the future is like the past and the assumed model is correct.[7] We have high (95%) confidence that the actual probability that no large crude oil spill will occur during the operation of Liberty lies between 85% and 96%. That is, large crude oil spills associated with the Liberty Development Project are unlikely.

- The estimated probabilities (expressed in percentage terms) that there will be 1, 2, or 3 large spills are approximately 7.8%, 0.3%, and < 0.01%, respectively.

- The odds against one or more large spills occurring are approximately 11:1. The odds against two or more large spills occurring are nearly 285:1.

- If a single large crude oil spill were to occur, then a reasonable estimate of the probable spill volume (using actual data directly as well as fitting statistical models) is 1,000 bbls. Allowing for the possibility of multiple large spills, the estimated spill volume is only slightly larger than 1,000 bbls. However, because large spills are infrequent, the weighted-average large spill volume is estimated to be 85 bbls[8].

- Because there is a distribution of large spill volumes, it is possible that the cumulative large spill volume—given the unlikely event that one occurs—would be greater than 1,000 bbls. Monte Carlo simulations, explained in the text, indicate that the 95% confidence interval on the volume of large spills (given that one occurs) is from 225 to 4,786 bbls.

It is important to note that, because the throughput of the Liberty Development Project is only a small fraction of the total ANS crude oil throughput, it is more likely that any future large crude oil spill will come from one of the other producing fields than from Liberty.

The Liberty Final EIS (USDOI, MMS, 2002) concluded on the basis of engineering judgment that the original designs would produce a "minimal chance of a significant oil spill reaching the water." This conclusion was based on the results gathered from several spill analyses done for Liberty that applied trend analysis and looked at causal factors. All showed a low likelihood of a spill, on the order of a 1 – 6% chance or less over the estimated 15 – 20 year life of the field.

---

[6] Note that this statement applies only to large crude oil spills. Many small spills (addressed later in this appendix) are likely to occur. Note also that probabilities can be expressed in two equivalent ways, as fractions between zero and one and as percentages. Thus, for example, a probability of 0.5 is exactly equivalent to a probability expressed in percentage terms of 50%--as likely as not in this case. For many readers it is more intuitive to think of probabilities as percentages. To avoid confusion, we insert the percentage symbol (%) to denote a probability expressed in percentage terms.

[7] This model is conceptually plausible and has been validated by historical experience in the Gulf of Mexico and ANS areas.

[8] As noted, if a large spill occurs, the volume estimate is approximately 1,000 bbls. But because the probability of a large spill occurring is so low, the weighted average volume of a large spill is much lower.

Small spills of either crude oil or refined product are more numerous than large spills. However, the average size of a small spill is very much smaller than the average size of a large spill, with the result that the aggregate volume of small spills is only about 28% of the total volume spilled (for crude). This analysis also develops estimates of the volume of small spills associated with Liberty. For small crude oil spills:

- The estimated total volume (throughout the operating lifetime of the Liberty Project) based on the observed ratio of the volume of small spills to ANS production is approximately 34 bbls. The Liberty Project Description (BPXA, 2006) does not specify the economic life of the project. Assuming a 20-year project lifetime, the average small crude-oil volume spilled per year would be approximately 1.75 bbl/year.

- The 95% confidence interval on the total volume of small crude oil spills ranges from 6 to 100 bbls.

Refined product spills, though numerous, are very small on average. Using the same method as that employed to project small crude oil spills, the following estimates are derived for the expected and 95% confidence limits on the volume of refined product spills yields the following estimates:

- The estimated total volume (throughout the operating lifetime of the Liberty Development Project) based on the observed ratio of the volume of small spills to ANS production is approximately 42 bbls, equivalent to approximately 2 bbl/year over a 20-year project lifetime.

- The 95% confidence interval on the total volume of small crude oil spills ranges from 10 to 125 bbls.

Introduction

This appendix provides an analysis of historical crude oil and refined product ("product") spills occurring on the Alaska North Slope (ANS) and develops projections of future spills associated with the operation of the Liberty Development Project using models originally developed by the Minerals Management Service (MMS) of the US Department of the Interior. Other sections of this Environmental Impact Analysis address a trajectory scenario and fate and effects of crude oil and product spills. As noted above, we believe that the estimates provided in this analysis are conservative in the sense that these are (if anything) likely to overstate spills originating from the Liberty Development Project because this facility will take maximum advantage of existing infrastructure.

Crude oil spills are among the most visible of the environmental impacts associated with industry exploration and production (E&P) activities and, as such, merit careful attention in any study of the environmental consequences of proposed ANS oil development.

This analysis begins with a characterization and analysis of historical crude and product spills. Crude oil is produced via deep wells, the oil/water/gas mixture is transported via flow lines to the production facilities, the three-phase mixture is processed (to remove water, solids, and gas), and then transported off the North Slope to refineries located in Alaska and elsewhere. Refined oil products, including aviation fuel, gasoline, diesel fuel, turbine fuel, motor oil, hydraulic oil, transformer oil, transmission oil, and engine lube oil, are used during E&P operations (MMS, 2002; BLM, 1998). Spills associated with operation of ANS facilities include both crude oil and product spills.

A brief description of Typical ANS Oil and Gas facilities

It is useful to provide a brief description of the ANS oilfields in order to understand possible sources of crude oil and product spills. This description is abstracted from discussions found in several *environmental impact statements* [EISs] (e.g., NPR-A, BLM, 1998). Oil is produced from wells (typically located on gravel *production pads*) and flows from wellhead manifolds to production facilities (PF) [termed flowstations, gathering centers, or central processing facilities depending upon the particular field and nomenclature of the operators]. Offshore wells are located on islands. Produced oil is transported as a multiphase slurry (or three phase oil containing oil, gas, and water) by *facility oil pipelines* and the *flowlines* from the wellhead manifold to the PFs. A PF is the operational center of production activities in an oilfield. The PF typically includes production equipment, offices, maintenance facilities, storage tanks for fuel and water, power generators, and a communications facility. The oil production equipment includes three-phase separators (oil, gas, and water are produced in varying proportions from each well), gas conditioning equipment (to remove natural gas liquids from produced gas), pipeline manifold and pressure-regulation systems, and well monitoring and control systems. Oil from production wells is filtered (to remove sand and other solids) and processed (removing water and gas). After processing, crude oil (termed *sales oil*) is routed either via non-common carrier oil transit pipelines if the lines are still inside the oil and gas field or are routed through a sales meter and transportation on one or more common carrier *crude oil transmission pipelines*, (also termed *sales-oil pipelines*) for delivery to a larger-diameter mainline at *Pump Station 1* (PS-1) of the *Trans Alaska Pipeline System* (TAPS) for shipment to Fairbanks or Valdez and ultimate loading onto tankers. System pipelines are many and vary in what they are designed to carry (three-phase fluids, produced water, fresh water, salt water, gas, crude oil, diesel or other products such as methanol) and vary in diameter, depending upon function and necessary capacity, and are normally laid out in straight-line segments and installed above ground on *vertical support members* (VSMs). Above ground pipelines are less disruptive to the environment and easier to monitor, repair, and (when necessary) reconfigure than are buried pipelines. Only one offshore field (Northstar) is connected into the system via a buried *(subsea)* pipeline.

Thus, the production-processing-distribution system on the North Slope consists of wells, facility oil piping, flowlines, PFs, transmission pipelines, and various associated equipment (e.g., pumps, valves of various kinds, and separators). Tanks are used to store water, refined products, and certain other fluids.

In principle, crude oil or product spills can occur at any of the types of facilities described above. Crude oil spills result when the integrity of the production-processing-transport system is breached. Product spills can result from a variety of other causes.

The Liberty Development Project design and scope have evolved from an offshore stand-alone development field in the OCS (production/drilling island and subsea pipeline as described in the original *Final EIS* [FEIS], [MMS, 2002]) to use existing infrastructure involving an expansion of the Endicott *Satellite Drilling Island* (SDI)[9]. The present plan uses *ultra-extended-reach drilling* (uERD) from the SDI.[10] BPXA estimates (see main text) that the Liberty Development Project could recover approximately 105 million bbls of hydrocarbons by waterflooding and using the *LoSal*™ *enhanced oil recovery* (EOR) process.

Thus, the Liberty Development Project is properly viewed as an onshore facility that takes maximum advantage of existing infrastructure. Spill rates are assumed to be similar to those experienced historically on the ANS.

Types of spills

This section provides information on the various types of E&P crude oil and product spills that have occurred over the operating history of the ANS fields, including information on causes, effects, and corrective actions/countermeasures. Because of the importance of large spills to spill totals (see above) it is appropriate to focus on these spills. (This analysis includes both large and small spills, however.)

Table 1 provides a list of the crude oil spills greater than or equal to 200 bbls that have occurred on the North Slope since 1985.[11] These spills range in volume from 225 bbls to 4,786 bbls. The spills shown in Table 1 list the volume of crude oil released in the event, even though other liquids may have also been released (e.g., produced water in the case of spills from some pipelines).

Causes of ANS E&P spills reported in various environmental assessments and EISs (e.g., Parametrix, 1997; BLM, 1998; MMS, 2002) include leaks from or damage to storage tanks, faulty valves/gauges, faulty connections, vent discharges, ruptured lines, seal failures, various human errors (e.g., tank overfill, tank damage, and failure to ensure connections), and explosions. Several of these causes are reflected in the brief spill descriptions given in Table 1. Many of the spills were also contained and not released into the environment, but the volume given is the total amount that was released even if to secondary containment.

---

[9] The SDI is not an onshore location. It is an existing gravel island attached to land via a causeway and is similar in construction to an onshore gravel pad facility. SDI facilities are also similar to onshore facilities (i.e., pipelines are aboveground and there is no need for an undersea buried pipeline). The SDI, while not an onshore facility more closely resembles an onshore facility than the offshore gravel island identified as the proposed action in the Liberty FEIS.

[10] BP has extensive experience with the use of extended reach drilling in overseas locations.

[11] Justification for use of the period from 1985 to 2006 is provided in a later section. The dates included are from 1 January 1985 until 31 December 2006.

Table 1. ANS crude oil spills greater than or equal to 200 bbls (1985-2006) – spill event description.

Rank	*Date*	*Volume (bbls)*	*Description of Spill Event*
1	2 Mar 06	4,786	Crude oil spill caused by corrosion and failure of a buried section of the pipe from GC-1 to GC-2.
2	28 Jul 89	925	The oil reserve tank overflowed because the high-level tank alarm system failed. The crude oil overflowed into a reserve pit.
3	21 Aug 00	715	Communication systems experienced a glitch which tripped some, but not all, shut down procedures. As a result, a tank continued to fill and overflowed.
4	17 Aug 93	675	A hole caused by external corrosion in a divert tank released a mixture of crude oil and produced water. Spill volume is crude oil only.
5	26 Sep 93	650	A Sulzer pump failure caused an overflow of Tank 7003. To alleviate rising tank levels, the inlet valve was closed and the outlet valve was opened, allowing material to spill into a containment dike. High winds carried some light oil mist to snow outside of the containment dike.
6	25 Aug 89	510	A 16 inch pipeline valve failed, allowing crude oil to leak from a piping system.
7	30 Dec 93	375	Wind-induced vibration caused a flowline leading from the well house to the manifold building to crack. Crude oil sprayed out of the crack. High winds carried some of the crude oil away from the pad towards Spine Road. At the time, the low-pressure safety system was disabled.
8	10 Jun 93	300	During a shutdown, a high-level alarm on a knockout drum failed.
9	20 Feb 01	225	During maintenance of a pipeline for thawing and displacement, pipeline ruptured, releasing the 'dead' crude mixture in the pipe.

Table 2 provides information similar to that given in Table 1 for ANS ***product spills.*** Table 2 provides information on spills greater than or equal to 50 bbls (rather than greater than or equal to 200 bbls). Spill volumes for the eleven largest product spills range from 50 bbls to 262 bbls – very much smaller on average than for crude oil spills. The largest product spills released diesel fuel, drilling oil, and drag reducing agent. As one would expect, the largest product spills involve materials kept on site in large quantities. However, the database also includes information on numerous small product spills for materials such as aviation fuel, brake fluid, chain saw oil, crankcase oil, cutting oil, engine lube oil, fuel oil, gasoline, gear oil, grease, hydraulic fluid, hydraulic oil, jet fuel, lube oil, motor oil, natural gas liquids, oil phase mud, slop oil, transformer oil, transmission fluid, turbine oil, used oil and waste oil as well as unknown products listed as 'other'. Causes for many of these spills include vehicle accidents, corrosion, faulty valves, broken fuel lines, and human errors (e.g., accidental overfill).

The spill database

The statistical analyses presented here are based upon data collected in a database developed over several years and used in several earlier spill studies. Initially, the database was developed for use in the *Trans Alaska Pipeline System Environmental Report* (TAPS ER) in support of an application for renewal of the TAPS pipeline *right-of-way* (ROW). The TAPS ER was prepared by an internal task force assisted by a team

Table 2. ANS refined product spills greater than or equal to 50 bbls (1985-2006) – spill event description.

Number	*Date*	*Volume (bbls)*	*Description of Spill Event*
1	17 Nov 03	262	Human error allowed a tanker truck to overfill at the MCC fuel dock. A seam failed and released diesel to secondary containment.
2	19 May 97	180	A needle valve on the fill line of a diesel storage tank broke, causing the diesel to drain into a lined containment area.
3	2 Mar 00	143	A release of drag reducing agent. All material was recovered.
4	16 Oct 86	100	Broken fuel line.
5	22 May 85	95	A faulty connection on a diesel tank truck caused this spill. A camlock fitting failed, allowing diesel to spill next to the truck.
6	28 Feb 03	85	A filter on a diesel spill at the MCC fuel dock failed and released diesel. Majority of spill was to secondary confinement.
7	31 Jul 91	75	Diesel released from a hole in annulus.
8	22 Jan 01	68	A diesel spill at a well pad.
9	5 Oct 95	50	Drilling oils released and contained on pad.
10	25 Nov 89	50	A maintenance issue allowed a valve to vibrate open and release diesel.
11	25 May 85	50	Heavy vehicle accident released diesel.

of external experts retained by the TAPS Owners (TAPS Owners, 2001) to characterize oil spills from 1977, when the first barrels of ANS oil flowed through the TAPS system, until August 1999. Details on data sources, compilation methods, and consistency checks are discussed in the TAPS ER and related documents (TAPS Owners, 2001). Prior to the release of the ROW documents, TAPS Owners performed extensive data audits and validation checks and appropriate corrections and adjustments were made (Niebo, 2001a,b and Maxim, 2001; Maxim and Niebo, 2001).

In 2002, this database was updated to provide information for a study commissioned by the *National Research Council* (NRC). The NRC study documented and evaluated information on the cumulative environmental effects of ANS oil and gas activities (NRC, 2003). As part of the study, the oil spill database was updated with government and industry records for crude oil and refined product spilled through 31 December 2001.

The current version of the oil spill database includes ANS crude oil and refined product spills from 1977 to 31 December 2006. In total, the ANS oil spill database provides information on nearly 8,000 spill events totaling approximately 20,300 barrels of material (including both crude oil and refined product) spilled over the 30-year period.

-Updating the oil spill database for the Liberty Development Project

The oil spill database needed to be updated for the Liberty Development Project. The original database was compiled from spill records maintained by both the Alaskan oil industry and state and federal agencies.

To update the oil spill database for the Liberty Development Project, electronic spill records were collected from *Alaska Department of Environmental Conservation* (ADEC) spill database and those maintained by BP Exploration (Alaska) [BPXA] and ConocoPhillips. Records were requested for the period from 1 January 2001 to 31 December 2006[12]. Once received, spill records were sorted based on the type of material spilled and segregated into two lists; a list of crude oil spills and a list of refined products spills. The lists were examined for duplicate spill records and duplicate records were removed and kept for reference. Duplicate spills were identified by comparing the date of each spill, identity of the spilled material, reported spill volume, and spill location.

There are differences between the industry and ADEC spills databases. Current spill reporting regulations are described in 18 AAC 75.300 and summarized on the ADEC website at http://www.dec.state.ak.us/spar/spillreport.htm#requirements. Differences between the industry and ADEC databases include:

- By regulation, some small spills are not reportable to ADEC, but industry has generally kept records of these small spills. Thus, there are some spills included in the industry databases that are not included in the ADEC database.

- The ADEC database also includes some spills that are not listed in the industry databases. As might be expected, some spills on the North Slope are not directly attributable to the oil industry and some may be related to government or military installations. These spills are not frequent and are typically related to spills of refined products. By combining relevant spill data from both industry and ADEC datasets, the resulting ANS oil spill database proves a more accurate picture of the spill history on the North Slope.

- Some spills are included in both databases, but a different spill volume is listed in each. These discrepancies occur for several reasons. In some cases a spill volume is used in the ADEC data base, that is subsequently revised (either upwards or downwards) and the revised data may not be listed (i.e. the spill record may not have been updated). In other cases, for example, the large crude oil spill discovered in March 2006, ADEC includes a margin of error (+33%) to allow for possible errors of estimation, whereas the oil industry data report uses an estimated value.

[12] Requesting data from Jan. 1, 2001 provided a useful check against the 2001 data already in the database. Some of the 2001 spill records in the existing database required changes to account for information that was entered at a later date. For example, an initial spill volume in an August 2001 spill record may have been updated with a final volume during 2002.

For most spills, the ADEC and industry oil data match very well. When the records matched (e.g., had same volume, spilled material, date and location) the record with the most supplemental information was retained for the database. That is, if the industry record had information on the circumstances of the spill or clean up that were not provided with the ADEC record, the industry record was kept for the final database. If the ADEC record contained more information than the industry record, the ADEC record was retained.

In some cases, the ADEC database and industry database do not agree on spill volumes even though they report the same spill. There are three reasons for disagreement. First, the ADEC spill database sometimes provides information on the total amount of liquid spilled during a spill event. A single spill event may release numerous types of liquids (such as produced water and crude oil from a pipeline leak, or diesel fuel, motor oil and hydraulic fluid in the case of a vehicle accident). The industry records generally identify the volume of specific types of liquid spilled. In instances where it was clear by that the ADEC data record had not disaggregated the spilled materials, the industry data records were used.

Second, conversations with ADEC personnel[13] indicated that the ADEC oil spill database recently had gone through revisions and a software upgrade. As a result, some of the smaller spills (reported to the agency as less than one gallon or in fractional gallons) had been rounded up. For example, the ADEC data may list a spill of two gallons while the industry database lists it as 1.5 gallons. In these cases, the industry record was used because of the precision of the volume. In general, the rounding appears to primarily have occurred with small spill of less than 2 gallons.

Third, for more recent spills, records in the ADEC database have not been "closed." That is, some of the spill response activities are still ongoing and the spill volume listed may be preliminary. In those instances, the industry records were used. This issue is only relevant for spills occurring during 2006.

To update the database, North Slope spills were added to the database. Specifically, spills were added from the ANS E&P facilities and pipelines and from records tagged by ADEC as occurring on the North Slope. All TAPS facilities were excluded from the database. Thus, there are no spills attributed to the TAPS pipeline or associated pump stations on the North Slope. Spills occurring from facilities in the town of Deadhorse were included in the update because those spills might be related to oil and gas activities on the North Slope. Spills from the neighboring towns and villages were not included. Typically, spills from these villages are usually small volumes of refined products.

[13] Personal Comm. with Camille Stephens, ADEC Environmental programs Spec III (907) 465-5242, January 19, 2007.

-Period of analysis

The ANS oil spill database contains records back to the beginning of oil production on the ANS in 1977. However, there are fewer spill records during the years from 1977 to 1985 (see Fig. 1) and the completeness and accuracy of the older records has been questioned. In fact, several observers believe that the accuracy of oil spill data on the North Slope is naturally greater for the period after 1985 (MMS, 2002) or 1989 (BLM, 1998) than for the earlier years.

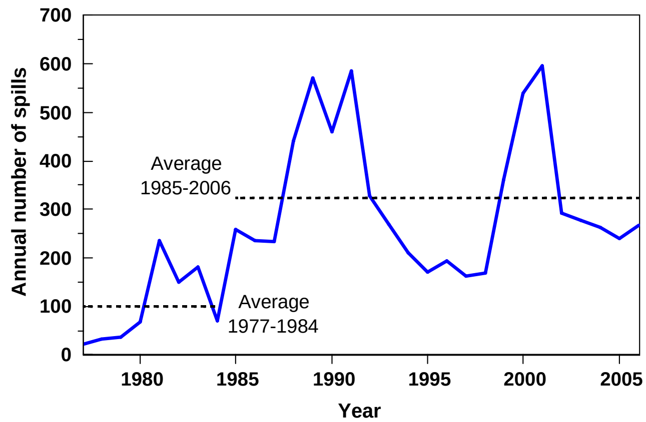

Fig. 1. Annual number of crude and product spills listed in ANS oil spill database, 1977 to 2006.

It has been suggested that spills may have been under-reported in the earlier years.[14] One report (AGRA, 2000) claims that prior to the 1990s only 10% of spills on tundra were reported to the ADEC and included in the State's files. We know of no reliable basis for estimating the extent (if any) of under-reporting prior to 1985.

Another issue that confounds accurate assessment of the spill record prior to 1985 is that prior to 1985, the ADEC spill records, the only source that may have been available for public scrutiny, were kept as paper files. After 1985, the system was converted to an electronic database. The written records for many spills prior to 1985 are now missing or incomplete; a search of the paper records by MMS contractor Hart Crowser in 1999 revealed that very little of the paper record existed publicly through ADEC.

Analysis of the updated spills database indicates that there are fewer spill records per year in the early years of ANS production. Figure 1 plots the annual number of crude oil and refined product spills in the database from 1977 through 2006. The average number of spills reported from 1977 to 1984 was 100 per year. The average number of spills reported from 1985 to 2006 was 324 spills per year—greater by a factor of three.

Currently, we have no definite explanation why fewer annual spills were reported in the early years. However, to avoid any possible under-estimation of future spill quantity projections, and to acknowledge that the data prior to 1985 can not be easily validated through a public source, we restricted our analysis to spills that occurred from

[14] It is difficult to assess the validity of this claim. On the one hand, reporting thresholds for spills have decreased over time, which would be consistent with this hypothesis. As well, spill awareness has also increased. However, on the other hand, large spills account for the bulk of the total volume and changes in the reporting threshold or spill awareness would probably not affect the likelihood of reporting large spills.

1 January 1985 to 31 December 2006—an assumption supported by MMS personnel. *The database used for this analysis includes 22 years of ANS spill history and thousands of spill records for statistical analysis.*

Spill data and spill rates

As the term is used here, "oil spills" are unintentional accidental releases of crude oil or product. Accidents are fundamentally probabilistic, rather than deterministic, events. Accordingly, it is appropriate to analyze spill data in statistical terms.

-Size distribution of ANS spills

As noted above, the reporting threshold by regulation is quite low, and the oil industry maintains records of spills below the reporting threshold. For this reason, ANS spill records in the database range more than six orders of magnitude in volume, from 0.01 *gallons* (7.5 teaspoons) to 4,786 *barrels*[15]. That is, relatively small spills are quite frequent, but there is a long "tail" to the distribution—the total volume is dominated by relatively few large spills. This characteristic (see below) has important implications for the appropriate choice of a spill metric—it is *the total volume, not the total number of spills* that is relevant.

A key conclusion of this analysis is that smaller spills, although more numerous, account for only a small proportion of the total spill volume. This is best illustrated by a *Lorenz diagram*, which plots the fraction of the spill volume (on the vertical axis) versus the fraction of the number of spills (on the horizontal axis). It is constructed as follows. First, the spill data are sorted in ascending order of spill volume. Next the cumulative fraction of the total volume spilled (y-axis) is plotted as a function of the cumulative fraction of the total number of spills (x-axis). Figure 2 provides a hypothetical illustration of a Lorenz plot. If all spills were exactly the same size, the fraction of the spill volume would correspond exactly to the fraction of the number of spills. The 45° line "AB" in Fig. 2 depicts this situation. However, if some spills were larger than others, then the fraction of the spilled volume would be less than the fraction of the number of spills, as shown by the curve "AB" beneath the 45° line in Fig. 2. The area between the curve

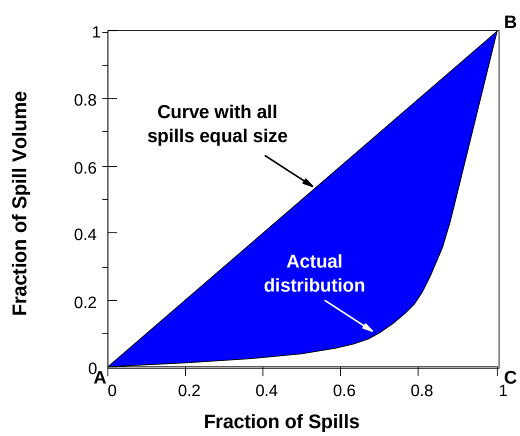

Fig. 2. A hypothetical Lorenz diagram: the size of the area between the line of constant spill volume and the actual Lorenz curve as a fraction of the bounding triangle ABC is used as a measure of inequality.

[15] One barrel is equal to 42 gallons.

and the straight line (the shaded area in Fig. 2) provides an indication of the degree of inequality in spill size distribution. Dividing the shaded area by the area of the triangle ("ABC" in Fig. 2) yields a normalized index or coefficient, denoted L, of the variability of spill volumes. L ranges from 0 (all spills the same size) to 1.

The diagram shown in Fig. 2 is hypothetical, included solely to illustrate the concept. The actual curves for ANS spills are more extreme. Figure 3 shows Lorenz plots for ANS crude (shown in red) and product spills (shown in blue) over the period from 1985 to 2006. As can be seen, there is substantial curvature in these plots (the computed Lorenz coefficients are 0.96 and 0.87 for crude and product ANS spills, respectively).

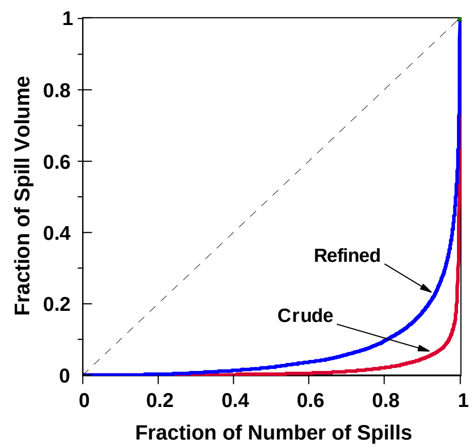

Fig. 3. Actual Lorenz curve for ANS crude and product spills (1985-2006).

The Lorenz plots provide a useful characterization of ANS spills. The clear message is that a few relatively large spills account for a majority of the total spill volume. This conclusion is suggested by numerous spill studies (Smith *et al.*, 1982; BLM, 1998, 2004, 2005; MMS, 2002, NRC, 2003; and Taps Owners, 2001). Most spills are relatively small:

- Fifty percent (the median) of ANS crude oil spills were less than or equal to 0.119 bbls (5 gallons). Fifty percent of product spills were less than or equal to 0.095 bbls (slightly less than 5 gallons).

- The smallest 90% of crude oil spills accounted for only approximately 4.4% of the total volume spilled and the smallest 95% of the spills accounted for only 7.4% of the spilled volume. The corresponding percentages for product spills were 17.6% and 26.6%, respectively.

- Another perspective on ANS spill volumes is evident from the *cumulative distribution function* (CDF). Figure 4 shows the CDF for ANS spills (crude and product) over the period from 1985 to 2006. The CDF plots the fraction of spills with a volume less than or equal to a specified amount x (on the y-axis) against the value of x (on the x-axis); crude oil spills are shown in red, product spills in blue. Because of the large variability in spill volumes, only a portion of the CDF is plotted in Fig. 4;

that for spills less than or equal to 5 bbls. This diagram clearly shows that most spills are relatively small. For ANS spills, 87.3% of crude oil spills and 94.7% of product spills are less than 2 bbls. A few specific spills are discussed below, but small spills are quite diverse (fueling vehicles, leaking drums, and splashes).

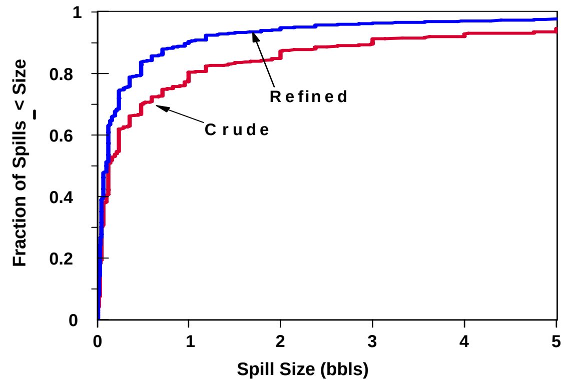

Fig. 4. Cumulative distribution function for ANS E&P spills less than 5 bbls (1985-2006).

Small spills are inherently of less concern than larger spills for the following reasons (TAPS Owners, 2001; McKendrick 2000 and references therein; NRC, 2003; BLM, 1998, 2005):

- Small spills are more likely to be contained on site,
- Small spills are also more likely to be fully recovered,
- Small spills have a lower potential to produce significant adverse environmental impacts, and
- Small spills collectively account for only a small proportion of the total volume spilled.

The above findings argue for an analytic focus on the *volume spilled*, rather than the *number of spills* and a corresponding emphasis upon the causes, effects, and consequences of larger spills.[16] Most EISs distinguish between small and large spills and, indeed, use separate methodologies for projection of future spills of each type.

In what follows, we first address large crude oil spills and develop methods for projection of future large spills associated with the Liberty Development Project. Next we develop projections for small crude oil and product spills for this project.

"Large" spill definition and projections

MMS and its contractors have developed useful methods for predicting "large spills" (Smith *et al.*, 1982; LaBelle and Anderson, 1985; Anderson and LaBelle, 1990, 1994; Amstutz and Samuels, 1984; MMS, 1987, 1990a,b, 1996, 1998, 2002; Eschenbach and Harper, 2006). (Historically, MMS has typically used 1,000 bbls as the threshold for a large OCS spill. We modify this definition below.)

[16] This is not meant to imply that North Slope operators disregard small spills. Many small spills (e.g., vehicle leaks) are easily prevented (e.g., periodic maintenance) or contained (e.g., use of drip pans) by simple devices and/or changes in operating procedures. Such measures (including simple housekeeping) are readily implemented and cost-effective. Each of the North Slope operators has developed *standard operating procedures* (SOPs) that are designed to combat both large and small spills.

This method examines the frequency of large crude oil spills in comparison to the volume of oil produced by calculating a spill rate expressed as the number of large spills per billion bbls produced.[17] Large spills are assumed to occur as a Poisson process and the Poisson distribution is used to estimate the future number of large spills for the forecast throughput over the planning horizon.[18] That is, if μ is the expected number of spills associated with a particular production volume, then the probability[19] of x = 0, 1, 2, 3,….k future spills is given by,

$$P\{x = k\} = \exp(-\mu)\,(\mu)^k/k!. \qquad (1)$$

Defining j as the observed number of large crude oil spills in the past associated with the production of y billion bbls (Bbbls), the observed (historical) large crude oil spill rate for pooled ANS facilities is calculated from the ratio j/y. If an additional z Bbbls are to be produced over some future time horizon, then the expected number of large spills over this horizon is calculated as $\mu = z\,(j/y)$.[20] The MMS methodology has been challenged by some,[21] but more recent analyses (e.g., Eschenbach and Harper, 2006) indicate that this basic model is appropriate[22]. For estimation of spill rates we use only data from ANS operations. We make no assumption that spill rates from other areas, such as the *Gulf of Mexico* (GOM), apply to the ANS.[23]

In principle, the threshold for definition of a large spill is (to a large extent) arbitrary, but prior analyses (chiefly those of spills in the GOM) have typically chosen a threshold of 1,000 bbls. However, in preparing the spill projections for the Liberty field (MMS, 2002), MMS used a lower large spill threshold of 500 bbls (MMS, 2002). There were both policy[24] and practical reasons for this choice; when this analysis was originally

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[17] Other exposure measures have been proposed and analyzed, such as time, pipeline km for pipeline spills, and platform years for oil platforms. Eschenbach and Harper (2006) show that these candidate exposure measures are generally correlated. In this analysis, we use production as the exposure metric. This is easy to understand, consistent with many earlier analyses, and does not require that pipeline and platform spills be disaggregated.

[18] Because of the limited number of large spills that have occurred it is not possible to distinguish between pad (platform) and pipeline spills. Instead, large spills are pooled for all *facilities*.

[19] The probability calculated using this question is expressed as a fraction, not in percentage terms.

[20] MMS has now developed a different model to describe offshore facilities that accounts for possible additional failure modes and mechanisms for undersea pipelines. As Liberty is properly viewed as an onshore development use of this new methodology was not considered necessary.

[21] For example, the *North Slope Borough Science Advisory Committee* (NSBSAC) made several trenchant comments on this methodology—or at least how this methodology was applied in recent EISs (NSBSAC, 2003). We believe that we have addressed their concerns in this analysis.

[22] Eschenbach and Harper (2006), in a study funded by MMS, have shown that the Poisson model provides an adequate representation. Specifically, they concluded:

> "The Poisson distribution for pipeline and platform spill rates is satisfactory. Other distributions could be chosen, but the Poisson
> 1. Fits with historical practice
> 2. Has a theoretical foundation – it is not just an empirical curve fit
> 3. Is "not rejected" at reasonable levels of statistical confidence
> 4. Even though the fit of any distribution may be imperfect, the key question when estimating rates, is 'how much do these imperfections change the estimated rate? Generally, the answer is very little.'"

[23] This was one of the concerns of the NSBSAC (NSBSAC, 2003) in reviewing MMS methodology—the possible lack of similarity between ANS and GOM operations.

[24] MMS typically uses a large spill volume of greater than or equal to 500 bbl for Alaska North Slope EIS documents.

undertaken, no spills greater than 1,000 bbls had ever occurred on the North Slope. More recently (Eschenbach and Harper, 2006) MMS has examined various thresholds for the definition of an OCS large spill as low as 50 bbls.

As noted above, the threshold for definition of a large spill is (to a large extent) arbitrary. Nonetheless, there are some practical reasons for choosing one threshold compared to another:

- The volume threshold must be sufficiently high to include a reasonable number of "large" spills in the data set for analysis. As described above, upper and lower confidence limits are calculated based on the available data—the width of the confidence interval depends upon the number of data points included. If there are only a few data points included, then the results will not be precise. This criterion argues for relatively lower volume threshold to increase the available sample size.

- It is possible that the statistical characteristics of "large" spills differ from that for "small" spills. If the threshold for a large spill is set too low, then the population of "large" spills would also include an appreciable proportion of small spills, which might bias the analysis. This possibility argues for a higher volume threshold.

In the end, it is a matter of judgment as to the appropriate threshold. In this analysis we have chosen 200 bbls as a practical compromise. Reference to Table 1 shows that using a threshold of ≥ 200 bbls implies that a total of nine large spills occurred over the period from 1985 to 2006.[25]

Probability calculations for future large spills from the Liberty Development Project

This section provides probability calculations for number of large crude oil spills associated with the development and production of the Liberty Development Project. For the *base case* we use a threshold of 200 bbls for the definition of a large spill. Over the period from 1985 through the end of 2006 nine large spills occurred, accounting for approximately 72% of the total volume of crude oil spilled. A total of 10.976 billion barrels (Bbbls) of crude oil was produced over this period.

The estimated mean spill rate μ (given these assumptions) is 9 spills/10.976 Bbbls = 0.82 large spills/Bbbls produced. This and other calculations are shown in Table 3.

-Estimate of future large spills from the Liberty Development Project

As noted above, the estimated total production from the Liberty Development Project is 105 million bbls (0.105 Bbbls). Thus the estimate of the expected number of large crude oil spills associated with this production volume (assuming that spill rates in the future are the same as those observed historically) is 0.82 large spills/Bbbls x 0.105 Bbbls = 0.086 large spills (see Table 3). Using this spill rate and the Poisson model (equation [1]) it is possible to estimate the probability of 0, 1, 2, 3…large spills

[25] If the threshold were set at 100 bbls, 17 large spills would have occurred. If the threshold were set at 500 bbls, then six large spills would have occurred.

associated with the development of the Liberty Project. As shown in Table 3[26], the best estimate of the probability of 0 large spills is approximately 0.9175 (nearly 92%), of exactly 1 large spill is 0.0789 (nearly 8%), of exactly 2 large spills is 0.0034 (0.3%) etc. The probability of 1 or more large spills from this facility is 1 – P(0) = 1 – 0.9175 = 0.0824 (approximately 8%).

Table 3. Calculation of large spill probabilities and confidence intervals for Liberty field.

Inputs:

Quantity	*Units*	*Value*	*Source/remarks*
Confidence level, p	NA	0.05	Conventional statistical assumption
Large spill threshold	Bbls	200	Assumption
# large spills in baseline period	NA	9	ANS data from 1985 through 2006 for all facilities
Throughput in baseline period	Bbbls	10.976	ANS data from 1985 through 2006
Large spill rate	spills/Bbbls	0.8200	ANS estimate of mean large spill rate
Exact LCL on spill rate	spills/Bbbls	0.3749	Computed exact lower confidence limit
Exact UCL on spill rate	spills/Bbbls	1.5566	Computed exact upper confidence limit
Throughput for Liberty Project	Bbbls	0.105	Estimated future production of Liberty field from Liberty Project description December 2006 (BPXA, 2006)

Future estimates:

	Lower confidence limit			*Best estimate*			*Upper confidence limit*		
Expected number of large spills over life of Liberty field	0.0394			0.0861			0.1634		
Number of large spills,	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***
x	**x**	**<= x**	**x| x>=1**	**x**	**<= x**	**x| x>=1**	**X**	**<= x**	**x| x>=1**
0	0.96139589	0.96139589		0.91750529	0.91750529		0.84921846	0.84921846	
1	0.0378492	0.99924508	0.98044466	0.0789944	0.99649968	0.95756918	0.13879525	0.98801372	0.92050563
2	0.00074504	0.99999013	0.01929956	0.00340059	0.99990027	0.04122189	0.01134227	0.99935598	0.07522317
3	0.00000978	0.9999999	0.00025327	0.00009759	0.99999786	0.00118303	0.00061792	0.9999739	0.00409813
4	0.0000001	1	0.00000249	0.0000021	0.99999996	0.00002546	0.00002525	0.99999915	0.00016745
5	7.58E-10	1	0.00000002	0.00000004	1	0.00000044	0.00000083	0.99999998	0.00000547
6	4.97E-12	1	1.29E-10	5.19E-10	1	6.29E-09	0.00000002	1	0.00000015
7	2.80E-14	1	7.24E-13	6.38E-12	1	7.74E-11	5.25E-10	1	0.00000003
8	1.38E-16	1	3.56E-15	6.87E-14	1	8.33E-13	1.07E-11	1	7.11E-11

Number of large spills, x	***Probability x or more large spills***	***Odds 1: y***	***Probability x or more large spills***	***Odds 1: y***	***Probability x or more large spills***	***Odds 1: y***
1	0.03860411	24.9	0.08249471	11.1	0.15078154	5.6
2	0.00075492	1,323.60	0.00350032	284.7	0.01198628	82.4
3	0.00000987	101,273.20	0.00009973	10,026.00	0.00064402	1,551.80
4	0.0000001	10,310,096.50	0.00000214	467,874.60	0.0000261	38,318.40

[26] Several decimal places are shown in these calculations to assist the reader interested in replicating these calculations, not because of any assumed accuracy. These estimates have been rounded in summary statements. Probabilities shown in this and other tables are expressed as fractions; multiply by 100 to convert these to percentage terms. Note also that this calculation applies only to large spills. Many small spills (addressed later in this appendix) are likely to occur.

In plain language, if the frequency of future large (≥ 200 bbls) crude oil spills is similar to those observed historically, then the following statements can be made with respect to large spills associated with the development of the Liberty Project:

- The estimated number of large crude oil spills is approximately 0.09,[27]
- The probability that there would be no large crude oil spill (expressed in percentage terms) is approximately 92%, and
- The odds against one or more large spills are approximately 11:1. The odds against two or more large spills occurring are nearly 285:1.

Formulas to calculate a (1 – p)% confidence interval on this rate are given in various sources (see e.g., Eschenbach and Harper (2006) and references contained therein).[28] If μ_L and μ_U denote the lower and upper confidence limits on μ based on a total of x spills, these are given by the following formulas:

$$\mu_L = 0.5\,\chi^2\,(2x, p/2)/\ \text{exposure variable} \qquad (2)$$
$$\mu_U = 0.5\,\chi^2\,(2(x+1), 1- p/2)/\ \text{exposure variable} \qquad (3)$$

where χ^2 is the value of the Chi-square distribution. In this example, the 0.025 and 0.975 confidence limits on the mean rate calculated from equations (2) and (3) are approximately 0.37 and 1.56 large crude oil spills/Bbbls, respectively (as shown in Table 3). And, therefore, the 95% confidence interval on the estimated number of large crude oil spills associated with the Liberty Development ranges from 0.37 spills/Bbbls x 0.105 Bbbls = 0.039 spills to 1.56 spills/Bbbls x 0.105 Bbbls = 0.163 spills.

Associated with each of these spill rates are probabilities similar to those cited above. Thus, for example:

- We have high confidence (95%) that the chance that there would be no large crude oil spill associated with the development of the Liberty Project is between 85% and 96%.
- If a large crude oil spill should occur, then the probability that there is exactly one large spill ranges from 0.92 (92%) to 0.99+ (> 99%). That is, it is very likely that no more than one large spill would occur, even if one spill did occur.

[27] As noted elsewhere the number of large spills must be an integer, that is 0, 1, 2, 3, etc. The estimated number of spills is calculated by multiplying the number of spills (an integer) by the probability that this many spills would occur and summing over all possibilities. The significance of a very small number (0.09 in this instance) is that it is very likely that no large spills will occur.

[28] One of the NSBSAC criticisms of earlier MMS analyses was the omission of any calculation of confidence limits on projected quantities. Confidence limits are used extensively in this analysis. Other sources for equations to calculate confidence limits on the mean of a Poisson distribution are available electronically at http://hyperphysics.phy-astr.gsu.edu/hbase/math/poifcn.html#c2, http://www.math.mcmaster.ca/peter/s743/poissonalpha.html, and http://www.hep.fsu.edu/~harry/Public/Morelia2002-1.pdf.

- The odds against one or more large spills associated with development of the Liberty Project range from 5.6:1 to 24.9:1.

As noted above, we believe that 200 bbls strikes a reasonable balance among competing objectives in setting a threshold. To illustrate the sensitivity of this assumption, Tables 4 and 5 show replicate computations if the large-spill threshold were set at 500 bbls (65% of total spilled) or 100 bbls (82.3% of total spilled).

Table 4. Calculation of large spill probabilities and confidence intervals for Liberty field assuming a large spill threshold of 500 bbls.

Inputs:

Quantity	*Units*	*Value*	*Source/remarks*
Confidence level, p	NA	0.05	Conventional statistical assumption
Large spill threshold	Bbls	500	Assumption
# large spills in baseline period	NA	6	ANS data from 1985 through 2006 for all facilities
Throughput in baseline period	Bbbls	10.976	ANS data from 1985 through 2006
Large spill rate	spills/Bbbls	0.5466	ANS estimate of mean large spill rate
Exact LCL on spill rate	spills/Bbbls	0.2006	Computed exact lower confidence limit
Exact UCL on spill rate	spills/Bbbls	1.1898	Computed exact upper confidence limit
Throughput for Liberty Project	Bbbls	0.105	Estimated future production of Liberty field from Liberty Project description December 2006 (BPXA, 2006)

Future estimates:

	Lower confidence limit			*Best estimate*			*Upper confidence limit*		
Expected number of large spills over life of Liberty field	0.0211			0.0574			0.1249		
Number of large spills,	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***
x	**x**	**<= x**	**x| x>=1**	**x**	**<= x**	**x| x>=1**	**X**	**<= x**	**x| x>=1**
0	0.979156	0.97915626		0.944218	0.94421823		0.882558	0.88255763	
1	0.020625	0.99978124	0.989505	0.054196	0.99841443	0.971576	0.110259	0.9928166	0.938835
2	0.000217	0.99999847	0.010421	0.001555	0.99996981	0.027883	0.006887	0.999704	0.058645
3	1.53E-06	0.99999999	7.32E-05	2.98E-05	0.99999957	0.000533	0.000287	0.99999081	0.002442
4	1E-08	1	3.9E-07	4.3E-07	1	7.66E-06	8.96E-06	0.99999977	7.63E-05
5	3.38E-11	1	1.62E-09	0	1	9E-08	2.2E-07	1	1.91E-06
6	1.19E-13	1	5.70E-12	4.69E-11	1	8.41E-10	0	1	4E-08
7	3.57E-16	1	1.71E-14	3.85E-13	1	6.89E-12	8.32E-11	1	7.08E-10
8	9.41E-19	1	4.52E-17	2.76E-15	1	4.95E-14	1.30E-12	1	1.11E-11

Number of large spills, x	***Probability x or more large spills***	***Odds 1: y***	***Probability x or more large spills***	***Odds 1: y***	***Probability x or more large spills***	***Odds 1: y***
1	0.020844	47	0.055782	16.9	0.117442	7.5
2	0.000219	4,570.30	0.001586	629.7	0.007183	138.2
3	1.53E-06	652,203.30	3.02E-05	33,122.10	0.000296	3,377.30
4	1E-08	123,982,510.20	4.3E-07	2,314,985.10	9.19E-06	108,852.50

Table 5. Calculation of large spill probabilities and confidence intervals for Liberty field assuming a large spill threshold of 100 bbls.

Inputs:

Quantity	***Units***	***Value***	***Source/remarks***
Confidence level, p	NA	0.05	Conventional statistical assumption
Large spill threshold	Bbls	100	Assumption
# large spills in baseline period	NA	17	ANS data from 1985 through 2006 for all facilities
Throughput in baseline period	Bbbls	10.976	ANS data from 1985 through 2006
Large spill rate	spills/Bbbls	1.5488	ANS estimate of mean large spill rate
Exact LCL on spill rate	spills/Bbbls	0.9023	Computed exact lower confidence limit
Exact UCL on spill rate	spills/Bbbls	2.4798	Computed exact upper confidence limit
Throughput for Liberty Project	Bbbls	0.105	Estimated future production of Liberty field from Liberty Project description December 2006 (BPXA, 2006)

Future estimates:

	Lower confidence limit			***Best estimate***			***Upper confidence limit***		
Expected number of large spills over life of Liberty field	0.0947			0.1626			0.2604		
Number of large spills,	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***	***Probability***
x	**x**	**<= x**	**x| x>=1**	**x**	**<= x**	**x| x>=1**	**X**	**<= x**	**x| x>=1**
0	0.90961255	0.90961255		0.84990768	0.84990768		0.77075674	0.77075674	
1	0.08617355	0.99578609	0.95337953	0.1382184	0.98812608	0.92088923	0.20069154	0.97144828	0.87545231
2	0.00408189	0.99986799	0.04515994	0.01123906	0.99936514	0.07488098	0.02612828	0.99757656	0.11397621
3	0.0001289	0.99999689	0.0014261	0.00060926	0.9999744	0.00405924	0.00226778	0.99984434	0.00989247
4	0.00000305	0.99999994	0.00003378	0.00002477	0.99999917	0.00016504	0.00014762	0.99999197	0.00064396
5	5.78E-08	0.999999999	0.00000064	0.00000081	0.99999998	0.00000537	0.00000769	0.99999965	0.00003353
6	9.13E-10	1	0.00000001	0.00000002	0.999999999	0.00000015	0.00000033	0.99999999	0.00000146
7	1.24E-11	1	1.37E-10	5.07E-10	1	3.38E-09	1.24E-08	1	0.000000054
8	1.46E-13	1	1.62E-12	1.03E-11	1	6.87E-11	4.04E-10	1	0.000000002

Number of large spills, x	***Probability x or more large spills***	***Odds 1: y***	***Probability x or more large spills***	***Odds 1: y***	***Probability x or more large spills***	***Odds 1: y***
1	0.09038745	10.1	0.15009232	5.7	0.22924326	3.4
2	0.00421391	236.3	0.01187392	83.2	0.02855172	34
3	0.00013201	7,574.00	0.00063486	1,574.20	0.00242344	411.6
4	0.00000311	321,367.80	0.0000256	39,063.50	0.00015566	6,423.40

Empirical cumulative distribution function (CDF) of ANS large spill volumes

The above sections develop estimates (and associated 95% confidence limits) of the probability of 1, 2, 3… large crude oil spills associated with production from the Liberty Development Project. This and following sections develop an estimate of the probable *volume of a large spill* (if one occurs) and the cumulative number of large spills (if more than one occurs).

The available data for estimation of the volume of a large spill consist of the observed historical (over the period of interest) ANS large spill volumes x_i (i = 1, n), in ascending order so that $x_1 \leq x_2 \leq x_3 \ldots \leq x_n$. If μ denotes the cutoff volume used to define a large spill, then $\mu \leq x_i$ for all i, by definition. As noted above, for example, if ≥ 200 bbls is defined as the cutoff volume for definition of a large spill, based on the ANS spill data, then there are nine large spills (n = 9). As shown in Table 1, these volumes are (rounded) as follows; 225, 300, 375, 510, 650, 675, 715, 925, and 4,786 bbls.[29]

The CDF is a plot of the fraction (or percentage) of the observed large spill volumes less than or equal to a specific volume x, denoted F(x), versus the spill volume x. Because the observed number of large spills is finite, the CDF can be directly[30] estimated only at each of the individual data points, $F(x_i)$. The conventional estimator of $F(x_r) = r/n$, where x_r is the volume corresponding to the r^{th} data point in the ordered list.[31] Thus, for example, F(225) = 1/9, F(300) = 2/9 etc.

Other estimators of $F(x_r)$ suggested in the literature include; (r – 0.3)/(n + 0.4), Gross (1996);[32] (r - ½)/n, Guttman *et al.*, (1982) or Gilbert (1987); (3r – 1)/(3n + 1), Koch and Link, (1971); and r/(n + 1), Mosteller and Rourke (1973) or Uusitalo (2004).[33] When n is large, these different estimators do not differ materially, but when n is small (as it is in this case) the differences are more appreciable. Unless otherwise noted, we use the convention $F(x_r) = (r – 1/2)/n$. Given this plotting convention, Fig. 5 shows the empirical CDF of large ANS spills (assuming γ = 200 bbls). As can be seen, the empirical CDF

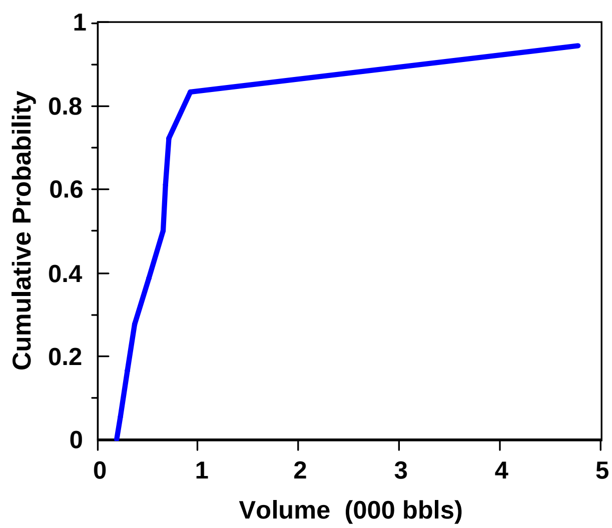

Fig. 5. Empirical CDF of ANS large (≥ 200 bbls) spills 1985-2006.

[29] As noted above, the largest spill volume is given as 4,786 bbls, which is the calculated estimate of the spill volume for the spill detected on 2 March 2006. The source of the spill was an above-ground 34 inch diameter crude oil transit line between Gathering Center 2 (GC-2) and GC 1, Western Operating Unit, Prudhoe Bay. ADEC lists this volume in their database as 6,357 bbls, the upper confidence limit of a range of approximately +/- 33%. Additional studies are underway to estimate this spill volume. Lacking more precise estimate of this spill volume, we use the calculated estimate of 4,786 bbls in this analysis.

[30] Other percentiles of the CDF can also be estimated by fitting distributions (see e.g., Gilbert, 1987).

[31] See, e.g., the probability-probability plots entry within an online glossary of statistical terms at http://sunsite.univie.ac.at/textbooks/statistics/glosp.html.

[32] This was suggested specifically for the three-parameter Weibull, see Gross, B., (1996). Least Squares Best Fit Method for the Three Parameter Weibull Distribution: Analysis of Tensile and Bend Specimens With Volume or Surface Flaw Failure, NASA Technical Memorandum 4721, NASA Lewis Research Center, Cleveland, OH, available electronically at http://gltrs.grc.nasa.gov/reports/1996/TM-4721.pdf.

[33] See, Uusitalo, K., (2004). The empirical cumulative distribution function, its inaccuracy and probability plotting, Helsinki, Finland, available electronically at http://www.helsinki.fi/ ~kuusital/doc/ecdf-inaccuracy-and-probability-plotting.pdf.

shows that most of the large spills (if fact 8 out of 9) were less than 1,000 bbls.[34] The empirical CDF appears irregular because the number of large ANS spills over the period from 1985 to 2006 is relatively small.

There are two basic approaches for handling the large spill data in order to make an estimate of the likely volume of any future large spills associated with the Liberty Development Project; (1) fitting the empirical data to a defined statistical distribution and (2) analyzing the empirical data directly. Both approaches are explored in this analysis.

-Fitting the large spill data to a probability distribution

Prior analyses of large spill volume data by MMS and others (see, e.g., Anderson and Labelle, 1990, 1994, 2000; Eschenbach and Harper, 2006; Hart Crowser, Inc., 2000; Lanfear and Amstutz, 1983; MMS, 2002; Smith *et al.*, 1982; Stewart, 1976; Stewart and Kennedy, 1978; and TAPS Owners, 2001) suggest that these spill volumes appear to conform to, or at least can be satisfactorily described by, a statistical probability distribution. Several candidate distributions have been suggested in the literature, including the Weibull, Gamma, and lognormal models. The three-parameter Weibull distribution (favored by several authors), for example, has the following density and cumulative distribution functions:

$$f(x) = (\alpha/\beta)((x-\gamma)/\beta)^{(\alpha-1)} \exp(-((x-\gamma)/\beta)^{\alpha}) \quad (4)$$

$$F(x) = 1 - \exp(-((x-\gamma)/\beta)^{\alpha}) \quad (5)$$

where:

α = continuous *shape* parameter ($\alpha > 0$)

β = continuous *scale* parameter ($\beta > 0$), and

γ = continuous *location* parameter (γ = minimum spill volume).

The three-parameter Weibull distribution has found wide applicability for such diverse applications as modeling spill volumes, environmental pollution, reliability theory, weather forecasting, and the breaking strengths of materials. Apart from any theoretical justification, this model is quite flexible and capable of mimicking many other continuous distributions.[35]

The parameters of the Weibull distribution (α, β, and γ[36]) can be fitted using several statistical approaches, including (1) matching the observed CDF with the empirical CDF, (2) maximum likelihood, and (3) the method of moments. By matching CDFs (squared error criterion, using (r – ½)/n as the basis for the empirical CDF) we developed the following best-fit estimates; γ = 200 bbls (definition) α = 1.213 and β =

[34] Using Table A-22 in Natrella (1963) the 95% confidence bounds on the proportion of samples that would be expected to be less than 1,000 bbls range from 0.557 to 0.994. Thus, there is high confidence that the median spill volume is less than 1,000 bbls for this data set.

[35] See e.g., Eschenbach and Harper, (2006); Gilbert, (1987); and Johnson and Kotz, (1970). Some readily available electronic references include: http://en.wikipedia.org/wiki/ Weibull_distribution and http://www.itl.nist.gov/div898/handbook/ apr/section1/apr162.htm.

[36] In this case it is not necessary to fit γ as this is specified in the definition of the large spill threshold.

493.54.[37] Figure 6 shows the best-fit three-parameter Weibull CDF (the solid line) and the empirical CDF (the points) using the above parameter estimates. The fit appears quite good. Another way of examining the quality of the fit is to show a P – P diagram; this diagram (shown in Fig. 7) plots the fitted CDF versus the empirical CDF. As illustrated in Fig. 6, this plot shows that the quality of the fit is quite good.

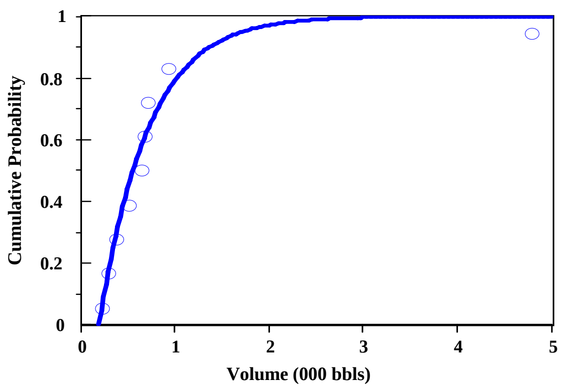

Fig. 6. A comparison between the observed (plotted points) and best-fit three-parameter Weibull distribution to ANS large (≥ 200 bbls) spill data.

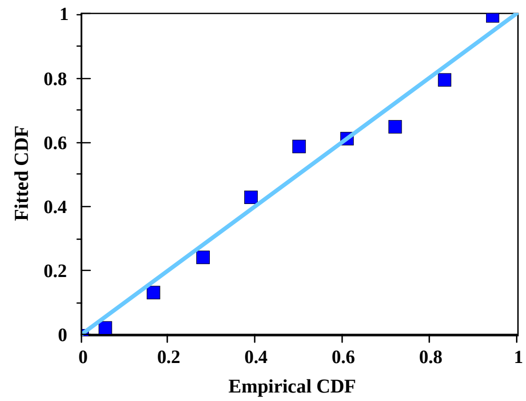

Fig. 7. A "P-P" plot showing the comparison between observed and fitted ANS large (≥ 200 bbls) spill CDFs.

The choice of fitting technique affects the resulting parameter estimates. For example, the best-fit parameter values determined using a commercially available computer program are; γ = 200 bbls (definition) α = 0.84 and β = 426.88,[38] which has a very similar CDF to that estimated by matching CDFs. Figure 8 shows a comparison of the fits made by matching the CDFs (the blue line) and maximum likelihood (the green line). Table 6 shows the Kolmogorov-Smirnov and Anderson-Darling statistical tests on this fit. These tests indicate that the three parameter Weibull distribution provides an adequate fit to the observed data.

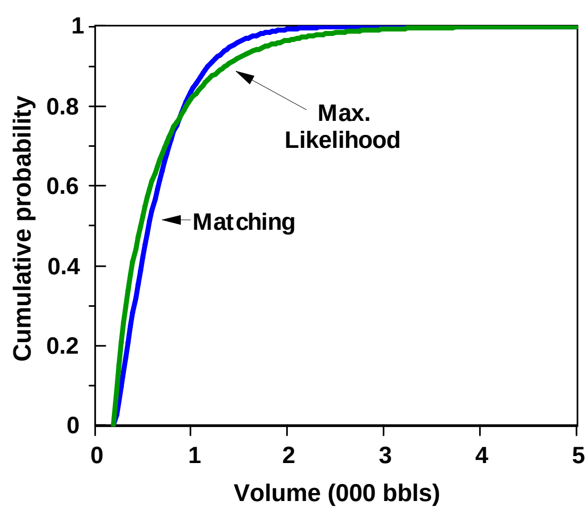

Fig. 8. Best-fit three-parameter Weibull distributions using two fitting criteria.

[37] These estimates were derived using as a criterion function the sum of squared differences between the empirical CDF values (nine points) and the predicted CDFs. The criterion function was minimized using the *Solver*™ routine in the spreadsheet program *Excel*™.

[38] Fitted using EasyFit™ software from Mathwave Technologies, see http://www.mathwave.com/products/easyfit.html.

Table 6. Statistical tests of adequacy of fit for the three-parameter Weibull model.

Goodness of Fit – Details
Three-parameter Weibull

Kolmogorov-Smirnov

Sample Size	9				
Statistic	0.09934				
P	0.2	0.15	0.1	0.05	0.01
Critical Value	0.339	0.36	0.388	0.432	0.514
Reject?	No	No	No	No	No

Anderson-Darling

Sample Size	9				
Statistic	0.7809				
P	0.2	0.15	0.1	0.05	0.01
Critical Value	1.3749	1.6024	1.9286	2.5018	3.9074
Reject?	No	No	No	No	No

Direct maximization of the likelihood function in *Excel*™ using the *Solver*™ subroutine results in slightly different parameter estimates; γ = 200 bbls (definition) α = 0.744467 and β = 654.8.

Once an adequate statistical representation is found, the best-fit model can be used to estimate the mean or any percentile of the spill volume distribution, given that a large spill occurs.[39] For the three-parameter Weibull distribution, the equations for the mean and 1 – pth. percentile volumes of the large spill size distribution are:

$$\text{Mean} = \gamma + \beta\,\Gamma(1 + 1/\beta) \quad (6)$$

$$x_{(1-p)} = \gamma + \beta\,[-\ln(p)]^{(1/\alpha)} \quad (7)$$

where

Γ = Incomplete gamma function and

$x_{(1-p)}$ = The volume of the (1-pth) percentile of this distribution (bbls).

Thus, for example, if the CDF is approximated by (r – ½)/n, and the “matching CDFs” fitting criterion is used, the best-fit parameters are γ = 200 bbls (definition) α = 1.213 and β = 493.54. Using equations (3) and (4) the estimated median (p = 0.5), mean, and 95% percentile (p = 0.05) of the large crude oil spill volume distribution are approximately 565 bbls, 663 bbls and 1,419 bbls, respectively.

[39] This provides a conceptual advantage over the use of the data directly for small sample sizes where estimation of extreme quantiles may be difficult, as it is in this case.

As shown in Table 7, these estimates are a function of the fitting technique and the convention used to estimate the CDF. This said, the estimates do not differ by much for the median and mean values. Depending upon the conventions used, the estimated median large spill volumes range from approximately 480 to 600 bbls and the estimated mean large spill volumes range from approximately 620 – 984 bbls. The differences are larger for the estimated 95% upper confidence limit on size; these range by a factor of approximately two from 1,400 to 3,060 bbls. The reason for the greater discrepancy of the 95% percentile values is the differential "leverage" of the largest spill in the data on the parameter estimation techniques.

Table 7. Summary of results for fitting a three-parameter Weibull distribution to the ANS large spill data (≥ 200 bbls threshold).

Fit criterion	***Matching CDFs Empirical CDF estimated as:***				***Maximum likelihood***	***EasyFit™***
Quantity	r/n	(r - 1/2)/n	(3r-1)/(n+1)	r/(n+1)	N/A	N/A
Parameters:						
γ	200	200	200	200	200	200
β	429.39	493.58	499.56	513.20	654.81	426.88
α	1.0698	1.2135	1.1400	1.0105	0.7445	0.8378
Spill sizes (bbls):						
Median	505	565	562	557	600	476
Mean	618	663	677	711	984	669
95% percentile	1,397	1,419	1,508	1,720	3,058	1,782

The estimates shown in Table 7 all assume that the three-parameter Weibull model provides an adequate fit to the data—as, indeed, it does (see Table 6). Fitting the data to a different model would produce slightly different estimates. However, these differences are relatively small. For example, fitting a three-parameter lognormal model to the data results in median and mean large spill volumes of approximately 530 and 1,029 bbls, respectively. Both the Gamma and generalized extreme value (see e.g., Castillo *et al.*, 2005 or Evans *et al., 2000*) models estimate comparable median and mean spill sizes. Thus, use of a variety of plausible statistical distributions (which have generally comparable fits) leads to similar estimates for typical spill volumes.

-Using the raw data directly (nonparametric methods)

The second approach for estimating a typical size of a large spill is to use the raw data without assuming a particular model for fitting this distribution. The median large spill volume from these data is 650 bbls. (The median value is that value which divides the data in half, i.e., 50% of the values is greater than the median and 50% of the values are less than the median.) The arithmetic mean large crude oil spill volume is 1,018 bbls. (The median of a data set is often preferred to the mean as a measure of central tendency if outliers might be present in the data.)

Summary: likely large crude oil spill volume

Use of the data directly or fitting a three-parameter Weibull model to the large spill volume data produce estimates of the mean spill volume that are equal to or less than 1,000 bbls. This figure is used as an average or expected large spill volume—or point of departure—for estimation of possible environmental impacts of future large crude oil spills.

Future cumulative spill volumes

As noted above, 1,000 bbls is taken as a nominal large spill volume, given that one large spill occurs. Use of the Poisson model based on the actual number of large spills that have occurred over the period from 1985 to 2006 indicates it is highly likely that number of large spills associated with development of the Liberty Project would be zero, but it is also possible (though highly unlikely) that 1, 2, 3 or more large spills would occur. This section estimates the expected total large spill volume.

Table 8 (see also Table 3) shows these calculations for the most likely large spill rate (0.82 spills per Bbbls) assuming that a large spill is at least 200 bbls and an average large spill has a volume of 1,000 bbls. Two sets of calculations are made; (1) based on the estimated probabilities that 0, 1, 2, 3, large spills would occur throughout the life of the Liberty Project and (2) based on the assumption that at least one large spill occurs. The total expected spill volumes corresponding to these two cases are approximately 86 and 1,043 bbls, respectively.

If the nominal volume of a large crude oil spill is 1,000 bbls, why is it that the expected large crude oil spill volume is only 86 bbls? The answer is that there is a very high probability (approximately 92%, see Tables 3 or 8) that there would be no large crude oil spills over the lifetime of the Liberty Project. The 86-bbls figure weighs each of the possible spill volumes; zero if there are no large spills, 1,000 bbls if there is exactly 1 large spill; 2,000 bbls if there is exactly 2 large spills, etc, by the estimated probability of 0, 1, 2, … spills.

The second calculation shown in Table 8 estimates the average total large spill volume *given that at least one large spill occurs* (itself an unlikely event). This quantity is 1,043 bbls. Why 1,043 bbls when the possibilities are 1,000 bbls, 2,000 bbls, etc? The result, 1,043 bbls, weights these values by the probabilities of 1, 2, 3, 4, …spills given that at least one occurs. In this instance, the total volume is slightly larger than the volume of 1 large spill because, even assuming that at least one spill has occurred, it is unlikely that 2 or more have occurred. *Thus, our best estimate of the total large crude oil spill volume is low—86 bbls because it is unlikely that any large spills would occur. However, if at least one large crude oil spill occurs, then the expected large spill volume would be approximately 1,043 bbls—only marginally higher than the nominal large spill volume because the estimated probability of 2 or more large spills is so small.*

Table 8. Calculation of aggregate large spill volume for Liberty field.

Inputs:

Quantity	*Units*	*Value*	*Source/remarks*
Confidence level, p	NA	0.05	Conventional statistical assumption
Large spill threshold	bbls	200	Assumption
# large spills in baseline period	NA	9	ANS data from 1985 through 2006 for all facilities
Throughput in baseline period	Bbbls	10.976	ANS data from 1985 through 2006
Large spill rate	spills/Bbbls	0.8200	ANS estimate of mean large spill rate
Exact LCL on spill rate	spills/Bbbls	0.3749	Computed exact lower confidence limit
Exact UCL on spill rate	spills/Bbbls	1.5566	Computed exact upper confidence limit
Throughput for Liberty Project	Bbbls	0.105	Estimated future production of Liberty field from Liberty Project description December 2006 (BPXA, 2006)

Future estimates:

	Best estimate
Expected number of large spills over life of Liberty field	0.0861
Expected volume of large spill (bbls)	1,000.00

Number of large spills,	***Probability***	***Extension***	***Probability***	***Extension***
X	**x**		**x| x>=1**	
0	0.91750529	0.0000		
1	0.07899440	78.9944	0.95756918	957.5692
2	0.00340059	6.8012	0.04122189	82.4438
3	0.00009759	0.2928	0.00118303	3.5491
4	0.00000210	0.0084	0.00002546	0.1019
5	0.00000004	0.0002	0.00000044	0.0022
6	5.19E-010	0.0000	6.292E-009	0.0000
7	6.384E-012	0.0000	7.739E-011	0.0000
8	6.871E-014	0.0000	8.3283E-013	0.0000
Expected total spill volume		86.10		1,043.67

-Confidence intervals

The above estimates are based on expected values, including the expected number of large crude oil spills and the expected volume of a large crude oil spill or total volume given that a spill occurs. It is useful to estimate lower and upper confidence limits for these quantities. To do this we conservatively assume that the large spill distribution matches the empirical large spill distribution—that is, it includes the 4,786 bbls spill discovered in March 2006. Accordingly, Table 9 shows the results of 50,000 Monte Carlo simulations calculating the total large crude oil spill volume over the lifetime of the Liberty Project. Two cases are included (1) using the expected large spill rate and (2) using a 95% upper confidence limit on this rate. The mean total spill volumes are quite close to those calculated above. However, the upper 95% confidence limit (95^{th} percentile) total spill volume is 4,786 bbls.

Table 9. Results of large crude oil spill simulations.

	Expected spill rate		
Quantity	***Best estimate***	***Upper 95% confidence limit***	***Units***
Number of trials	50,000	50,000	trials
Average total spill volume	1,055	1,108	bbls
Minimum total spill volume	225	225	bbls
Median total spill volume	650	650	bbls
75th percentile spill volume	925	945	bbls
95th percentile spill volume	4,786	4,786	bbls

Large crude oil spill estimates in this analysis compared to FEIS estimates

The Liberty Final EIS (USDOI, MMS, 2002) offered the following comments on the chance of a large oil spill occurring:

> "The analysis of historical oil-spill rates and failure rates and their application to the Liberty Project provides insights, but not definitive answers, about whether oil may be spilled from a site-specific project. Engineering risk abatement and careful professional judgment are key factors in confirming whether a project would be safe.
>
> We conclude that the designs for the Liberty Project would produce minimal chance of a significant oil spill reaching the water. If an estimate of change must be given for the offshore production island and the buried pipeline, our best professional judgment is that the chance of an oil spill greater than or equal to 500 bbls occurring from the Liberty Project and entering the offshore waters is on the order of 1% over the life of the field…
>
> We base our conclusion on the results gathered from several spill analyses done for Liberty that applied trend analysis and looked at causal factors. All showed a low likelihood of a spill, on the order of a 1 – 6% chance or less over the estimated 15 – 20 year life of the field."

While not identical, the projections made in this report are broadly consistent with the results of the final Liberty EIS; both estimates indicate that it is unlikely that a large crude oil spill would occur. As to differences:

- The original analysis defined a large spill as one 500 bbls or greater, whereas this analysis uses ≥ 200 bbls as the threshold of a large spill.[40] As shown below, the probability that no large spill would occur (assuming a 500 bbl threshold) is 94.4%--numerically closer[41] to that estimated in the final EIS. (The 95% confidence interval on the probability that no large crude oil spill would occur assuming a 500 bbl threshold is from 88.3% to 97.9%. This confidence interval overlaps the 94% - 99% range specified in the final Liberty EIS.)

[40] This choice of 200 bbls as the threshold was made on statistical grounds.
[41] This estimate is within the range of plausible estimates given in the final EIS.

- The original spill estimates were based on the definition of a large crude oil spill from the offshore production island and buried pipeline reaching the water. This analysis addresses the occurrence of a large crude oil anywhere in the facility and makes no assumption regarding whether or not the spill reaches the water.

- The estimate developed in this document is based solely on the assumed production volume of Liberty and actual spill statistics from ANS operations updated through 2006. That presented in the final EIS used data from several sources and ultimately was based on engineering judgment.

Small spills

As noted above, spills have been divided into large and small spills. For crude oil, the base case large spill threshold was assumed to be ≥ 200 bbls. What can be said of the small spills?

-Small crude oil spills

Experience at ANS and elsewhere shows that typically there are many more small crude oil spills than large spills. Using ANS data, for example, over the period from 1985 to 2006, a total of 1,662 small (< 200 bbls) crude oil spills were reported—compared to only nine large spills. Thus, small spills accounted for 99.46% of the total *number* of spills. However, the average spill size of small spills is very much smaller than that of large spills. For the same period, the average volume of a small spill was approximately 2.14 bbls. (The median small crude oil spill volume, approximately 0.12 bbls, is even smaller.) Figure 9 shows the empirical CDF (x-axis plotted as the natural logarithm of the spill volume) of all small ANS crude oil spills for the period from 1985 to 2006. The irregularities in the CDF reflect rounding of spill volumes in the reporting process.

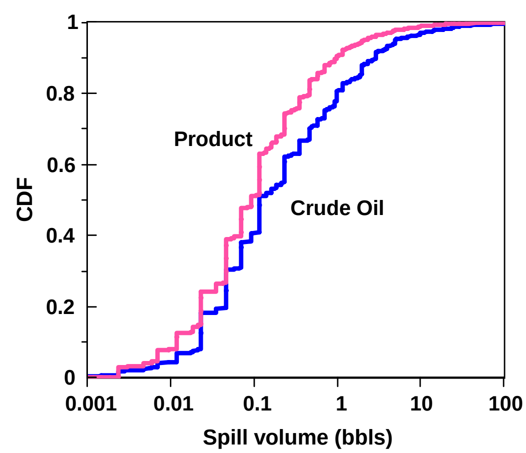

Fig. 9. Empirical CDFs of 1,662 small crude oil spills and 5,456 produced spills for ANS 1985-2006. Note that x-axis shows natural logarithm of spill size.

Figure 9 also shows the empirical distribution of refined product spills (n = 5,456) that occurred over the same time period. (Product spill data are discussed below.)

In aggregate small crude oil spills accounted for slightly less than 28% of the total volume spills over the period from 1985 to 2006, even though these occurred much more frequently.

The analytical method used in this analysis (and many others, see, e.g., TAPS Owners, 2001) to estimate future small spill volumes is to calculate a *volumetric spill rate* (VSR) defined as the ratio of the aggregate small spill volume (bbls) to the ANS production (Bbbls). Next, we multiply the appropriate VSR by the estimated total production of the Liberty Development Project (0.105 Bbbls) to estimate the total small spill volume that would result from operation of Liberty. This procedure assumes that the observed VSR for Liberty will be the same as that experienced historically for the North Slope as a whole.[42] Before accepting this assumption uncritically, however, it is appropriate to see if there are any time trends in the observed small spill VSRs. If, for example, VSRs tended to decrease (increase) with time, use of an average VSR would overstate (understate) future spill volumes.

Table 10 provides relevant data and computed small ANS crude spill VSRs for the period from 1985 to 2006. Figure 10 shows a time series of the observed VSRs (solid line) and the average VSR (dashed line) of 324 bbls spilled per Bbbls production. Earlier analyses (see e.g., TAPS Owners, 2001[43]) found no statistically significant trend in these data although visually there appeared to be a slight downward trend. Linear regression of the data plotted in Fig. 10 indicates that there is a slight, but not statistically significant (p = 0.58), downward trend. The VSR for 2006 has a studentized residual of 2.945, which indicates that this point might be an outlier. And, indeed, if this point is deleted, the downward time trend in VSR is statistically significant (p = 0.03).

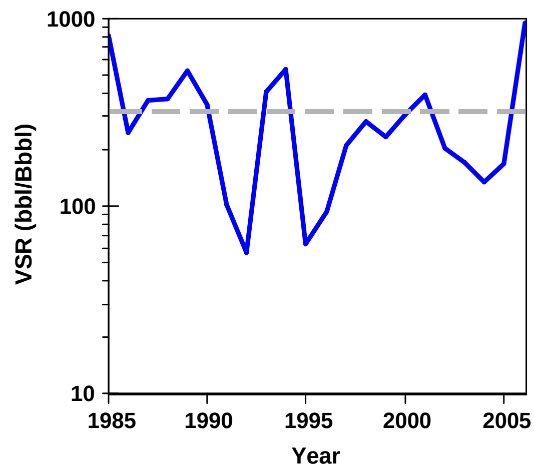

Fig. 10. Volumetric spill rates (VSRs) for ANS small crude oil spills, 1985-2006.

However, to avoid possible understatement of spill volumes, we have not made any allowance for a possible time trend in the data.

[42] It is probably appropriate to see if there is any statistically significant relation between the annual small spill volume and the production in any year. Analysis shows that there is a weak (R^2 = .24), but statistically significant (p = 0.021) relation.

[43] The estimated VSR for ANS obtained in this source was 860 bbls/Bbbls. This VSR included both large and small crude oil spills as well as product spills and applied to a different time period (1977 – 1999). If we add the estimated VSR for product spills (400 bbls/Bbbls see Table 11) a total of 724 bbls/Bbbls results. This estimate is consistent with the earlier TAPS ANS analysis, which includes the contribution of spills > 200 bbls.

Table 10. Small crude oil spill characteristics, 1985-2006.

Years since 1985	*Year*	*Production volume (Bbbls)*	*Number of spills*	*Total volume (bbls)*	**Volumetric spill rate** *(VSR) (bbls spilled / Bbbls produced)*	*Average Spill volume (bbls)*
0	1985	0.649	91	535.429	824.641	5.884
1	1986	0.664	91	164.667	248.091	1.810
2	1987	0.700	97	256.643	366.734	2.646
3	1988	0.722	129	270.702	374.702	2.098
4	1989	0.669	161	355.048	531.022	2.205
5	1990	0.636	101	223.264	350.953	2.211
6	1991	0.641	140	65.562	102.280	0.468
7	1992	0.612	70	34.800	56.852	0.497
8	1993	0.564	57	230.534	409.005	4.044
9	1994	0.553	51	298.758	539.852	5.858
10	1995	0.526	39	33.333	63.355	0.855
11	1996	0.495	52	46.260	93.375	0.890
12	1997	0.461	39	97.888	212.470	2.510
13	1998	0.417	44	118.494	284.124	2.693
14	1999	0.372	50	87.025	233.762	1.741
15	2000	0.345	94	106.802	309.926	1.136
16	2001	0.340	90	134.917	396.915	1.499
17	2002	0.348	52	70.778	203.364	1.361
18	2003	0.346	60	59.965	173.547	0.999
19	2004	0.324	62	44.210	136.350	0.713
20	2005	0.308	42	52.062	168.863	1.240
21	2006	0.284	50	271.647	957.938	5.433
Totals		**10.976**	**1,662**	**3,558.786**	**324.232**	**2.141**

Note: Production volume data taken from US Dept. of Energy, Energy Information Administration, data for crude oil production on Alaska's North Slope as presented in January, 2007. Only partial data for year 2006 was available. To calculate an annual figure, the monthly 2006 production values were averaged and added to the partial year total. Current data area available at ttp://tonto.eia.doe.gov/ dnav/pet/hist/manfpak1M.htm

The estimated total volume of small crude oil spills associated with the operation of the Liberty Project is, therefore, 324 bbls/Bbbls x 0.105 Bbbls = 34 bbls in total.[44] This estimate is much smaller than the expected total large spill volume (86 bbls) or the expected volume (~1,000 bbls) given that a large spill were to occur. Taking the empirical VSRs over the period from 1985 to 2006, the approximately 95% confidence limits on the total spill volume range from approximately 6 to 100 bbls.

[44] If the average small size for Liberty matches that observed for ANS historically, then this means that there would be approximately 34/2.14 ~ 16 small crude oil spills.

-Product spills

As noted above, spills are not limited to crude oil. Refined product spills also occur—indeed, product spills have historically been more numerous than crude oil spills. Over the period from 1985 to 2006 a total of 5,456 product spills have been reported on the North Slope. Most of these are quite small—smaller on average than small crude oil spills, although as shown in Table 2 a few larger product spills have resulted.[45] Product spills sizes range from approximately 8 teaspoons (0.01 gallons) to 262 bbls (approximately 11,000 gallons) in size.

Figure 9 also shows the empirical CDF of ANS product spills. Compared even to small crude oil spills, product spills are typically smaller. For example, the median and mean product spills over the period from 1985 to 2006 were 0.095 and 0.8 bbls, respectively. 90% of product spills were less than 1 bbls. For purposes of this analysis we treat all product spills as being small spills. That is, we do not use the MMS methodology for large crude oil spills to represent data on product spills. Instead we use the volumetric spill rate method described earlier for use on small crude oil spills.

Figure 11 shows the time trend in VSR for product spills (compare to Fig. 10 for crude oil spills.) and Table 11 shows the data. There is no statistically significant time trend in the data ($p = 0.257$). As with the small crude oil spills, we use the average VSR for the entire time period, 400 bbls/Bbbls of production. *Based on this average, the estimated product spill volume for the Liberty Project is 400 (0.105) = 42 bbls. The 95% confidence interval on this estimate is [10, 125 bbls].*

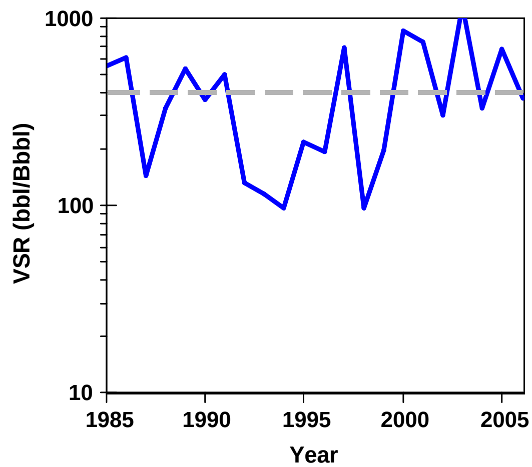

Fig. 11. Volumetric spill rates (VSRs) for ANS product spills, 1985-2006.

Summary of small spill projections

To summarize briefly, this analysis considers small spills for both crude oil and product spills associated with the development of the Liberty Project. For small crude oil spills, it is estimated that 34 bbls will be spilled (expected value) over the life of the project; the 95% confidence interval on this estimate ranges from 6 to 100 bbls. For product spills, it is estimated that 42 bbls will be spilled (expected value); the 95% confidence interval on this estimate ranges from 10 to 125 bbls.

[45] Because of the very small number of "large" refined product spills it is unrealistic to model these separately. Instead, we use the same VSR spill rate approach used for small crude oil spills.

Table 11. Small product spill characteristics, 1985-2006.

Years since 1985	*Year*	*Production volume (Bbbls)*	*Number of spills*	*Total volume (bbls)*	*Volumetric spill rate (VSR) (bbls spilled / Bbbls produced)*	*Average Spill volume (bbls)*
0	1985	0.649	168	363.167	559.331	2.162
1	1986	0.664	145	410.405	618.325	2.830
2	1987	0.700	137	102.101	145.899	0.745
3	1988	0.722	312	240.940	333.506	0.772
4	1989	0.669	408	364.638	545.365	0.894
5	1990	0.636	359	234.846	369.159	0.654
6	1991	0.641	445	324.861	506.797	0.730
7	1992	0.612	259	81.796	133.629	0.316
8	1993	0.564	209	65.213	115.699	0.312
9	1994	0.553	159	54.226	97.986	0.341
10	1995	0.526	132	115.865	220.219	0.878
11	1996	0.495	141	97.307	196.415	0.690
12	1997	0.461	123	321.655	698.164	2.615
13	1998	0.417	124	40.562	97.259	0.327
14	1999	0.372	311	74.117	199.088	0.238
15	2000	0.345	444	297.554	863.465	0.670
16	2001	0.340	505	253.905	746.969	0.503
17	2002	0.348	241	107.111	307.761	0.444
18	2003	0.346	218	410.586	1188.296	1.883
19	2004	0.324	200	107.316	330.976	0.537
20	2005	0.308	199	213.568	692.708	1.073
21	2006	0.284	217	106.087	374.107	0.489
Totals		**10.976**	**5456**	**4,387.827**	**399.764**	**0.804**

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Appendix B

Prevention Plan from Endicott and Badami Oil Discharge Prevention and Contingency Plan

2 PREVENTION PLAN [18 AAC 75.425(e)(2)]

2.1 PREVENTION, INSPECTION AND MAINTENANCE PROGRAMS [18 AAC 75.425(e)(2)(A)]

2.1.1 Prevention Training Programs [18 AAC 75.007(d)]

BP Exploration (Alaska), Inc. (BPXA) and contractor personnel are trained in company and state pollution prevention measures applicable to their duties affected by 18 Alaska Administrative Code (AAC) 75 Article 1 as required by 18 AAC 75.007(d). Trained personnel sign a training roster. BPXA's training courses are assigned a number and have course specifications e.g., objectives, material, and trainer qualifications. BPXA makes a computerized record to document the training.

BPXA and contractor oil-handling personnel receive training on the operation and maintenance of oil equipment, oil spill protocols, general facility operations, and contents of the Spill Prevention, Control, and Countermeasures (SPCC) Plan. Oil spill prevention training and oil spill prevention briefings for oil-handling personnel are held annually and meet U.S. Environmental Protection Agency SPCC training requirements in 40 CFR 112.7(f)(1) and (3).

Unescorted workers on BPXA leases receive spill prevention training through the North Slope Training Cooperative program. The one-day training seminar, mandatory for workers on the North Slope, covers the following topics:

- *North Slope Environmental Handbook*,
- *Alaska Safety Handbook*,
- Camps and Facilities Safety Orientation,
- Environmental Excellence,
- Hazard Communication (HAZCOM),
- Hazardous Waste Operations and Emergency Response (HAZWOPER) Awareness,
- Personal Protective Equipment (PPE), and
- Hydrogen Sulfide.

BPXA employees and contractor personnel working on the North Slope receive copies of the *North Slope Environmental Field Handbook* and *Alaska Safety Handbook*. The *North Slope Environmental Field Handbook* provides an overview of state and federal spill prevention regulations and programs applicable to the North Slope oil fields and summarizes procedures to comply with those regulations. In particular, the handbook explains fluid transfer procedures, drip liner usage, secondary containment and spill reporting.

The *Alaska Safety Handbook* provides standardized safety instructions for BPXA and contractor personnel. The handbook covers employee safety, including PPE, equipment safety, chemical handling, transportation safety, work permitting, and incident reporting.

Facility and response personnel are provided a mandatory site orientation that includes familiarization with facility Emergency Response Plans.

Facility personnel also receive training on the BPXA Environmental Management System Awareness & Hotline. BPXA's Environmental Management System promotes continual improvement in environmental performance. The system uses direct input from technical specialists and field personnel and information developed through routine loss control and incident investigations to minimize the potential recurrence of events. Safety and environmental communications and bulletins are regularly distributed to ensure specific safety and environmental issues are communicated. Most supervisors discuss safety and environmental communications and bulletins with their crews during daily and weekly toolbox safety meetings.

Waste management training using the *Alaska Waste Disposal and Reuse Guide*, also known as the "Red Book," is designed to familiarize North Slope personnel with the regulatory classification and disposal requirements for industrial wastes. The training covers waste classification, transportation requirements, and a description of waste disposal facilities on the North Slope. BPXA and ConocoPhillips Alaska, Inc. track waste by manifesting waste destined for a disposal facility. The course is mandatory for waste generators, transporters, and receivers.

BPXA maintains records of its employees' oil spill prevention training required by 18 AAC 75 Article 1. Records are kept for at least five years. They are provided to the Alaska Department of Environmental Conservation upon request.

The BPXA Learning and Organizational Development Group maintains a database with records of courses completed by BPXA employees. Access to the database is through the BPXA intranet. Individual training records are available through an employee's immediate supervisor or by contacting the Training Coordinators. Contractors maintain their own training records.

In summary, personnel who handle oil equipment receive training in general North Slope work procedures, spill prevention, environmental protection awareness, safety, and site-specific orientation. Personnel receive training in oil spill notification protocols, oil spill source control, and HAZWOPER safety. The *Alaska Safety Handbook* and the *North Slope Environmental Field Handbook* supplement spill prevention training.

2.1.2 Substance Abuse Programs [18 AAC 75.007(e)]

BPXA policy provides guidance for an environment free of substance abuse, related accidents, and emergencies. This environment is maintained through adherence to strict alcohol and drug abuse policies and professionally recognized rehabilitation programs. The company has jurisdiction to intervene and impose disciplinary measures when problems are identified.

The BPXA drug policy promotes the safety of employees, contractors, and non-employees, and provides a safe working environment. The company prohibits the following in the workplace or on the job:

- Possession of illicit drugs,
- Possession of controlled substances without a physician assistant's knowledge,
- Use of drug or alcoholic substances, and
- Distribution or sale of drugs or alcohol.

BPXA complies with regulations promulgated by the U.S. Department of Transportation (DOT) at 49 CFR 40, which mandates biological testing and supervisory training programs. BPXA employees involved in safety-sensitive positions within natural gas, liquefied natural gas, and hazardous liquid pipeline operations are required to undergo pre-employment biological testing and testing for reasonable cause following reportable accidents, alcohol or drug rehabilitation, and on a random basis in accordance with this regulation. Other BPXA employees fall under the company's drug testing program. Each of these groups is randomly tested at a rate of a minimum of 25 percent per year. Contract personnel maintain their own drug testing records. The testing must meet the minimum standards set by BPXA.

BPXA employees and contract personnel must be free from the influence of drugs or alcohol on company premises. Implementation of the BPXA Substance Abuse Program is divided into three parts as follows:

- **Education.** Training is available to both employees and supervisors to teach them to detect signs of abuse in themselves and the people with whom they work. Information is provided on the available rehabilitation programs.
- **Intervention.** The company has jurisdiction to perform a drug test on employees when there is legitimate cause, such as medical surveillance following rehabilitation, or as periodic drug screening. The company makes every effort to support its employees and strongly encourages medical rehabilitation.
- **Discipline.** Upon the discovery of illicit drug use, controlled substance abuse, or alcoholic beverage possession, an employee will be suspended.

The BPXA Work Life and Employee Assistance Program (EAP) is an elemental part of rehabilitation. EAP is a confidential counseling and referral service provided free-of-charge to employees and their families. BPXA also supports medical rehabilitation programs outside of the EAP program, which are covered by the BPXA medical plan.

2.1.3 Medical Monitoring [18 AAC 75.007(e)]

New BPXA employees receive an entrance physical to establish baseline health conditions. Under federal Occupational Safety and Health Administration (OSHA) and Alaska Department of Occupational Safety and Health requirements, medical monitoring is conducted as required by the type of work performed. Emergency response personnel have annual medical examinations, which include a physical exam, audiogram, respiratory exam, electrocardiogram, x-rays, and blood work. All other BPXA employees who are field workers receive annual respiratory exams and audiograms.

2.1.4 Security Programs [18 AAC 75.007(f) and 40 CFR 112.20(h)(10)]

Access to BPXA's North Slope operations is controlled through BPXA security checkpoints and with Security personnel and records in the operating areas. Each BPXA employee and contractor is issued an identification badge with the employee's or contractor's name and badge number. The security badge system provides a method for monitoring personnel moving on and off BPXA leases.

2.1.5 Fuel Transfer Procedures [18 AAC 75.025]

Measures are taken to prevent spills or overfilling during a transfer of oil into Alaska Department of Environmental Conservation (ADEC)-regulated storage tanks, as required by 18 AAC 75.025(a). Loading rates are reduced at the beginning and end of a transfer, as required by 18 AAC 75.025(a).

Each person involved in a transfer of oily fluids into an ADEC-regulated tank is capable of clearly communicating orders to stop a transfer at any time during the transfer, as required by 18 AAC 75.025(d).

A positive means is provided to stop a transfer of oily fluid into an ADEC-regulated tank in the shortest possible time, as required by 18 AAC 75.025(e).

Before beginning a transfer to or from an ADEC-regulated tank at an area not protected by secondary containment, the valves in the transfer system are checked to make sure they are in the correct position, as required by 18 AAC 75.025(f). Manifolds not in use are blank flanged or capped. Transfer piping and hoses used in the transfer are checked for damage or defects before the transfer and during the transfer. The lowermost drain and the outlets of a truck oily fluid tank are examined for leaks before the truck's tank is filled and again before the truck departs, as required by 18 AAC 75.025(g). The truck's manifold is blank flanged or capped and valves are secured before it leaves the transfer area. Surface liners at inlet and outlet points are the primary prevention mechanisms against discharge to the ground during the transfer of liquids.

Effective communication and planning are key factors in preventing spills. Trucks are continuously staffed during fluid transfers and transfer personnel have radios. For transfers from trucks to ADEC-regulated tanks, manual shutoff valves are available to the truck operator to stop transfers.

The Endicott fuel transfer area, Skid 610, is located approximately 40 feet north of the gasoline and diesel storage tanks. Mobile equipment such as trucks and forklifts park on a lined containment area during fueling. The diesel and gas lines are buried, coated with a protective wrapping, and are cathodically protected.

Badami's fueling system consists of one storage tank (TK-0004), two transfer pumps and one vehicular diesel pump. Two emergency shutdown valves (ESDV-1209 and 1210) provide isolation of the storage tank within the dike. The transfer pumps can be stopped and started manually from the local panel, or they can be stopped remotely. Valve ESDV 1210 opens when either of the pump motors is started and is closed whenever both motors are off. A low-pressure trip is provided on the common pump discharge header in case of pressure loss due to a leak. Alarms are triggered when the transfer pumps are stopped.

The dispenser operation requires that one of the diesel transfer pumps be started from the motor starter panel. Valve ESDV-1210 will then open. The hose is removed from the fuel dispenser, and the dispenser on switch is activated. The vehicular diesel pump on the fuel dispenser will start and fuel is pumped at a regulated pressure. Once the dispenser switch is turned off, the vehicular diesel pump stops.

2.1.6 Operating Requirements for Exploration and Production Facilities [18 AAC 75.045]

Produced oil from flow tests and other drilling operations is handled to prevent spills (18 AAC 75.045(a)). Oil produced from flow tests may be flowed directly to the plant or stored in mobile tanks. Facilities are staffed 24 hours a day. At each shift change, personnel inspect oil tank levels and tankage, sumps, drains, piping, valves, glands, wellheads, pumps, and other machinery for indications of oil leaks.

The requirements for platform integrity inspections and isolation valves for pipelines leaving platforms do not apply (18 AAC 75.045(b) and (c)).

Catch tank requirements do not apply (18 AAC 75.045(e)).

Information pertaining to oil storage tanks and facility oil piping is found later in Part 2 and in Part 3. Impermeable well cellars at Endicott fulfill the requirements for drip pans or curbing at offshore facilities and well head sumps for onshore facilities (18 AAC 75.045(d)). Well cellars with concrete floors at Badami fulfill the requirement for well head sumps for onshore drilling (18 AAC 75.045(d)).

2.1.7 Leak Detection, Monitoring, and Operating Requirements for Crude Oil Transmission Pipelines [18 AAC 75.055]

The crude oil transmission pipeline is equipped with a system capable of detecting a leak with a daily rate equal to one percent of daily throughput, as required by 18 AAC 75.055(a)(1). Flow is verified at least once every 24 hours, as required by 18 AAC 75.055(a)(2). The flow of incoming oil can be stopped within one hour after detection of spill, as required by 18 AAC 75.055(b). The control board operator proceeds through a series of steps to determine the cause of the alarm. Ground-based surveillance may be requested. Verification of a leak would facilitate pipeline shut in. See also Section 2.5.6.

ADEC is notified in writing within 24 hours if a significant change occurs in or is made to the leak detection system and if as a result of the change the system does not meet the “equal to not more than one percent of daily throughput” criterion [18 AAC 75.475(d)(1)].

2.1.8 Oil Storage Tanks [18 AAC 75.065 and 0.066]

This section describes the management of ADEC-regulated tanks, i.e., oil tanks greater than 10,000-gallon capacity whether stationary or portable and that are “in service.” In this plan the term “in service” describes oil tanks that remain in regular inspection and maintenance programs whether the tank holds oil or not, unless noted otherwise, a usage consistent with 18 AAC 75 Article 1. The meaning differs from that in API 653. Part 3 provides information for stationary and portable oil storage tanks greater than 10,000 gallons as required by 18 AAC 75.425(e)(3)(A). Containers are constructed of materials compatible with the stored products. Tanks for processing muds and cuttings on drill rigs are not oil storage tanks.

Inspections

Stationary oil storage tanks greater than 10,000 gallons and in service on BPXA leases are maintained and inspected consistent with API Standard 653, third edition 2001, and Addendum 1, September 2003, or API Recommended Practice 12R1, fifth edition 1997, as required by 18 AAC 75.065(a). Inspection intervals for field-constructed tanks are not based on similar service as outlined in API 653. Furthermore, a tank’s inspection interval may not be risk-based as outlined in API 653 unless ADEC approves.

As required by API Standard 653, Section 6.3.1, monthly visual inspections are conducted on tanks that are “in service” as the term is used by API 653. API 653 uses the term “in service” to mean in operation, e.g., storing product. Consequently, tanks not in operation are not required to receive monthly in-service inspections.

Shop-fabricated oil tanks are not precluded from the similar service and risk-based inspection interval procedures outlined in API 653.

Inspection results and corrective action descriptions of oil storage tanks greater than 10,000 gallons are kept for the service life of the tanks. They are provided to ADEC for inspection and copying upon request, as required by 18 AAC 75.065(d).

Notifications and Service Status

BPXA's CIC group follows its written procedure to notify ADEC before a BPXA-owned field-constructed oil storage tank greater than 10,000 gallons and on a BPXA lease undergoes "major repair" or "major alteration" as defined in API 653, Section 12.3.1.2 and again before the tank is filled [18 AAC 75.065(e)]..

A field-constructed oil tank greater than 10,000 gallons capacity that has been removed from a maintenance and inspection program required by 18 AAC 75.065 for more than one year is made free of accumulated oil, marked with the words "Out of Service" and the date taken out of service, secured to prevent unauthorized use, and blank flanged or disconnected from facility piping. BPXA notifies ADEC when those tasks are complete and when the tank has been out of service for up to one year. Shop-constructed tanks have no service status notification and placarding requirement.

Construction

Internal steam heating coils are designed to control leakage through defects, as required by 18 AAC 75.065(f).

If an oil storage tank greater than 10,000 gallons has an internal lining system, it is installed in accordance with API 652, as required by 18 AAC 75.065(g).

As required by 18 AAC 75.065(i), field-constructed oil storage tanks greater than 10,000 gallons and installed after May 14, 1992, meet the following construction standards unless they have an ADEC waiver:

- Constructed and installed in compliance with API 650, 1988 edition, or API 12, D, ninth edition 1989, F tenth edition 1989, and P first edition 1986, or another standard approved by ADEC, and
- Not of riveted or bolted construction, and
- With cathodic protection or another ADEC-approved corrosion control system to protect the tank bottom from external corrosion if local soil conditions warrant, and
- Having a leak detection system that an observer from outside the tank can use to detect leaks in the tank bottom, such as secondary catchment under the tank with a leak detection sump, or a sensitive gauging system or another leak detection system approved by ADEC.

As required by 18 AAC 75.065(h), field-constructed oil storage tanks greater than 10,000 gallons and installed before May 14, 1992, meet the following standards unless they have an ADEC waiver:

- Having a leak detection system that an observer from outside the tank can use to detect leaks in the tank bottom, such as secondary catchment under the tank with a leak detection sump, or a sensitive gauging system or another leak detection system approved by ADEC, or
- Cathodic protection in accordance with API 651, first edition 1991, or
- A thick film liner in accordance with API 652, first edition 1991, or
- Another leak detection or spill prevention system approved by ADEC.

Shop-fabricated, ADEC-regulated oil tanks first placed in service before December 30, 2008, are not subject to an ADEC-requirement for construction standards.

As required by 18 AAC 75.065(k) and .066(g), stationary and portable oil storage tanks greater than 10,000 gallons have one or more of the following overfill protection means:

- High liquid level alarm with signals that sound and display, or
- High liquid level automatic pump shutoff device, or
- A means to immediately determine the tank's liquid level, including close monitoring of the liquid level during a transfer to the tank, or
- Another system approved by ADEC which notifies the operator of high liquid level.

Overfill Protection Device Inspections

Overfill protection devices on ADEC-regulated tanks are tested before each transfer to them or monthly, whichever is less frequent. However, if the monthly test would interrupt the operation of a continuous flow system, then the device is inspected monthly and tested annually, as required by 18 AAC 75.065(l).

Overfill protection devices on ADEC-regulated tanks that are part of continuous flow systems, such as process tanks, and that can be tested without interrupting operations are tested monthly as required by 18 AAC 75.065(k). Overfill protection devices on ADEC-regulated tanks not part of continuous flow systems are tested monthly or just before filling, whichever is less frequent. See the tank tables in Part 3.

A test of the overfill protection device is a manipulation of part of the system for the purpose of eliciting a response. Devices are tested in a variety of ways depending on how they are used and frequency of use. Overfill protection devices are tested by level transmitter calibration, level transmitter calibration with annunciation of the alarm, level transmitter calibration with annunciation of the alarm and strapping, testing the level indicators and alarms by lowering the high liquid level alarm set point to below the actual liquid level to force a false alarm, checking the circuit continuity, changing the level in the tank to verify the level transmitter or alarm enunciator, strapping to calibrate the continuous level indicator in the control room and comparing sight glasses to a measured volume. Some methods are part of regular preventative maintenance procedures.

Inspections for each type of overfill protection device on continuous flow oil storage tanks over 10,000 gallons whose operation would be interrupted by a test are visual observations of one or more parts of the device's system that are visible from the outside of the tank. An example is daily reading sheets which show recordings of the tank liquid level heights reported by the level sensor from the control room readout.

2.1.9 Secondary Containment for ADEC Oil Storage Tanks [18 AAC 75.075]

Stationary and Portable Oil Storage Tanks

Single-wall oil storage tanks greater than 10,000 gallons are located within secondary containment with the capacity to hold the volume of the largest tank plus precipitation within the containment, unless there is a waiver of this requirement by ADEC. Secondary containment areas are constructed of bermed/diked/retaining walls. The containment areas are lined with materials resistant to damage and are impermeable as required by 18 AAC 75.075. Oil storage tanks are listed in Part 3.

Portable, shop-built aboveground oil storage tanks of a vaulted, self-diked, or double-walled design are not required to be placed within bermed, lined, secondary containment areas if they are equipped with catchments that positively hold overflow due to tank overfill or divert it into an integral secondary containment area [18 AAC 75.075(h)].

Secondary containment systems are maintained free of debris, vegetation, and other materials or conditions, including excessive accumulated water that might interfere with the effectiveness of the system as required by 18 AAC 75.075. Debris and vegetation that might interfere with the secondary containment effectiveness is that which threatens the containment integrity or reduces its capacity to less than 110 percent. Some fabric liner bottoms are held in place with a gravel layer.

Facility personnel visually check for the presence of oil leaks or spills within ADEC tank secondary containment daily, and conduct documented inspections of secondary containment areas. The containment areas are visually inspected for holes weekly. The records of the daily and weekly inspections are entered weekly as noted in Table 2-7.

Snowmelt runoff, debris, and accumulated rainwater are vacuumed out, or dewatered, and disposed of through the waste handling procedure. See Table 2-7 for visual inspection for sheens on discharge water.

BPXA notifies ADEC in writing within 24 hours if a significant change occurs in or is made to an ADEC-regulated tanks secondary containment system and if as a result of the change the system no longer meets the ADEC performance requirement [18 AAC 75.475(d)]. Vegetation, debris and accumulated water that does not interfere with the impermeability of the system or reduce its capacity below 110 percent of the largest tank capacity are not significant changes.

Tank Truck Loading and Unloading Areas

Endicott has two permanent tank truck unloading areas, one at the 305 Module ADEC-regulated tanks and another at the diesel and gasoline fuel tanks. Badami has a single permanent tanker truck loading area at the 15,000-barrel (bbl) diesel tank TK-0004.

The tank truck loading areas are maintained free of debris that might interfere with the effectiveness of the system. The areas have warning signs to prevent premature vehicular movement as required by 18 AAC 75.075(g)(4).

The tank truck loading and permanent unloading areas are visually inspected before transfers or at least monthly (see Table 2-7).

2.1.10 Facility Oil Piping and Flow Lines

Corrosion Management Program

Facility oil piping is in a corrosion control program as required by 18 AAC 75.080(b). The Corrosion Management Program meets the commitment made by BPXA to the State of Alaska in the “Charter for Development of the Alaskan North Slope” by providing the ADEC an annual report *Commitment to Corrosion Monitoring* on BPXA’s corrosion monitoring programs. The report provides data and discussion relating to the corrosion control, monitoring and inspection programs that together form the core of the integrity management system.

The Corrosion Management Program covers pipelines, flow lines, well lines, wellheads, headers, pressure vessels and tanks, as well as other field and facility piping systems. Corrosion monitoring and mitigation tools can include but are not limited to corrosion weight-loss coupons, electrical resistance probes, non-destructive examination inspection techniques, smart pigs, visual inspections, Kinley caliper surveys, monitoring of process flow conditions, and bioprobes. Badami currently has no specific corrosion monitoring program because production fluids are considered low risk from a corrosivity standpoint; however, an inspection program for corrosion detection is in place.

Corrosion management entails two main functions, corrosion monitoring and corrosion control. Corrosion control is the action of preventing or reducing corrosion to acceptable levels. Corrosion control measures reflect the active or potential corrosion mechanisms in the system. For pipelines, corrosion control measures can be broadly subdivided into internal and external corrosion mechanisms. The external corrosion mechanism is constant for all services while the internal differs with service. The metal loss criteria for pipe replacement are in American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME) B31G-1984, *Manual for Determining the Remaining Strength of Corroded Pipelines, A Supplement to ANSI/ASME B31 Code for Pressure Piping*. Corrosion control measures encompass a range of alternatives including chemical inhibition, materials selection, coatings, cathodic protection, and process control. These may be applied individually or in combination.

Inspection programs share similarities with monitoring programs but measure corrosion directly. Inspection provides documentation of equipment fitness for service. Inspections are generally performed on a quarterly to annual basis, but in some cases it may be five years or longer between inspections. Examples include ultrasonic testing, radiographic testing and smart pig inspections.

Internal Corrosion and Erosion of the Endicott Production System

The Endicott production system transports multiphase fluids. The properties of fluids are similar throughout the system, although temperature, pressure, and velocity vary. The water cut, gas-to-oil ratio (GOR), and solids content vary from line to line. There is a low risk of corrosion for the Badami pipelines, as there is little water production and low carbon dioxide content. Table 2-1 summarizes the significant corrosion mechanisms.

TABLE 2-1: INTERNAL CORROSION MECHANISMS RELEVANT TO ENDICOTT PRODUCTION SYSTEM

CORROSION MECHANISM	SEVERITY OF MECHANISM	CONTROL METHOD
Carbon dioxide corrosion	High	Materials
Velocity enhanced carbon dioxide	High	Materials Velocity control
Erosion	Medium/High	Velocity Well POP procedure Erosion monitoring
Microbially Induced Corrosion (MIC)	Low	Materials
Chemical attack	Low	Chemical selection Operating procedures Equipment design

Carbon dioxide corrosion is the primary corrosion mechanism. The control of carbon dioxide corrosion is achieved primarily through materials selection. The majority of the producing system is constructed from corrosion-resistant duplex stainless steel. The only surface production equipment made of carbon steel is the C-spools that connect the well to the well lines. The C-spools are inspected frequently to assure their integrity and are repaired or replaced as needed.

Velocity-enhanced carbon dioxide corrosion has become more predominant as mixture velocities have increased with increases in gas handling capacity. Velocity-enhanced carbon dioxide corrosion is managed via velocity control.

Erosion is associated with extremely high velocities and solids production. Solids production is unpredictable because it is the result of an event downhole, such as the breakdown of a cement job or production of unconsolidated reservoir rock. Velocity limits for erosion control rely on the approach defined in API RP 14E, using the C-factor of 100. Lines are ranked approximately monthly in terms of risk using the ratio V/Ve, where V is the mixture velocity and Ve is the calculated erosion velocity limit. An operating limit of 3.0 is used. These limits are subject to revision as more experience is gained at managing erosion.

Microbially induced corrosion (MIC) has not been accurately quantified in the Endicott production systems. However, sulfate-reducing bacteria (SRB) and general anaerobic bacteria (GAnB) are present. Control of MIC is through materials selection, the same as carbon dioxide corrosion.

Chemical attack has been associated with highly corrosive scale inhibitor pooling in production pipework during shut-ins. There have also been instances of injection quill failure, leading to contact of the neat (pure) chemical with the pipewall during normal operations. Chemical attack at Endicott is no longer a concern as the scale inhibition program has been discontinued.

Internal Corrosion of the Produced Water and Seawater System

The produced water injection system is defined as starting at the water outlets off the separation vessels and ending at the reservoir. It includes the process piping, storage tanks, injection pumps, flow lines and well lines that store or transport produced water, and the injection wells. At Endicott, the produced water is co-mingled with very low amounts of seawater and injected simultaneously into the formation. Table 2-2 summarizes the major corrosion mechanisms relevant to this produced water/seawater system.

TABLE 2-2: INTERNAL CORROSION MECHANISMS RELEVANT TO PRODUCED WATER AND SEAWATER INJECTION SYSTEM

CORROSION MECHANISM	MECHANISM SEVERITY	CONTROL METHOD
Carbon dioxide corrosion	Low	Corrosion inhibition
MIC	High/Medium	Corrosion inhibition Biocide injection Maintenance pigging
Oxygen corrosion	Medium/Low	De-aeration and oxygen scavenger injection
Chemical attack	Medium	Chemical selection Operating procedures Equipment design

Carbon dioxide corrosion is a significant issue for the upstream system but the oil stabilization process removes the vast majority of the carbon dioxide, substantially reducing its partial pressure. The carbon dioxide corrosion inhibitor is dosed into the produced water/seawater system and is fully capable of controlling carbon dioxide corrosion.

MIC is an issue in the injection system because the low fluid velocities in tanks and pipework allow bacteria colonies to become established and thrive. The current corrosion inhibitor is known to be toxic to

SRBs and GAnBs and the bacteria count has decreased. In addition, the Inter-Island Water Line that transports injection water from the production facility to the Satellite Drilling Island is regularly pigged to displace solids and bacteria. Periodic biocide treatment on this line is also conducted.

The Endicott crude oil transmission pipeline is scheduled to be maintenance pigged quarterly depending on pipeline condition and fluid velocity. The Badami crude oil transmission pipeline is maintenance pigged two times per year. These frequencies are subject to change as data and conditions dictate.

Oxygen corrosion is not an issue in production water systems alone. However, because the production water and seawater are co-mingled at Endicott, the chance increases of introducing oxygen into the injection system from dissolved oxygen in the seawater. Raw seawater is highly corrosive to carbon steel due to the presence of high levels of dissolved oxygen. Due to the extreme corrosivity of raw seawater, it is only handled in corrosion-resistant materials, such as stainless steels, copper or nickel based alloys, or plastics. The seawater treatment plant removes the vast majority of the oxygen from the water by mechanical means. Additionally, dissolved oxygen is further lowered by supplemental injection of oxygen scavenger into the seawater. At current levels seawater is only mildly corrosive, and carbon steel is a suitable material.

Internal Corrosion of the Gas Lift, Gas Injection, and Miscible Injectant Systems

The gas lift, gas injection, and miscible injectant systems contain dehydrated gas, which is non-corrosive. There are therefore no active corrosion mechanisms and correspondingly no corrosion control activities.

External Corrosion

External corrosion is a risk to equipment outside of modules and facilities. It can be subdivided into atmospheric corrosion and corrosion under insulation (CUI). No production equipment is buried directly in the tundra. Therefore, external corrosion at pipewall/soil interfaces is not an issue. Atmospheric corrosion in the Arctic is a slow process due to the low relative humidity, lack of rainfall, and low temperatures. External corrosion is only a significant issue for insulated equipment, where the polyurethane (PU) foam insulation can trap moisture next to the pipewall. This warm, moist environment, together with the oxygen in the air, can lead to corrosion.

Insulation-and-jacket systems or tape wrap that exclude water serve as one means of protective coating. The insulation systems used on pipelines is a combination of shop-applied PU foam on the linepipe spools with an external galvanized steel jacket. Badami facility piping does not utilize galvanized steel jacketing. The insulation is completed at weld joints using a range of methods, but involve the application of PU foam and galvanized steel jacketing. This insulation is generally resistant to moisture ingress, except at areas of damage. The major challenge in managing external corrosion is detection. Once it is detected it can be easily and effectively mitigated by removing wet insulation.

Evidence of external corrosion is investigated to determine the extent of corrosion. Pipeline repairs necessitating pipe replacement are cause for an internal inspection of the affected sections of pipe in the immediate vicinity to establish repair boundaries.

Pipeline Examination and Replacement

In compliance with 18 AAC 75.080(g), buried or below-grade facility oil piping is inspected for damage and corrosion any time it is exposed in accordance with API 570, Section 9.2.6, *Piping Inspection Code:*

Inspection, Repair, Alteration and Rerating of In-Service Piping Systems. If damage is found, piping is repaired or replaced with fusion-bonded epoxy-coated or stainless steel piping.

Replacement buried or below-grade facility oil piping installed after May 14, 1992, will be corrosion-protected and welded with no clamped or threaded connections in accordance with 18 AAC 75.080(d).

Corrosion Surveys

Corrosion surveys are part of the Corrosion Management Program. Corrosion survey methods include smart pigging, conventional nondestructive testing (NDT) methods, guided wave inspections, and excavation and visual inspection. The technologies are discussed in detail in Part 4.10. Table 2-3 demonstrates the Corrosion Survey Programs for various pipeline segments.

TABLE 2-3: SUMMARY OF PIPELINE CORROSION SURVEYS

PIPELINE	NUMBER OF ROAD/ANIMAL CROSSINGS	CORROSION SURVEY METHOD	FREQUENCY
Endicott			
Crude Oil Transmission Pipeline	25	NDT, Smart pig, Excavation & Visual	1 to 10 years, depending on method
Diesel/Gas Line	1	NDT, Excavation and Visual inspection	5 years
Inter-Island Water Injection &, Inter-Island Gas Line	1	NDT, guided wave validation	5 years
Well Line Water Injection Line	2	Guided wave validation for carbon steel line;	5 years
Three-Phase Production Line	1	NDT & Visual inspection in vaults	Annually
Badami			
Crude Oil Transmission Pipeline	1	Smart Pig	Every 5 years if flows allow

The three-phase Endicott production pipeline is fabricated of duplex stainless steel, which is corrosion-resistant. The three-phase line at the road crossing between Satellite Drilling Island (SDI) and Main Production Island (MPI) is in a vault, and is visually inspected annually for corrosion. The well water injection line is also fabricated of duplex stainless steel, servicing Well 5-03.

Other Requirements

Aboveground facility piping is supported consistent with the ASME B31 standard to which it was built.

As required by 18 AAC 75.080(n)(1), aboveground facility piping and valves are inspected visually as described in Table 2-7.

In compliance with 18 AAC 75.080(n)(2), the aboveground diesel transfer lines at MPI and the Badami facility pad pipelines exposed to traffic are protected from damage by vehicles with bollards marked with reflectors.

As required by 18 AAC 75.080(o), BPXA notifies ADEC within one year after facility oil piping is no longer in ADEC-required maintenance and prevention programs and the tasks to remove facility piping from service are complete. Facility piping removed from service for more than one year is free of accumulated oil, identified as to origin, marked with the words “Out of Service” and the date taken out of service, secured to prevent un-authorized use, and blank-flanged or isolated from the system. Notification of the out of service status and the task completions may be made by the one-year anniversary of removal from the maintenance and prevention programs.

Flow line regulations 18 AAC 75.047 do not apply to Badami.

Endicott flow lines no longer maintained under an ADEC-required corrosion monitoring and preventive maintenance program are within one year made free of accumulated oil and isolated from the system. The pipe is treated with a cleaning pig, completely drained of oil, or blown with air or with another method to evacuate standing oil. ADEC is then notified within one year of the removal from service and when the tasks are complete [18 AAC 75.047(f)]. Placarding is not required. For the purposes of complying with ADEC flow line regulations, “in-service” means included in a regular maintenance and inspection program required by 18 AAC 75.047, whether the piping holds oil or not. Notification of the out of service status and the task completions may be made by the one-year anniversary of removal from the maintenance and prevention programs.

The aboveground portions of flow lines are supported as outlined in *Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids* (ASME B31.4) [18 AAC 75.047(g)].

2.2 DISCHARGE HISTORY [18 AAC 75.425(e)(2)(B)]

Discharge history of oil spills to water or tundra and other oil spills greater than 55 gallons was obtained for the period January 1992 through June 2006 by querying BPXA’s spill reporting database. The discharge history is provided in Appendix B and includes the following information:

- Date of discharge,
- Material discharged,
- Amount discharged, including the volume that reached navigable waters as applicable,
- Cause, and
- Corrective and preventive actions taken.

2.3 POTENTIAL DISCHARGE ANALYSIS [18 AAC 75.425(e)(2)(C) and 40 CFR 112.20(h)(4)]

The potential for oil spills is understood from historical spill data. Examples of potential oil spills are described in Table 2-4. Table 2-5 summarizes potential pipeline spills and release quantities. Spill prevention actions involve the training, operating procedures, leak detection, inspections, and secondary containment outlined in Part 2.

TABLE 2-4: POTENTIAL SPILLS FROM VARIOUS SOURCES

LOCATION	CAUSE	PRODUCT	SIZE	DURATION	ACTIONS TAKEN TO PREVENT POTENTIAL DISCHARGE
Fuel tank	Rupture Overflow	Fuel	595 bbl 20 bbl	4 hours 8 minutes	Bermed and lined storage areas and double-walled tanks.
Fuel lines transfer	Rupture	Fuel	500 bbl	varies	Berms are provided and liners are used in sensitive areas that may be affected by a spill.
Fuel delivery vehicle	Rupture Broken hose	Fuel	200 bbl 75 bbl	4 hours 1.5 hours	Unified Fluid Transfer Procedures.
Fuel transfer on land	Line rupture	Fuel	100 bbl	2 hours	Permanent and portable liners.
Wellhead	Leak	Crude Oil	100 bbl	varies	Cellar boxes initially and automatic shut-off.
Well	Uncontrolled flow from wellbore	Crude Oil	2,250 bbl per day	varies	Blowout prevention equipment.
Diesel transfer to tank truck	Tank overfill	Diesel	200 gallons	30 seconds	Transfer procedures in place; secondary containment.
Diesel transfer from barge to diesel tank	Hose rupture	Diesel	440 to 880 gallons	1 to 2 minutes	Transfer procedures in place; secondary containment; hose watch.
Diesel tank	Tank rupture	Diesel	15,000 bbl	Instant	Secondary containment; tank inspection program.

TABLE 2-5: POTENTIAL PIPELINE SPILLS AND RELEASE QUANTITIES

PIPELINE SEGMENT	TYPE OF FAILURE	LENGTH OF PIPE (feet)	POTENTIAL LOSS (bbl)	ACTIONS TAKEN TO PREVENT POTENTIAL DISCHARGE
Endicott				
MPI to Y	Corrosion or accident	16,541	3,800	Leak detection system & corrosion management
Y to 200-ft. breach	Corrosion or accident	2,794	640	Leak detection system & corrosion management
200-ft. breach	Corrosion or accident	352	90	Leak detection system & corrosion management
200-ft. breach to 500-ft. breach	Corrosion or accident	4,962	1,140	Leak detection system & corrosion management
500-ft. breach	Corrosion or accident	595	140	Leak detection system & corrosion management
500-ft. breach to shore valve	Corrosion or accident	12,848	2,950	Leak detection system & corrosion management
Shore to Sagavanirktok River	Corrosion or accident	44,899	10,300	Leak detection system & corrosion management
Sagavanirktok River to Trans Alaska Pipeline System	Corrosion or accident	46,940	10,780	Leak detection system & corrosion management
Badami				
Sagavanirktok River	Corrosion or accident	3,604 ft.	543 bbl	Leak detection system & corrosion management
Shaviovik River	Corrosion or accident	3,953 ft.	593 bbl	Leak detection system & corrosion management
No Name River	Corrosion or accident	1,152 ft.	189 bbl	Leak detection system & corrosion management
Other low point (Mile 17)	Corrosion or accident	4,000 ft.	600 bbl	Leak detection system & corrosion management
Kadleroshilik River	Corrosion or accident	1,406 ft.	203 bbl	Leak detection system & corrosion management

2.4 CONDITIONS INCREASING RISK OF DISCHARGE [18 AAC 75.425(e)(2)(D)]

Conditions specific to BPXA's North Slope operations that potentially increase the risk of an oil spill, and actions taken to reduce the risk of a spill, are as follows:

- Heat may cause gases to expand, increasing the likelihood of discharge. North Slope facilities are engineered to accommodate temperature fluctuations.
- Icy roads, white-out conditions, and cold snaps present obvious threats to field operations. BPXA Security's strict adherence to vehicle safety, speed limits, and the posting of warning signs assist in minimizing the potential for vehicular accidents that may result in a spill. In addition, North Slope facilities are engineered to withstand arctic conditions.

- Changes in traffic patterns may increase the risk of vehicles colliding into well lines. BPXA Security's strict adherence to vehicle safety, speed limits, and the posting of warning signs or traffic cones helps to minimize the potential for vehicular accidents that may result in a spill.

- If the Trans Alaska Pipeline System (TAPS) unexpectedly shuts down the pipeline, the risk to BPXA systems increases. BPXA's advanced communication system enables immediate communication between TAPS and the North Slope operators, which allows for the coordination of impacts and minimizes the risks due to a shutdown of the pipeline.

- High winds could increase the risk of discharge during fuel transfers, particularly during barge to tank transfers. If wind speed appears to pose a threat to communications or hoses and booming, transfer operations will be postponed until the wind subsides.

- As the fields age, the discharge potential increases. To minimize spills related to aging facilities, BPXA uses a computerized preventative maintenance program, has a corrosion control program, does valve inspections in accordance with Alaska Oil and Gas Conservation Commission (AOGCC) regulations, has leak detection monitoring, and conducts regular visual inspections.

- High water and/or ice during break-up could increase the risk of discharge over river crossings. The pipeline support members have been designed to withstand ice conditions expected at the river crossings. High water and ice conditions are monitored during weekly overflights of the Badami pipeline as well as during routine flights to and from Badami.

The Endicott pipeline has one river crossing at the Sagavanirktok River. To prevent damage to the crossing from ice floes, slots are cut in river ice prior to break-up each year. In addition, river water levels are monitored during high water to ensure that lateral bridge support members do not become submerged. The crossing is observed daily by Security personnel who are responsible for reporting abnormal conditions.

2.5 DISCHARGE DETECTION [18 AAC 75.425(e)(2)(E) and 40 CFR 112.20(h)(6)]

2.5.1 Drilling Operations

Each drilling rig has a system of controls, monitors, alarms and procedures to assist in the early detection of potential discharges. For both down hole and surface operations, these detection systems include automated monitoring devices as well as standard operating procedures (SOPs) governing the monitoring, handling and containment of fluids.

During down hole operations, much of the discharge detection effort centers on well control with an emphasis on detecting wellbore influxes (kicks). The primary control to prevent a discharge associated with a kick is the density of the hydrostatic column of drilling fluid in the wellbore. The drilling fluid density and other critical parameters are closely monitored by drilling fluid specialists and trained members of the rig crew. Modifications to the mud density are made in accordance with the AOGCC approved well plan to maintain the proper fluid density at various intervals. The BOPE (blow out prevention equipment) and associated mechanical well control equipment is defined as the secondary well control system. The AOGCC requires frequent documented testing of these safety systems and such tests are normally witnessed and verified by AOGCC field representatives.

For surface operations, discharge detection systems use automated equipment, visual, audio or manual detection in combination with policies and procedures governing the handling and containment of fluids. Rig pit systems are equipped with pit volume totalizers (PVT) that constantly monitor and record pit volume gains and losses. Unexpected gains or losses of drilling fluids initiate alarms, which sets in motion initial crew responses to secure the well. The well is monitored to further identify the cause of the event. If events indicate a kick or loss of circulation, countermeasures are initiated through written procedures to ensure well control is maintained. Countermeasures are initiated by means of the secondary well control equipment until the well can be stabilized with the primary well control means (e.g., weighted drilling muds) or installed barriers (e.g., cement plugs, bridge plugs).

Rig surface systems are continuously monitored for external leakage as well. Fluid transfers associated with drilling operations are carefully planned, permitted and monitored using BPXA and contractor fluid transfer guidelines. Strict adherence to these procedures ensures immediate detection of spills associated with fluid transfer operations, which significantly reduces the probability of occurrence.

2.5.2 Automated Methods

Operator control of the system is through computers. The system is reliable as the communications network is completely redundant. Each of the three operator consoles is a separate entity, and critical process loops are under redundant control.

Automated control systems and visual monitoring of instrument/control panels are used to control flow rates as well as detect potential discharges. The control systems and instrumentation consist of a “process control” system as well as an independent emergency shutdown (ESD) system. Several independent ESD systems limit the scope of any single failure. An ESD can be initiated by process conditions outside set limits or manually by operators at the instrument/control panels and by personnel at ESD punch-button locations throughout the facility. Process conditions that will trigger the ESD system include loss of pressure in a pipeline, excess pressure or equipment malfunction within a production facility, or high or low liquid levels in vessels and tanks. The ESD system is provided and maintained for the explicit purpose of stopping oil flow when these pipeline or facility problems are encountered. A cascading shutdown system is used to shut in wells and pipelines prior to relieving pressure on vessels or other process systems at the production facilities.

The Endicott control system monitors and operates the oil production wells, process facilities, and pipelines. The control system involves a microprocessor-based distribution control system (DCS) that employs three major categories of digital instrumentation and control, integrated into a single system. The three categories are the DCS, the Supervisory Control and Data Acquisition (SCADA), and the Programmable Logic Controller (PLC). The combined system interfaces with the communications network.

When an emergency requiring shutdown of one or more of the facilities occurs, the PLC system is used. The PLC system is integrated into the DCS. The PLC processor can accept operator commands and transfer status/alarm information to the main operator's console. The MPI and SDI have redundant PLC systems that provide maximum system integrity for performance of ESD functions. Operational and ESD procedures are discussed in the following paragraphs.

At each process center, control systems and visual monitoring of instrumentation are used to control injection flow rates, pressures, and distribution. Pressure-relieving devices are installed on pressurizing units. The facilities are visually inspected on a routine basis for detection of spills and equipment malfunctions.

Production facilities at Endicott are continuously monitored with a microprocessor-based DCS. Incoming alarms from the facilities, wells, or pipelines are documented by date and time via an alarm typewriter in the Unit 601 control room. This system capability allows for the quick tracking of cause-and-effect relationships during upset conditions. In addition, a manually operated, fully automated shutdown system is available if the computerized system is down and the facilities experience excess pressure or malfunction during production. Production wells automatically shut in when low producing pressures are detected.

Automated control systems and visual monitoring of instrument/control panels at the Badami facility are used to control flow rates as well as detect potential discharges. Programmable Logic Controllers (PLC) based control systems control the process in the plant. The operators interface with the PLCs by using the HMI (Human Machine Interface). The HMI system consists of two redundant personal computer servers with operating software that allows the operator to monitor the process, start up and shut down the plant and individual processes and equipment, and make process adjustments. As part of the PLC system, an independent ESD system automatically limits the scope of any single failure. An ESD can be initiated by process conditions outside set limits or manually by operators at the instrument/control panels and by personnel at ESD punch-button locations throughout the facility. Process conditions that will trigger the ESD system include excess pressure or equipment malfunction within a production facility, or high or low liquid levels in vessels and tanks. The ESD system is provided and maintained for the explicit purpose of stopping oil flow when pipeline or facility problems are encountered.

2.5.3 Oil Storage Tanks

Badami's two stationary tanks, the diesel storage tank and slop oil tank, are fitted with level transmitters for control room monitoring of tank liquid levels.

The diesel tank is equipped with leak detection for the tank bottom and has been installed in accordance with API 650, Appendix I. The system includes a bathtub-shaped liner imbedded approximately 12 inches into the foundation gravels and coming up to the outside edge of the tank. A drain is installed in the center of the bottom of the liner. The drain consists of high-density polyethylene piping routed to a steel sump outside of the perimeter of the tank to allow for visual inspection for hydrocarbon leaks from the bottom of the tank. The tank is inspected as described in Table 2-7.

The slop oil tank is elevated above a secondary containment area that is visually inspected for leaks as described in Table 2-7.

Endicott stationary tanks are aboveground and mounted on modules or skids within secondary containment. Additional containment is provided via overflow lines to the secondary containment basins. The tanks are fitted with a level transmitter for control room monitoring of tank liquid levels. The tanks are visually inspected as described in Table 2-7.

Portable tanks may be used for oil storage, well work and dewatering operations. The tanks are monitored while they are in use and during fluid transfers. The tanks' secondary containments are visually inspected as described in Table 2-7 when the tanks are storing oil.

Badami's stationary and portable oil storage tanks less than 10,000 gallons and regulated by 40 CFR 112 are described in Appendix A.

2.5.4 Flow Lines

Lines from oil-producing wells are equipped with low-pressure transmitters used to isolate producing wells in the event of a line rupture. If the pressure in the line drops below thresholds the line shuts in. Small leaks that would not activate the low-pressure switch would be identified by operations personnel performing routine checks. Given that production fluids are mostly gas and water, with smaller amounts of oil, leaks would involve relatively large amounts of visible steam and gas easily identified by both sight and sound.

2.5.5 Wells

The production wells at Endicott are fitted with trees that consist of a manual master valve, a manual swab valve, hydraulically actuated Sub-Surface Safety Valve (SSSV), hydraulically actuated Surface Safety Valve (SSV), and hydraulically actuated wing valve (SDV-Shut Down Valve). When the low-pressure transmitter senses a pressure below the threshold it will close the SSSV and SSV simultaneously.

The Badami production wells are fitted with trees that consist of a manual master valve, a manual swab valve and hydraulically actuated SSV and wing valve (SDV-Safety Divert Valve). When the low-pressure transmitter senses a pressure below the threshold it will close the SDV first followed by the SSV.

2.5.6 Crude Oil Transmission Pipelines

The Endicott pipeline leak detection system monitors the crude oil transmission pipeline from the Main Production Island (MPI) to Pump Station 1 (PS1) for a loss of fluid. The system has demonstrated the ability to detect a daily discharge equal to not more than one percent of daily throughput.

Additionally, as a voluntary measure, Security provides daily drive-by visual surveillance of the Endicott crude oil transmission pipeline. The Endicott pipeline route is entirely road-accessible, and therefore does not require aerial surveillance. Visual pipeline inspection is facilitated by the aboveground construction of the pipelines.

Leak detection for the Badami sales oil pipeline consists of weekly aerial visual inspection unless precluded by safety or weather conditions and monitoring of flow variations in the pipeline. At the Central Processing Facility, meters are installed on the A, B and C meter runs. The C Meter run provides metering flows less than 1,056 barrels of oil per day (bopd). A flow conditioner smoothes the oil flow upstream from the meter. At the Badami pipeline tie-in with the Endicott pipeline, the flow of oil from the Badami pipeline into the Endicott pipeline is measured with a sensing elements designed to handle flow rates up to 2,000 barrels of oil per hour (boph). Oil flow data are transmitted from the meter at Remote Terminal Unit No. 3 (RTU-3) to the Badami control room and then relayed to Endicott via the process control network. The meter supports API equations for net oil calculations. The data also are used for leak detection in the Ed Farmer and Associates (EFA) Leak Net host computer at Endicott. MassPack segment 5 performs the oil mass balance calculations for the pipeline segment from Badami to RTU-3.

Custody transfer metering systems on the Endicott MPI, at Badami and at Pump Station 1 of the TAPS measure volumes accurately and enhance the performance of the leak detection system. The systems provide corrected flow data to the LeakNet System via connected Allen-Bradley PLC-5s on the MPI, Badami, and at PS1. Pressure, temperature, and instantaneous flow information is provided from both the MPI and PS1 locations.

The Endicott/Badami pipeline system to Pump Station 1 (PS1) is monitored using an EFA LeakNet system. Currently only the MassPack algorithm is used for leak detection.

The EFA Mass Pack software performs conventional mass balances over 1 minute, 1 hour, and 24 hours with three corresponding alarm thresholds. The system displays a volumetric flow balance and acquires total inlet and outlet (PS1) crude flow data every minute. Calculations are carried out as shown in Table 2-6.

TABLE 2-6: VOLUMETRIC FLOW BALANCE CALCULATIONS

FREQUENCY	WARNING (bbl)	ALARM (bbl)
Endicott to PSI		
Last minute	15	40
Last 60 minutes	60	300
Last 24 hours	150	170
Badami to Endicott Tie-In		
Last minute	20	25
Last 60 minutes	n/a	n/a
Last 24 hours	15	16

Results exceeding these tolerances trigger alarms and initiate a response to investigate the cause and shut down production if required.

Mass Pack includes intelligence for smoothing the volume balances for transients. Increases (line packing) in the inlet flow rate can be tuned to show up in the outlet over time. Mass Pack leak detection is based on first principles and is often the most reliable of the three software detection methods.

Leak Alarm Response

In the event of a catastrophic rupture of the Endicott/Badami crude oil transmission pipeline, the control operator would immediately detect a total loss of pressure while simultaneously sensing no reduction in flow. Following confirmation, the pipeline would be shut down.

The leak detection system also will alarm for smaller continuous leaks.

If a leak alarm sounds upstream of the Flow Station 2 bypass, the Eastern Offtake Center contacts the Endicott Control Room to determine whether the alarm can be explained. If the alarm is downstream of the Flow Station 2 bypass, Eastern Offtake Center personnel will explain the alarm.

If the alarm can be explained, the leak detection system is reset.

Following an "unexplained" alarm from Endicott and Badami to Pump Station 1, the Eastern Offtake Center contacts Security to request a ground-based visual surveillance of the specific pipeline segment. The Eastern Offtake Center provides Endicott with the results.

If weather or safety prevents ground-based surveillance, then Security requests a Forward Looking Infrared (FLIR) overflight by Shared Services Aviation. If the FLIR overflight reveals an anomaly, the aircraft radios Kuparuk Security which notifies BPXA Security.

BPXA notifies ADEC in writing within 24 hours if a significant change occurs in or is made to the crude oil transmission pipeline leak detection system, and if as a result of the change, the system no longer meets the ADEC performance requirements in 18 AAC 75.055 (18 AAC 75.475). Suspension of the leak detection capability trigger notices to ADEC only if they preclude detection within 24 hours of a leak as large as 1 percent of the annual average daily throughput.

2.5.7 Visual Inspections

Table 2-7 summarizes the visual inspections performed on regulated equipment. Supervisors regularly review the records of daily visual inspections of ADEC-regulated tanks' secondary containments that are required by 18 AAC 75.075.

Flow lines and pipelines are inspected at least monthly, as required by 18 AAC 75.080(n)(1).

More specifically, the following personnel have been identified to support the inspection process:

- Security fills out inspection forms following pipeline inspections. In addition, during routine trips, Security will report oil or gas discharges to the spill reporting telephone line.
- Employees are responsible for conducting visual inspections of their work areas and contacting the operator or Environmental Advisor for clean-up.

Contractors are responsible for visual inspections of work areas and cleaning up spills they may cause. The Environmental Advisor is available to provide support or verification of clean-up efforts.

2.5.8 DOT Pipeline Safe Operations and Emergency Response Equipment Inspection

Inspections of the DOT-regulated sales oil pipeline are conducted as follows:

- Visual inspections at intervals not exceeding three weeks, but at least 26 times per year,
- Mainline and branch valve inspections at intervals not exceeding 7.5 months, but at least two times each year,
- Vertical support member (VSM) inspections annually during the walking-speed survey, and
- A VSM elevation survey at least once every five years.

TABLE 2-7: VISUAL SURVEILLANCE REQUIREMENTS

INSPECTION	RESPONSIBLE POSITION	REGULATING AGENCY	INSPECTION DESCRIPTION	FREQUENCY	REGULATORY CITATION	RECORD KEEPING
Oil Storage Tank in Operation	Badami Operations Lead Tech Endicott O&M Team Lead	EPA (Badami)	Visual inspection bulk oil storage containers 55 gallons to 10,000 gallons	Annual	40 CFR 112.9(c)(3), 112.9 (d)	Appendix A-1, A-3, "EPA Storage Tank Integrity Inspection Procedure" or PRIDE
		ADEC	Visual inspection of external conditions of oil storage tanks >10,000 gallons in operation	Monthly	18 AAC 75.065 and .066 following API 653	ADEC-Regulated Oil Storage Tank Monthly In-service Inspection Report
Wastewater Tank 1802	Endicott O&M Team Lead	ADEC	Visual inspection of tank	Every 12 hours	See ADEC waiver letter in Part 2.6	Daily log
Secondary Containment Areas at ADEC-Regulated Tanks	Badami Operations Lead Tech Endicott O&M Team Lead	ADEC	Visual inspection for oil leaks or spills, defects and debris	Daily, without record and weekly with record	18 AAC 75.075	Visual field inspection form
		EPA (Badami)	Visual inspection	Regular	40 CFR 112.9(c)	Appendix A-1, A-3, "EPA Storage Tank Integrity Inspection Procedure" or PRIDE
Secondary Containment at ADEC Tank Truck Loading Areas	Badami Operations Lead Tech Endicott O&M Team Lead	ADEC	Visual Inspection	At transfer or at least monthly	18 AAC 75.075(g)	Visual field inspection form; Daily field shift log
Overfill protection device on field-built oil storage tanks >10,000 gallons	Badami Operations Lead Tech Endicott O&M Team Lead	ADEC	Test overfill protection device	Monthly	18 AAC 75.065(l)	Monthly In-Service Inspection Report
Facility Oil Piping and Valves outside Process Modules, from Well through Manifold Building; to and from ADEC Tank	Badami Operations Lead Tech Endicott O&M TL	ADEC	Visual inspection of oil piping and valves that are visible	Daily contingent on weather and safe access	18 AAC 75.080(n)(1)	Visual field inspection form; Daily field shift log; Wells daily review sheet
		EPA (Badami)	Examine for maintenance	Periodic	40 CFR 112.9 c (3)	Appendix A-1, A-3, "EPA Storage Tank Integrity Inspection Procedure" or PRIDE
Crude Oil Transmission Pipeline	Badami Operations Lead Tech/Shared Services Aviation Endicott Security	ADEC (Badami)	Aerial surveillance for remote pipelines	Weekly, unless precluded by safety or weather conditions	18 AAC 75.055(a)(3)	Visual field inspection form
		DOT	Surveillance of sales oil pipeline right of way surface conditions	26 times a year, not to exceed 3 weeks between surveillances	49 CFR 195.412(a)	Surveillance form (Badami); DOT Pipeline Inspection Checklist Report (Endicott)

2.6 COMPLIANCE SCHEDULE AND WAIVERS [18 AAC 75.425(e)(2)(G)]

Waivers follow this page. Waiver content is as follows:

- Request for Secondary Containment Waiver for [Endicott] Waste Water Tank (Tag No. T-E3-1802). ADEC Letter No. 96-43-RKW, File No. 305.50 (089) (December 17, 1996).
- Temporary Waiver of Requirement for Secondary Containment at Tank T-E3-1810 Tank Truck Loading Area (October 12, 2004)
- Waiver of Requirement for Secondary Containment at Tank BAD-01 Tank Truck Loading Area (October 12, 2004)
- Waiver of Daily Secondary Containment Area Inspection Requirements during Bad Weather at Greater Prudhoe Bay, Milne Point, and Endicott and Badami (March 4, 2005)

TABLES

Appendix C

Consultation with USDOI, Fish and Wildlife Service (ESA Threatened Species)

ru

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

SuRNAme
[illegible] RSLE

FEB 17 2006

Memorandum

To: Regional Director
Fish and Wildlife Service, Region 7

From: Regional Director,
Alaska OCS Region [signature]

Subject: Endangered Species Act Consultations: Designation of a Non-Federal Representative

This memorandum serves as notification that pursuant to 50 CFR 402.08 the Minerals Management Service (MMS) has designated BP Exploration (Alaska) Inc. (BPXA) as the non-Federal representative for Endangered Species Act (ESA) consultations for the Liberty development project. The BPXA is also the applicant in the proposed federal action. As the designated non-Federal representative, BPXA will conduct informal consultations with the U.S. Fish and Wildlife Service (FWS) and prepare any requisite Biological Assessment (BA).

In accordance with 50 CFR 402.07, we are also advising the FWS that the MMS will be the lead agency for ESA consultations for the Liberty development project. The MMS will independently review and evaluate the scope and contents of the BA and is ultimately responsible for compliance with section 7 of the ESA.

Liberty is an oil field located about 5.5 miles offshore in the central Beaufort Sea. The BPXA is proposing to develop Liberty from onshore using extended reach drilling (ERD) technologies. The Liberty ERD project envisions an on-shore satellite with production sent by pipeline to an existing processing facility (Badami or Endicott).

Attached for your information is a copy of a Memorandum of Understanding (MOU), dated February 2, 2006, between the MMS, the Army Corp of Engineers (COE) and BPXA. This MOU sets forth responsibilities and a schedule to affect timely National Environmental Policy Act (NEPA) and permit evaluation processes for the Liberty development project. Attachment 2 to the MOU is a schedule for conducting the ESA and EFH consultations.

Jeff Walker with this office and Peter Hanley, BPXA Liberty HSE Manager, briefed you and your staff on the Liberty ERD project last fall. Additional briefings were also provided to the FWS Fairbanks office. We would be pleased to arrange an update briefing at your convenience. We would also appreciate information regarding your designated point of contact for the ESA consultation.

RD CHRC

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

MAR 26 2007

Memorandum

To: Regional Director, Region 7
Fish and Wildlife Service

From: Regional Director (acting)

Subject: Endangered Species Act, Section 7 Consultation, Beaufort Sea OCS Planning Area

BP Exploration (Alaska) Inc. (BPXA) is proposing to develop the Liberty reservoir using ultra-extended reach drilling technology drilling from the existing Endicott satellite development island (SDI). The Liberty reservoir is located in the Outer Continental Shelf (OCS). All development activities will be conducted from the Endicott SID. No activities are proposed to be conducted on the OCS.

The Federal actions associated with this project are the approval of a Development and Production Plan (DPP) from the Minerals Management Service (MMS) and a Section 10 and 404 permit from the U.S. Army Corps of Engineers (CORPS) for expansion of the Endicott SDI.

As required under Section 7 of the Endangered Species Act (ESA), the MMS and CORPS will be evaluating potential effects of authorizing this action to species listed and designated critical habitat under the ESA and will consult with the U.S. Fish and Wildlife Service (FWS) regarding the proposed actions.

By this memorandum, we request that the FWS specify what ESA listed, proposed, or candidate species, as well as designated critical habitat, may be in or near the Liberty development project area. Attached is the vicinity map of the project area from BPXA's draft Liberty Development Project Description. The MMS has designated BPXA as the non-federal representative to prepare the Biological Evaluation. We will provide the list to BPXA to assist them in preparing the evaluation of potential effects to ESA-listed species.

We are aware of the following species in or near the Beaufort Sea with status under the ESA for which FWS has management authority and that may be potentially affected by the proposed actions:

Common Name	Scientific Name	ESA Status
Spectacled eider	*Somateria fischeri*	Threatened
Steller's eider	*Polysticta stelleri*	Threatened
Kittlitz's murrelet	*Brachyramphus brevirostris*	Candidate
Polar bear	*Ursus maritimus*	Listing proposed

The MMS is also aware that the FWS has received a petition to list the yellow-billed loon (*Gavia adamsii*) under the ESA. We request that you inform us as to whether you foresee this species being listed or designated as a candidate species under the ESA within the next two years.

Please notify us of your concurrence with, or necessary revisions to, the above list of species and add any critical habitats that you believe would need to be considered in any biological evaluations related to the proposed actions.

If you have any questions on this consultation request or require additional information, please contact Mr. Mark Schroeder, MMS, 3801 Centerpoint Drive, Suite 500, Anchorage, Alaska 99503-5823, (907) 334-5247, or by email at mark.schroeder@mms.gov.

Attachment

cc: Field Supervisor, FFWFO
Judy Wilson, Chief ECU (MS 4042)
Jill Lewandowski, ENVD-EAB
Mike Holley, U.S. Army Corps of Engineers
Peter Hanley, BPXA

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

April 3, 2007

John Goll, Regional Director
Minerals Management Service
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, AK 99503-5823

Re: Liberty Project
Beaufort Sea OCS Planning Area
Endangered Species List

Dear Mr. Goll:

This letter responds to your March 26, 2007 request for a list of endangered, threatened and candidate species and critical habitats pursuant to section 7 of the Endangered Species Act of 1973, as amended (Act). The following information is provided for the Minerals Management Service (MMS) in regards to the BPXA Liberty Project Development and Production Plan. The information below addresses only species and critical habitats that may be affected by activities within the Liberty project planning area. The following listed or candidate species are present:

Common Name	Scientific Name	Status
Steller's eider	*Polysticta stelleri*	Threatened
Spectacled eider	*Somateria fischeri*	Threatened
Polar Bear	*Ursus maritimus*	Listing Proposed
Kittlitz's murrelet	*Brachyramphus brevirostris*	Candidate

The Liberty project area is within the breeding ranges and migratory routes of the threatened Steller's eider and spectacled eider. Critical habitat has been designated for each threatened eider species, but none occurs in or near the Liberty project area.

The Liberty project area is within the range of the polar bear, which has been proposed for listing as a threatened species. No critical habitat has been proposed for the polar bear. A decision regarding the polar bear listing is expected in late 2007. While the polar bear is proposed for listing, the MMS may conference with the U.S. Fish and Wildlife Service (FWS) regarding potential effects of the Liberty project to polar bears.

Kittlitz's murrelet, a candidate species, occurs throughout southeast Alaska, and portions of the Bering and Chukchi Seas. Although Kittlitz'z murrelet is distributed outside of the immediate project area, they do occur within the maritime transportation corridor along coastal Alaska.

The Liberty project area is also within the breeding range of the yellow-billed loon (*Gavia adamsii*). The FWS has received a petition to list the yellow-billed loon under the Act, and a regional recommendation is currently under review by management in the FWS Washington office. A finding regarding the yellow-billed loon will hopefully be put forth in the near future.

This list applies only to endangered and threatened species under our jurisdiction. It does not preclude the need to comply with other environmental legislation or regulations such as the Clean Water Act. Please contact the National Marine Fisheries Service to determine the status of listed and proposed species under their jurisdiction in the shoreline and off-shore action areas.

Thank you for your query, and for your cooperation in meeting our joint responsibilities under the Act. The Fairbanks Fish and Wildlife Field Office is responsible for consultation, pre-listing, listing, and recovery activities pursuant to the Endangered Species Act for Interior and northern Alaska. If you need further assistance regarding the Liberty project, please contact Jewel Bennett with the Fairbanks Fish and Wildlife Field Office at (907) 456-0239.

Sincerely,

Jewel Bennett
Acting Branch Chief

Ted Swem
Branch Chief
Endangered Species

BIOLOGICAL ASSESSMENT
FOR SPECTACLED AND STELLER'S EIDERS
THE LIBERTY DEVELOPMENT PROJECT

Prepared by

LGL Alaska Research Associates, Inc.

1101 E. 76th Ave, Suite B, Anchorage, AK 99518

for

BP Exploration (Alaska) Inc.

P.O Box 196612

Anchorage, AK 99519-6612

May 2007

May 2007
P837

BIOLOGICAL ASSESSMENT FOR SPECTACLED AND STELLER'S EIDERS FOR THE LIBERTY DEVELOPMENT PROJECT

Prepared by

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Prepared for

BP Exploration (Alaska) Inc.

P.O Box 196612

Anchorage, AK 99519-6612

May 2007

Suggested format for citation:

LGL Alaska Research Associates, Inc. 2007. Biological assessment for spectacled and Steller's eiders for the Liberty Development Project. Report prepared by LGL Alaska Research Associates, Inc. for BP Exploration (Alaska), Inc. Anchorage, Alaska. 55 p.

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1. INTRODUCTION AND BACKGROUND

The Liberty Development Project is being proposed by BP Exploration (Alaska) Inc. (BPXA) to develop an offshore oil reservoir located east of the existing Endicott Development in the Alaskan Beaufort Sea (Figure 1). The Liberty Development may have the potential to affect two bird species, the spectacled (*Somateria fischeri*) and Steller's (*Polysticta stelleri*) eiders, which are listed as "threatened" under the Endangered Species Act (ESA). Prior to development a Section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) will be required. This Biological Assessment was prepared to provide an overview of the proposed Liberty Development and to present information on the distribution, abundance, and habitat use of the proposed project area by threatened eiders that can be used to determine how impacts from the proposed development may affect eiders. In addition, mitigation measures are presented that may be helpful in reducing or minimizing the potential impacts of the development on threatened eiders. This document is intended to provide support to the USFWS for the issuance of a Biological Opinion that will assess the proposed development and its potential to impact spectacled or Steller's eiders. The USFWS has also prepared Recovery Plans for both spectacled and Steller's eider (USFWS 1996, 2002) which will provide relevant information in development of a Biological Opinion.

The Liberty Development Project design and scope have evolved from an offshore stand-alone development on the Outer Continental Shelf (production/drilling island and subsea pipeline) — as described in the 2002 *Liberty Development and Production Plan Final Environmental Impact Statement* — to use of existing infrastructure involving an expansion of the Endicott Satellite Drilling Island (SDI) located on the Endicott causeway (Figure 1). This project evolution reflects a number of factors including environmental mitigation, advances in ultra-extended-reach drilling (uERD) technology, use of depth-migrated three-dimensional (3D) seismic data, and advances in reservoir modeling among others. As a result, BPXA believes Liberty can be developed with relatively few wells (up to six) and less environmental footprint and impacts than the originally proposed offshore development.

The Project Description that follows this introductory chapter is a summary of BPXA's *Liberty Development Project Development and Production Plan* (DPP; BPXA 2007) submitted to the Minerals Management Service (MMS) in April 2007. The DPP will initiate the permitting process and National Environmental Policy Act (NEPA) review.

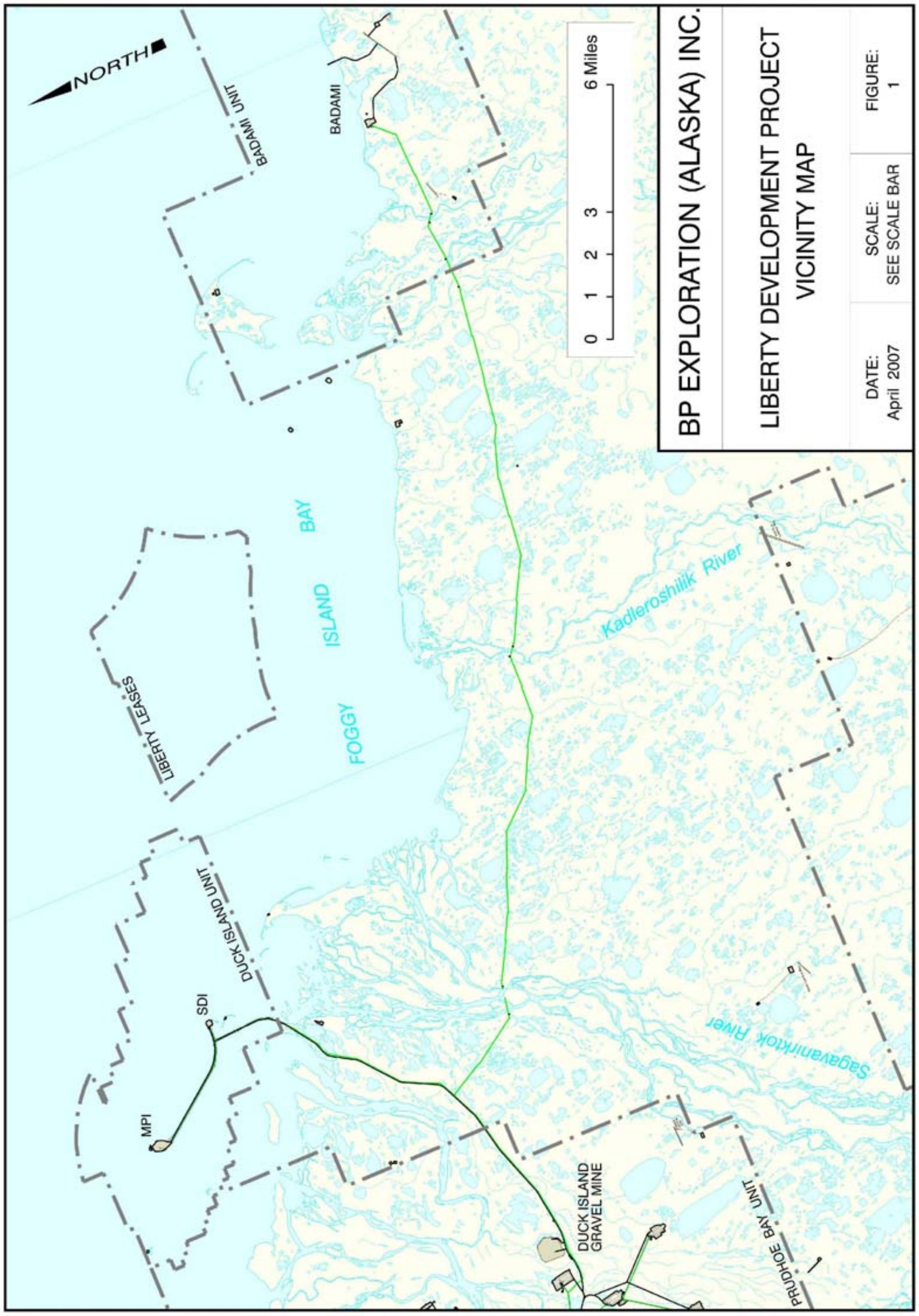

Figure 1. The Liberty Project area showing the offshore Liberty leases, the Endicott Main Production Island (MPI), and the Satellite Drilling Island (SDI) and the Endicott causeway.

Liberty Project History

BPXA has been moving forward on the Liberty Development Project since the fall of 1996, when BPXA first acquired Tract OCS-Y1650 in OCS Lease Sale 144 and initiated permitting activity for the Liberty #1 exploration well. The well was drilled and tested in the first part of 1997, and based on interpretation of geologic data, seismic data, and well tests, BPXA confirmed the discovery of the Liberty field on 1 May 1997. On 17 February 1998, BPXA submitted a DPP to MMS for review and approval of a Liberty Development Project based on a man-made gravel island with full production facilities and a buried subsea pipeline to shore. MMS issued a final environmental impact statement (FEIS) on the offshore project in 2002 (USDOI/MMS 2002). However, BPXA put the project on hold to further review design and economics after completion of its Northstar Project.

In August 2005, BPXA decided to pursue use of uERD from an onshore location. Such a project eliminates the offshore impacts of island and pipeline construction. Recent advancements in drilling technology have made such a project feasible. This change in project scope significantly mitigated the potential offshore environmental impacts related to the Boulder Patch, marine mammals, and concerns of the North Slope Inupiat communities related to the bowhead whale and subsistence whaling. It also made issues related to offshore pipeline design moot. This decision encouraged BPXA in August 2006 to pursue development of Liberty from an expansion of the existing Endicott SDI as summarized below. This decision to evaluate development using the existing infrastructure at Endicott further mitigates impacts of other options that were under consideration by avoiding construction of a pad on the shoreline of Foggy Island Bay or the coast near the Kadleroshilik River and an access road and pipelines crossing the Sagavanirktok River delta.

Project Overview

The Liberty prospect is located about 5.5 miles (8.8 km) offshore in about 20 ft (6 m) of water and approximately 5-8 miles (8-13 km) east of the existing Endicott SDI (Figure 1). To take advantage of the infrastructure at Endicott, BPXA has elected to drill the uERD wells from the SDI by expanding the island to support Liberty drilling. Liberty is one of the largest undeveloped light-oil reservoirs near North Slope infrastructure. BPXA estimates the Liberty Development could recover approximately 105 million barrels of hydrocarbons by waterflooding and using the ***LoSal™*** enhanced oil recovery (EOR) process (***LoSal™*** is a trademark of BP p.l.c.).

The development drilling program will include one to four producing wells and one or two water injection wells. No well test flaring is planned for this drilling program. Production from the Liberty uERD project will be transported by the existing Endicott production flowline system from the SDI to the Endicott Main Production Island (MPI) for processing. The oil will then be transported to the Trans Alaska Pipeline System via the existing Endicott sales-oil pipeline. Produced gas will be used for fuel gas and artificial lift for Liberty, with the balance being re-injected into the Endicott reservoir for enhanced oil recovery. Water for waterflooding will be provided via the existing produced-water injection system available at the SDI. This supply will be augmented by treated seawater if needed from the Endicott Seawater Treatment Plant. The ***LoSal™*** EOR process will be employed during a portion of the flooding and will be supplied by a ***LoSal™*** facility constructed on the MPI.

Associated onshore facilities to support this project will include upgrade of the existing West Sagavanirktok River Bridge or construction of a new bridge, ice road construction, and development of a new permitted mine site adjacent to the Endicott Road to provide gravel for expanding the SDI. Two new pipelines will be constructed from SDI to MPI for transport of water for injection and high pressure gas. Existing North Slope infrastructure will also be used to support the project.

All wells for this project will be outside current industry performance for this depth. As a result, the state-of-the-art of uERD must be advanced. BPXA first plans to drill a single well in order to assure that such drilling is feasible. If that well is successful and the technology is proven, then BPXA will proceed with drilling additional wells and installing new facilities to complete the project. The project will need to secure access to Duck Island Unit lands and Endicott area equipment for construction, drilling, and production operations. Terms for access must be agreed upon with the Endicott owners in a comprehensive facility sharing agreement. Negotiations on this agreement are ongoing.

2. PROJECT DESCRIPTION

Schedule

Figure 2 shows the overall project schedule for the proposed Liberty Development. The project currently includes the following milestones contingent on permits and facility access agreements:

- Construction of a purpose-built drill rig commencing in early 2008;
- SDI pad expansion and facilities installation in 2009;
- Construction of a new or upgrade of the existing West Sag River bridge in 2009;
- Fabrication and installation of well pad facilities in 2009;
- Rig assembly, commissioning, and crew training in early 2010; and
- Drilling the initial Liberty Development well starting in early 2010, with completion and first oil production in the first quarter of 2011.

Once the initial uERD technology has proven to be successful, BPXA will proceed with the remaining wells and facilities:

- Drilling of additional production and injection wells from mid- 2011 through the end of 2012;
- Installation of the Liberty inter-island pipelines in 2012; and
- Fabrication and installation of the ***LoSal™*** EOR process modules from mid-2011 through the end of 2012.

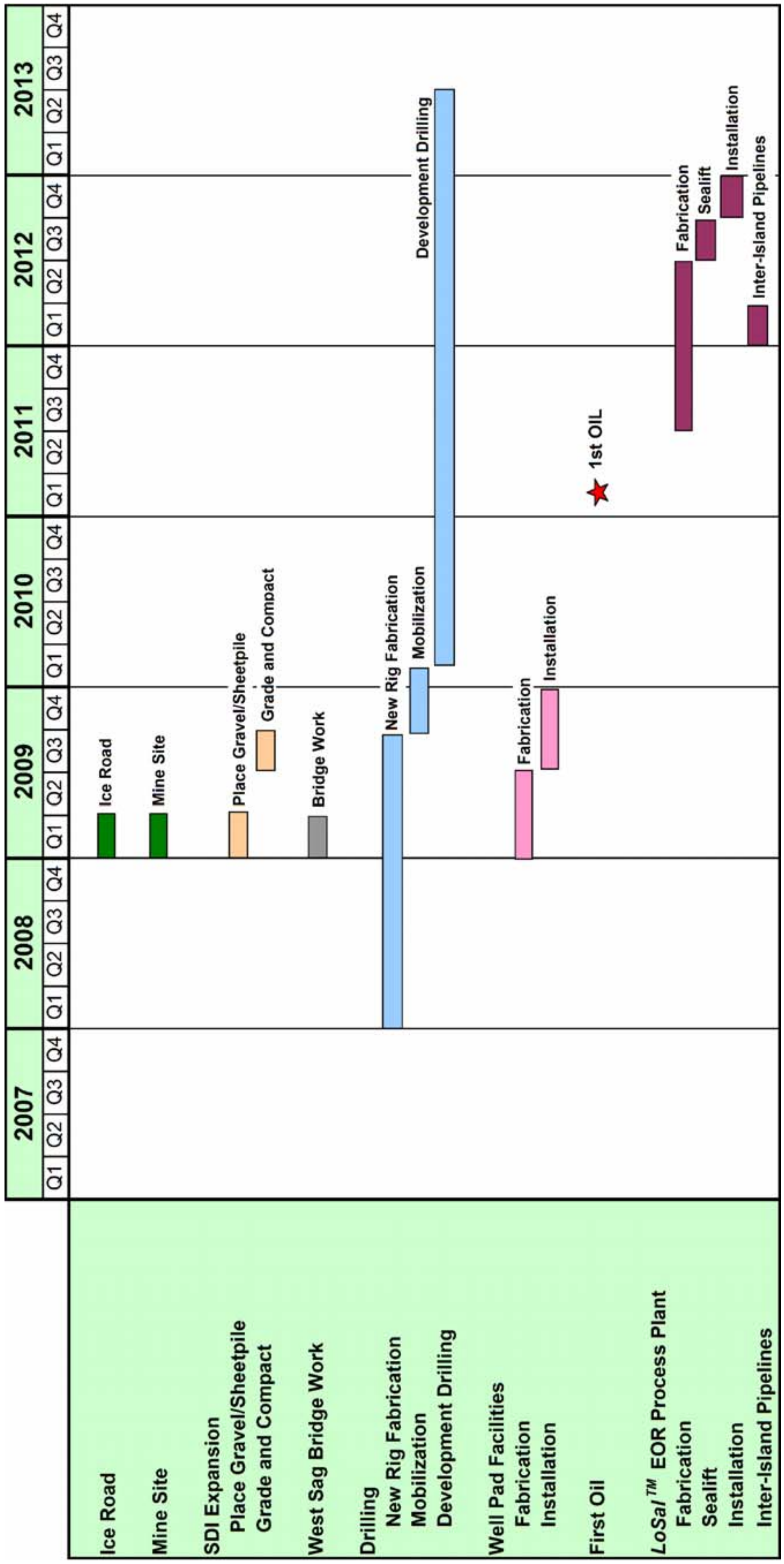

Figure 2. Schedule of development activities for the Liberty development.

Drilling operations may be required in subsequent years to accommodate development wells and/or existing well workovers. Final project abandonment would begin when project facilities are no longer needed, consistent with plans for abandonment of the Endicott facilities.

Construction

Liberty will use conventional North Slope construction methods, and the schedule will be governed by the usual seasonal constraints on North Slope activities.

Ice road construction

In order to expand the Endicott SDI, an ice road will be built starting in January 2009, or when seasonal conditions allow (Figure 3). The ice road is proposed to start from a new gravel mine site near the Duck Island mine site on the west side of the Endicott Road. The ice road will cross under one of the Endicott Causeway bridges (depending on water depth) in the Sagavanirktok (Sag) River delta and cross the sea ice to the south side of the SDI. This ice road will allow the gravel-haul trucks direct, unobstructed access to the SDI without affecting normal traffic on the causeway, which has a single-lane bridge.

Mine site development

The source of gravel for the SDI expansion is currently planned to be a new site east of the existing Duck Island mine site in the Sag River delta (Figure 3). Snow clearance and removal of unusable overburden will take place in January 2009 while the ice road is being built, followed by gravel excavation and hauling. The gravel haul will take place during a single winter season (early 2009). A mining and rehabilitation plan has been submitted to the State of Alaska, Department of Natural Resources, Division of Mining, Land and Water, for review and approval. Disposition of the overburden, plus any other stipulated reclamation measures, will be done according to the approved mining plan.

Satellite drilling island expansion

The Endicott SDI will be expanded to accommodate the new drilling rig, the Liberty wells, and the various production facilities and piping required to support the Liberty Development. The existing slope protection may be removed while the ice road is being built. The gravel haul will begin as soon as the ice road is ready, and the haul will be complete before breakup in mid-April 2009. In June and July following breakup, the fresh gravel on the SDI will be compacted to provide a suitable working surface, and new slope protection will be placed around the island.

West Sag River Bridge

BPXA is evaluating whether to upgrade the West Sag River Bridge or to construct a new bridge with up to two lanes upstream of the existing bridge. During 2009, the bridge may be upgraded or a new bridge may be constructed to accommodate increased traffic and vehicular loads for the project..

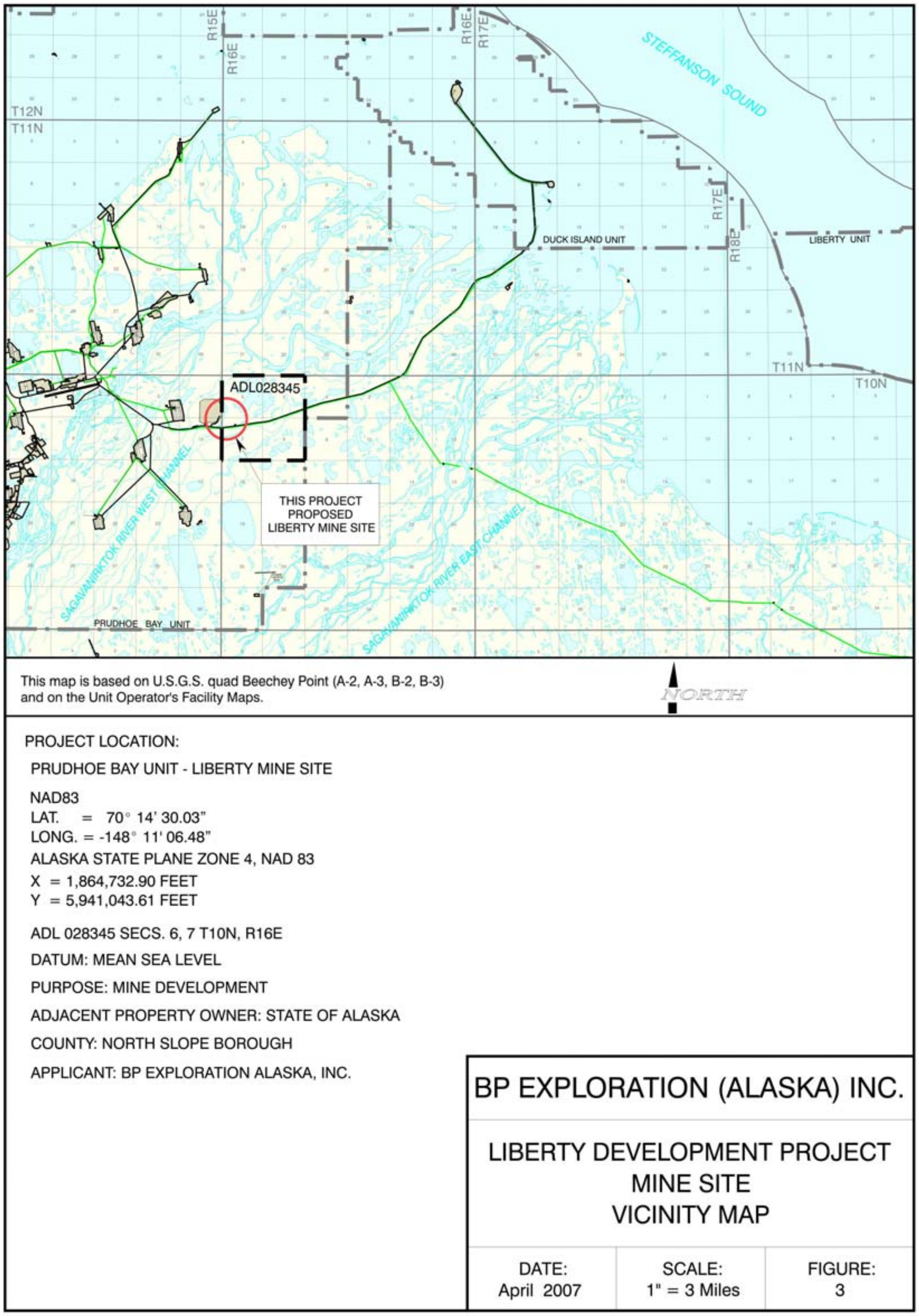

Figure 3. Location of proposed Liberty gravel mine site adjacent to existing Duck Island Mine Site.

Fabrication

Process facilities to support the initial drilling stage of the Liberty Development will be fabricated as truckable modules and shipped to the North Slope by road. These facilities include:

- A fuel gas conditioning skid to provide fuel to the rig engines;
- Interconnect piping, including production and test, gas lift, and water injection lines, for the initial wells; and

This work will commence in 2009 in order to be in place when drilling commences in the first quarter of 2010. A ***LoSal™*** enhanced oil recovery (EOR) process plant and supporting facilities will be fabricated during the second half of 2011 and first half of 2012 and sealifted to the site. This fabrication will be done at a site to be chosen later.

Pipeline construction

Two new pipelines will be constructed for ~3 miles between the Endicott MPI and SDI parallel to the existing inter-island pipelines: a ***LoSal™*** EOR process water injection pipeline and a high-pressure gas pipeline. Since these lines will be constructed on the Endicott Causeway, there are no seasonal constraints on their construction, however, installation of the pipeline is scheduled for winter 2012 in order to be operational by the time the ***LoSal™*** EOR process modules arrive. The current plan is for traditional North Slope elevated pipes placed on vertical support members (VSM).

Facilities installation

Facilities installation will take place in two stages. The relatively minor facilities required to support drilling and production of the first few wells will be installed in second half of 2009, while the ***LoSal™*** EOR process plant and associated modules will be installed in late 2012. Revamps to the Endicott Seawater Treatment Plant will occur during the summer of 2012 to support the ***LoSal™*** EOR process.

Drilling

Construction of the new, purpose-built drilling rig for the project is expected to begin by the first quarter of 2008. The first well should be spudded in 2010, with drilling of the remaining wells likely to extend through 2013.

Operations

Production operations will commence following hook-up of the first well in early 2011.

Project Access

Liberty Project transportation needs include safely transporting personnel, supplies, and equipment on a daily basis to and from the SDI during construction, drilling, and operations. During construction, quantities of pipe and gravel will be moved to the site. Drilling operations will require movement of a large quantity of pipe materials, heavy modules, chemicals, water, drilling mud, drill cuttings, and other supplies to and from the island. During ongoing field operations, limited equipment and supplies will be transported to the site. Equipment, supplies, and personnel will have access to and from the site via the existing Endicott road system, which connects with roads at Prudhoe Bay and with the Dalton Highway. Several different modes of transportation are currently available, and the following sections describe the basic features and limitations of each mode. Before construction begins, a detailed emergency evacuation plan will be completed addressing all phases of the project.

Air access

No regularly scheduled helicopter access to the Liberty area is needed because the Liberty Development is proposed as an extension to the SDI and is accessible from the existing Endicott road system. There will be sufficient area for helicopter landing for emergency evacuation of personnel on the SDI.

Ice roads

Ice roads are commonly used on the North Slope for winter travel, typically from late December through mid-April. Onshore and offshore ice roads will be built to support project construction, and in subsequent years, possibly to support drilling operations.

Marine access

Significant marine traffic is not needed to support Liberty construction and operation. A sealift by barge is planned to transport the ***LoSal™*** EOR process and power generation modules to the existing MPI dock. In addition, a dock is provided in the SDI design primarily for launching oil spill response boats and equipment. Extensive dredging is not expected to occur; however, some localized removal (e.g., screeding) of high spots on the seafloor may be required and will be determined by field survey.

Road access

The existing road system will provide access to Liberty facilities throughout the project. The West Sag River Bridge connecting the Endicott Road to the Prudhoe Bay road system provides access to the MPI and SDI from Deadhorse and other oilfield infrastructure, as well as the Dalton Highway. It is therefore a major transportation link for the project, but cannot support the load and traffic requirements for Liberty. BPXA is evaluating whether to upgrade the existing West Sag River Bridge or to construct a new bridge with up to two lanes upstream of the existing bridge.

The Liberty drilling rig is being designed in truckable modules for virtual year-round delivery. Following barging to Valdez or another suitable Alaskan port, from a fabrication site in the lower 48 states, approximately 460 tractor-trailerloads will be required via highway from Valdez to the SDI to transport the rig to the SDI drilling site for reassembly. The final rig mobilization plan will be developed as the rig construction schedule evolves and the fabrication site is chosen.

The existing road system will support the needs of Liberty uERD wells. Transportation of all drilling consumables, services, and support for Liberty will be similar to that for any other land-based project on the Prudhoe Bay road system. Because of the scale of each Liberty well, more of each product will be used per well, but the requirement will be spread over a much longer time. Thus, the daily traffic for moving drilling consumables will be about the same as for a typical North Slope well.

Drilling Pad

Conventional gravel placement will be used to extend the eastern and southern sides of the SDI to support project drilling, production operations, and infrastructure support functions (Figure 4; Table 1). The size of the SDI expansion is dictated primarily by the size of the drilling rig, storage requirements for drilling supplies, and a safe area for emergency evacuation and protection of workers.

The current working area of the existing SDI is approximately 11 acres, and the Liberty pad expansion will add approximately 20 acres of working area for facilities and drilling. Thus, the total combined working area will be 31 acres. Based on the slopes of the existing SDI and the expansion, the total footprint on the seabed of the expanded SDI will be approximately 40 acres versus the current 20 acres.

Island coordinates (NAD83) are 70°19'17.51"N, 147°34.8"W The island extension will be located in approximately 4 to 11 feet of water. Table 1 summarizes the SDI island design features.

Table 1. Summary of SDI design features.

ITEM	DESCRIPTION
Surface Dimensions (approximate)	704 by 1,394 feet
Height (working surface)	13 feet above MLLW
Gravel Volume	860,000 cubic yards
Dock Size	150 by 160 feet
Rock Riprap for Slope Protection	Approx. 6,000 cubic yards

Drilling pad structure

The extension of the SDI to accommodate the Liberty Project will be constructed of gravel from a new permitted gravel mine to the west of the Endicott Road; approximately 860,000 cubic yards of gravel will be required. The currently proposed island extension will have surface dimensions of 704 feet by 1,394 feet, and the gravel will be placed within a sheet-piled perimeter wall as protection from summer wave action and winter ice load. Consequently, the design bottom dimensions will be roughly the same as the

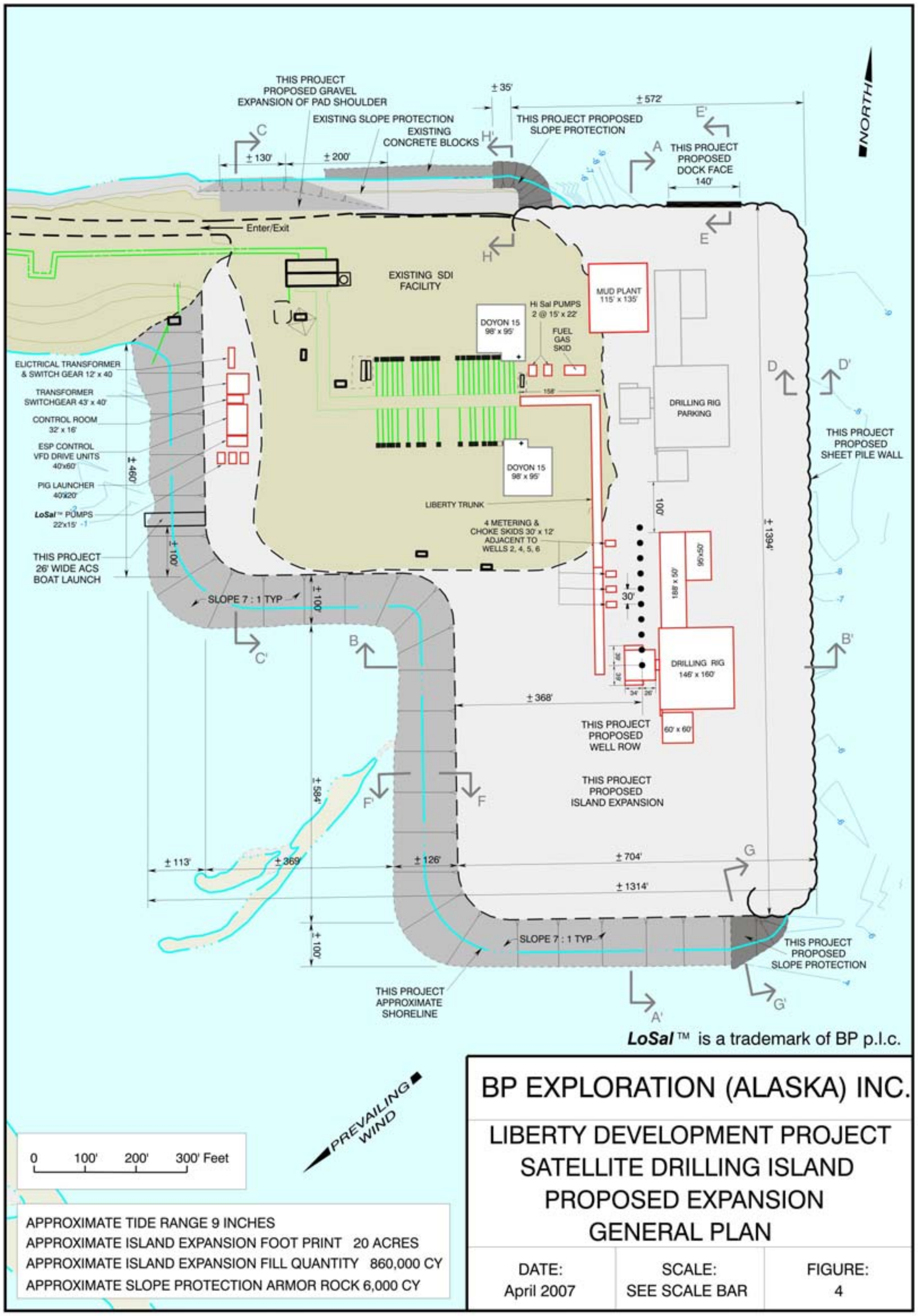

Figure 4. SDI expansion area and pad layout.

surface dimensions for the north and east sides. Where the sheet piling merges with the existing island slope protection, large pieces of rock will be used as riprap to stabilize the transition from the sheet piling to the existing concrete mat slope protection.

The island will have a working surface elevation of 13 ft above mean lower low water. The proposed sheet pile wall will protect the island form the erosive forces of waves, ice ride-up, and currents.

SDI surface layout

A single row of wells will be oriented north-south and offset from the existing SDI well rows by approximately 200 feet (Figure 4). The well row will start approximately 250 feet north of the southern end of the gravel expansion and will include 10 well slots (including spare slots) with the slots on 30-ft centers. The drilling rig will be capable of moving up and down the well row to access the desired well. The new Liberty wells will be tied into production, test, and water injection headers, which will in turn be tied into the existing SDI production test and injection headers.

The east side of the SDI expansion will be dedicated to drilling. Much of the work surface area on the island will be for storage of drilling consumables. The SDI has road access to the Prudhoe Bay drilling infrastructure for re-supply of drilling consumables.

Surface facilities that will be located on the SDI will include the following:

- Pipe rack and well tie-in piping
- Fuel-gas conditioning skid
- Booster pumps for high-salinity water injection
- Electrical transformer and switchgear
- Control room
- Transformer module for the electrical submersible pump variable frequency drive (ESP VFD)
- ***LoSal™*** pipeline pig-launcher module
- ***LoSal™*** EOR process injection pumps

The fuel-gas conditioning skid and the booster pumps for high-salinity water injection will be located to the north of the Liberty header tie-in to the existing Endicott pipe rack, while the ***LoSal™*** EOR process injection pumps will be located south of the existing Endicott SDI Module 405 on the south side of the existing pipe rack. The electrical transformer and switchgear and ESP VFD transformer module and the pig launcher module will be located south of Module 405 on the west side of the existing pipe rack.

Civil construction

Construction will commence during the winter of 2009. An ice road will be constructed along the west side of the Endicott Road in order to establish a traffic loop between the gravel mine site and the SDI for gravel hauling. The ice road will pass under one of the Endicott Causeway bridges depending on water depth.

The SDI island slope protection will be removed from east side of the existing island. This will occur progressively as gravel is dumped and pushed outward by front end loaders just beyond the intended expanded island perimeter. Gravel dumping and placement will continue until the whole footprint is complete. The island surface will be overbuilt to allow for settlement during the first summer.

A new gravel mine will be blasted and excavated just to the east of the existing Duck Island mine site. An ice road approximately 1,500 feet long will be constructed for access from the Endicott Road to the mine site. Vegetation and overburden will be stripped separately and stockpiled for restoration purposes. The gravel layer will be mined and hauled to the SDI using B70 haul units or similar.

Gravel will be hauled and dumped to build up the initial surface to approximately 1 to 2 feet above sea level. A vibratory roller will be used to provide initial compaction and provide a working surface for traffic. A mound of gravel will be stockpiled at the southwest corner of the island for eventual use for grading after the island has seasoned for the first summer. The existing slope protection on the east side of the SDI would be removed immediately prior to placing gravel.

Sheet piling would commence on the north side of the SDI, progress east and then south, and terminate at the southeast corner of the island expansion. The south end of the new island extension would not be sheet piled as it is not affected by ice or erosion forces. The sheet pile wall would be driven by a vibratory hammer to create an interlocking open-cell sea wall. Construction equipment would be supported on wooden mats. Additional gravel would be filled in behind the sea wall, which would be terminated at 13 feet above the MLLW sea level. A vibra-compaction roller would be used to consolidate the fresh gravel lift as placement progresses.

The gravel island will be overbuilt and allowed to settle during the summer after the placement of gravel. The gravel will be machine-graded during the summer to encourage settlement before the drilling equipment arrives on-site. If required, additional gravel will be hauled to the pad to make up for any localized settlement that may occur. The new island will be graded to integrate the surface drainage with the existing SDI drainage system, and a perimeter road will confine surface water drainage inside the island.

Pipeline System

Liberty production will be routed through facility piping from the wellheads into a new production header that will be tied into the existing SDI 24-inch-diameter production header. The commingled production from the SDI and Liberty will flow to the MPI for processing through Endicott's existing 28-inch-diameter flowline.

A ***LoSal™*** EOR process water injection line independent from the existing MPI-SDI water injection line will be routed between the MPI to the SDI. Additionally, a high-pressure gas line will be installed alongside the new water injection line.

Pipeline route

The pipeline route for the 10-in ***LoSal***™ water injection and the 6-in gas-lift pipelines will be along the existing Endicott gravel causeway between the SDI and MPI, a distance of approximately 3 miles (Figure 5). The pipeline will be on a new VSM system and on the lagoon side (west) of the existing Endicott SDI VSM system.

Design basis

The ***LoSal™*** and gas-lift pipelines will be elevated on standard VSMs. The ***LoSal™*** line will have a polyurethane foam insulation jacket. Expansion loops will be in an “L” loop configuration, spaced approximately 3,300 feet apart. The pipeline will have a minimum elevation of 7 feet above the ground surface.

Construction

The pipelines will be constructed in the first quarter of 2012. An ice road may be installed on the lagoon side of the Endicott Causeway to allow equipment access in winter. The water injection and gas pipelines will be supported on new VSMs between the MPI and SDI facilities. The above-ground pipeline will include expansion loops or offsets to account for thermal movement of the pipeline. Design and installation of the VSMs will be completed following typical procedures used for other elevated pipelines on the North Slope.

Safety and leak prevention measures

The proposed Liberty pipelines include the following measures to assure safety and leak prevention:

- The pipelines will be externally coated to prevent corrosion.
- Cleaning and inspection pigs will be run during operations.
- The elevated overland pipeline section will be conventional, proven North Slope design.

The existing 16-inch-diameter Endicott sales oil line will be used to export Liberty oil to Pump Station 1 of the Trans Alaska Pipeline System (TAPS). This line has isolation valves installed at both sides of the causeway bridges. The pipeline is monitored for leaks using the industry-standard mass-balance line-pack compensation system. The leak detection system meets all current Department of Transportation (DOT) and Alaska Department of Environmental Conservation (ADEC) leak detection requirements.

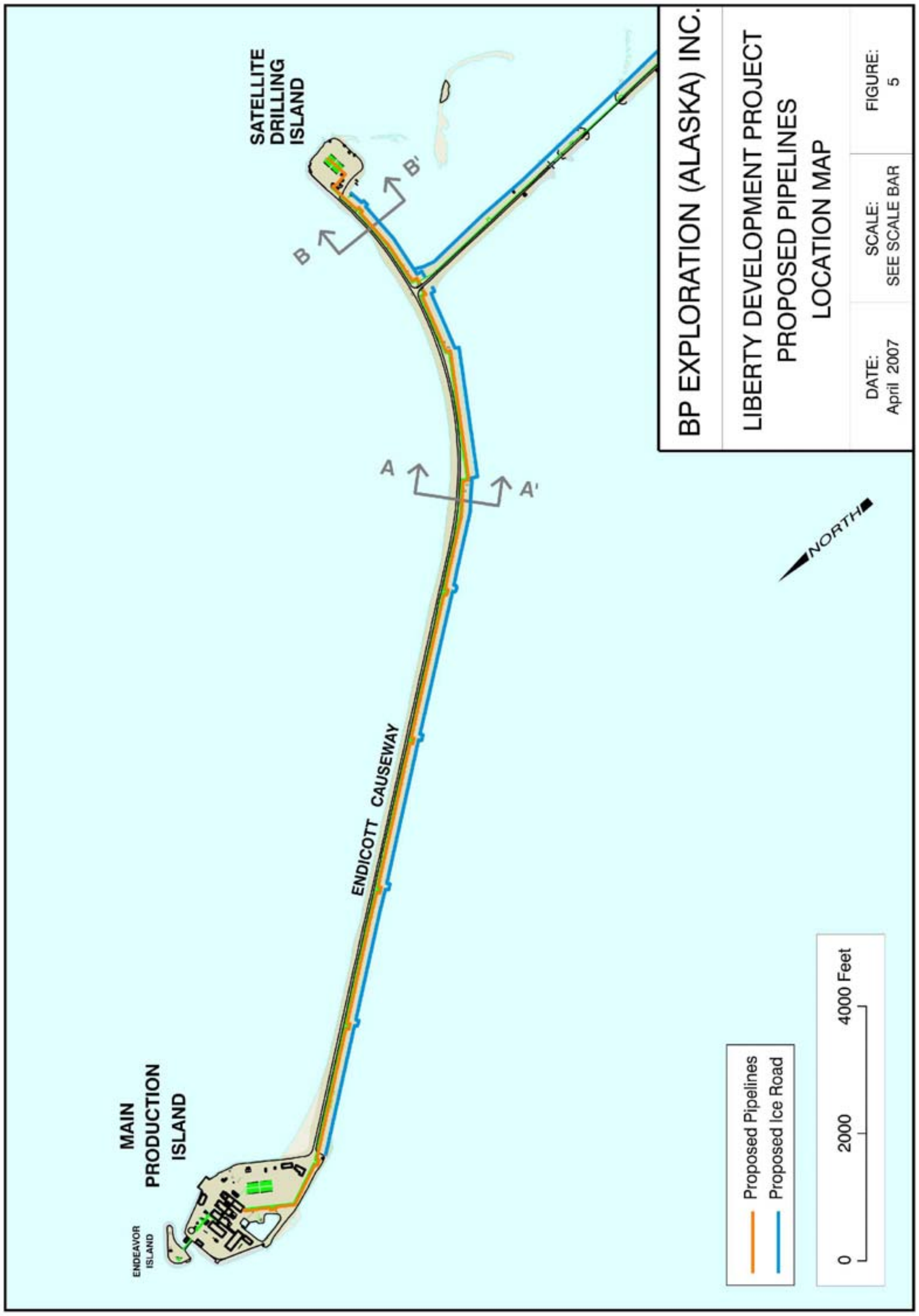

Figure 5. Location of proposed pipelines between SDI and the Endicott MPI, and possible winter ice road locations.

Monitoring and surveillance

Following is a summary of monitoring and surveillance for existing Endicott pipelines and planned new Liberty lines based on existing Endicott procedures. The *Oil Discharge Prevention and Contingency Plan* will provide detailed information on the proposed pipeline surveillance and monitoring program. The Liberty and Endicott pipelines will comply with ADEC regulations for surveillance, monitoring and record keeping for pipelines and flowlines (18 AAC 75).

- **Three-phase pipeline:** This existing 28-inch-diameter line is inspected annually to verify its condition. The pipeline material is duplex stainless, which is highly resistant to corrosion. It is not possible to smart-pig the line due to the non-magnetic properties of the steel. BPXA will conduct annual visual inspections combined with spot-item ultrasonic wall-thickness gauging, as well as digital radiography, to assess continuing pipeline integrity. Additionally, the line will be pigged annually with a cleaning pig to ensure that there is no deposition of sediment in the line.
- **Gas-lift pipeline:** This existing 14-inch-diameter line will be used initially to provide fuel gas for the Liberty Project. This line is visually inspected for external corrosion every year, with particular emphasis at the pipeline vault under the Endicott Causeway "T" junction.
- **Water injection pipeline:** This existing 14-inch-diameter water line is routinely pigged approximately once a month. The line was also smart-pigged in 2006 and its integrity was confirmed.
- **Gas and *LoSal*™ EOR water injection pipelines:** When Liberty production warrants, a new 6-inch-diameter gas line and 10-inch-diameter water line will be installed, and they will be smart-pigged at start-up to provide baseline wall-thickness data against which future pigging runs can be compared. The lines will then be pigged and inspected at a similar frequency to the existing Endicott gas and water injection lines.
- **Sales oil line:** The existing 16-inch-diameter Endicott sales line will be used to export Liberty production to Pump Station 1. This line was smart-pigged in 2006 to confirm its integrity. The line was verified to be in good condition, and it will continue to be smart-pigged every 5 years. The line is subject to routine cleaning pig runs every 3 months.

3. DESCRIPTION OF LISTED EIDERS OCCURRING IN THE LIBERTY PROJECT AREA

Spectacled Eider

Population status

The spectacled eider is a medium-sized sea duck that breeds along coastal areas of western and northern Alaska and eastern Russia, and winters in the Bering Sea (Petersen et al. 2000). Three breeding populations have been described: one in the Yukon-Kuskokwim (Y-K) delta in western Alaska, a second on the North Slope of Alaska, and the third in arctic Russia. During the 1970s approximately 50,000 female spectacled eiders nested in western Alaska. Data collected by the USFWS from ground-based study plots in the Y-K delta suggested that the number of female spectacled eiders nesting in the delta declined by approximately 8 to 14% per year from the 1970s to 1992 (Stehn et al. 1993; Ely et al. 1994). By 1992 the Y-K delta spectacled eider population was reduced to approximately 4% of the population existing there in the 1970s and it was federally listed as a threatened species in 1993 (58 *FR* 27474).

Little information is available describing the status of the North Slope spectacled eider population prior to 1992. Historically the North Slope population has likely been much smaller than the Y-K delta population. The USFWS began conducting aerial surveys for breeding eiders on the North Slope in 1992 that have continued annually through the 2006 breeding season (Larned et al. 2006). The 1992 survey was flown too late in the season to be included in analyses with subsequent years, but since 1993 the North Slope spectacled eider population has remained relatively stable with a non-significant decreasing trend (Larned et al. 2006). During this time period the indicated total spectacled eider population index for the North Slope survey area has ranged from approximately 5,000 to 9,000 birds. This index represents an unknown proportion of the population occupying the survey area during the nesting season that is based on the presence of adult males. The proportion is assumed to be constant among years and the index is used to track population changes through time. Eider nesting phenology on the North Slope is related to environmental conditions such as temperature and snow melt, and the timing of surveys can be an important factor when considering results of spectacled eider surveys (TERA 1997).

The largest spectacled eider breeding population is located in arctic Russia. The population there has been estimated at >140,000 individuals (Hodges and Eldridge 2001). Based on estimates of the wintering population in the Bering Sea, the total world population may number around 375,000 birds (Larned and Tiplady 1999).

Spring migration

Spring migration routes of spectacled eiders are not well documented. Most of the data are from counts of eiders as they pass Point Barrow in late May and early June (Suydam et al. 1997, 2000). During spring migration thousands of king (*Somateria spectabilis*) and common (*S. mollissima*) eiders follow offshore leads and small numbers of spectacled eiders have been recorded during spring counts. Richardson and Johnson (1981) also reported small numbers of spectacled eiders offshore during spring migration east of the Colville River at Simpson Lagoon although some of these birds may have been local breeders rather than migrants. Few researchers have conducted inland counts of migrating birds on the North Slope, but Myers (1958) reported that spectacled eider was the most abundant eider species migrating along river systems south of Barrow in spring. Since only small numbers of spectacled eiders have been recorded migrating along the coast during spring, it may be that most birds migrate overland across the Arctic Coastal Plain (ACP) following river drainages.

Nesting

Spectacled eiders arrive on the North Slope in late May or early June. They occur in low densities across the North Slope from Wainwright to at least the Shaviovik River east of the Prudhoe Bay area. The highest concentrations occur within ~70 km of the coast in the Northwest National Petroleum Reserve-Alaska (NPR-A) between Barrow and Wainwright, and in the Northeast NPR-A north of Teshekpuk Lake (USDOI/BLM/MMS 1998; USDOI/BLM/DU 2002; Larned et al. 2006). Overall densities during the eider breeding population surveys on the ACP have ranged from ~0.174 to 0.305 birds/km^2 between 1993 and 2006 (Larned et al. 2006). The density during the 2006 breeding population survey was 0.219 birds/km^2.

In general, spectacled eider density on the ACP is greater in the western portion of its range and decreases to the east although localized areas of relatively high density occur in the eastern portion of the range near the Colville River and Prudhoe Bay (Larned et al. 2006). The Liberty project area is located near the eastern edge of the ACP spectacled eider range. Spectacled eider density ranged from 0.02-0.44 birds/km^2 at locations relatively close to the Liberty project area (Table 2). TERA (2000) reported few spectacled eiders east of the Badami oil field during aerial surveys in 1999.

Table 2. Spectacled eider densities reported at various locations near the proposed Liberty project area.

Location	**Density (birds/km^2)**	**Reference**
Eastern NPR-A	0.02-0.04	Burgess et al. 2003a
Colville River Delta	0.2	Burgess et al. 2003b; Johnson et al. 2003a
Kuparuk Oil field	0.08	Anderson et al. 2003
Milne Point Area	0.22-0.44	TERA 1997
Prudhoe Bay Area	0.18-0.38	TERA 1996
Sagavanirktok River Delta	0.04-0.32	TERA 1996
Kadleroshilik River Area	0.12-0.22	TERA 1995
Shaviovik River Area	0.08-0.14	TERA 1995

In general on the ACP spectacled eiders breed near large shallow productive thaw lakes, often with convoluted shorelines and/or small islands (Larned and Balogh 1997) and nest sites are often located within 1 meter of a lake shore (Johnson et al. 1996). Spectacled eiders on the Colville River delta nested in salt-killed tundra, aquatic sedge with deep polygons, and patterned wet meadow, although only salt killed tundra was preferred based on an analysis of habitat selection (ABR 2002; Johnson et al. 2003a). However, because of the low sample size, the analysis may have lacked the power to determine significant preferences. In the Kuparuk oilfield Anderson et al. (1999) reported that spectacled eider nests were located in basin wetland complexes, a mosaic of water bodies with stands of emergent vegetation and complex shorelines with numerous islands and peninsulas. Spectacled eiders on the ACP nest mainly in areas near the coast rather than at inland locations (Derksen et al. 1981; Burgess et al. 2003b). Of 62 nests reported in the Colville River delta, none were further than 13 km from the coast (Burgess et al. 2003b).

Based on a small sample size of band returns, there is some evidence that spectacled eider males as well as females may exhibit both breeding site and mate fidelity (TERA 1997). Females begin to lay eggs during the second week of June and clutch sizes range from 4 to 9 eggs, although 5 to 6 is more common (Dau 1974). The incubation period is approximately 24 days and males depart the breeding grounds with the onset of incubation. Broods are quite mobile and may move as much as 1 to 3 km from the nest site within the first few days after hatching (TERA 1996). TERA (1996) reported that some broods moved to areas used for feeding by females prior to the onset of incubation. In the Y-K delta, Grand et al. (1994, cited in TERA 1995) reported that 1 spectacled eider brood moved as far as 14 km from the nest site. In most cases brood-rearing apparently does not occur in ponds adjacent to nest sites even if suitable habitat is present (TERA 1995) indicating that not only is the nest site location important, but spectacled eiders may also require a much larger area in the general vicinity of the nest site for brood-rearing. After an initial post-hatch dispersal in the Prudhoe Bay area there was a tendency for broods to settle into a particular area for a time, and then abruptly move to a new area. Juvenile birds in the Y-K delta departed the breeding grounds approximately 59 days after hatch (Flint et al. 2000a).

Post-nesting period

Most males depart the breeding grounds in mid-June after the onset of incubation moving to coastal bays and lagoons to molt and stage for fall migration. Important molting and staging areas include Harrison Bay and Simpson Lagoon, Smith Bay, Peard Bay, Kasegaluk Lagoon, Ledyard Bay, and eastern Norton Sound (LGL 1992; Larned et al. 1995; Springer and Pirtle 1997; Petersen et al. 1999; TERA 1999; Troy 2003). TERA (1999) and Troy (2003) reported that some males may travel overland to the Chukchi Sea, but that some birds also remain about 10 km offshore in Harrison Bay for 7 to 10 days before continuing their fall migration to molting areas such as Ledyard Bay in the Chukchi Sea. Based on satellite telemetry data, males moving overland along the coast directly to the Chukchi Sea departed the breeding grounds earlier than those that lingered in the Beaufort Sea (Troy 2003). However, Petersen et al. (1999) reported that molt and fall migration occurred in offshore waters and found no evidence that spectacled eiders nesting on the ACP migrate over the coastal plain in the fall. Fischer et al. (2002) reported that spectacled eiders were generally uncommon in offshore surveys from Harrison Bay to Brownlow Point with small numbers occurring in July and August in Harrison Bay. During this time, Simpson Lagoon and Harrison Bay may be important staging areas for several weeks (TERA 1999; Petersen et al. 1999).

Successful females and young of the year begin to depart the breeding grounds in late July and movement continues until the end of August. Early departing females may be non-breeders or have had failed nesting attempts. Troy (2003) reported that female spectacled eiders use Beaufort Sea waters from east of the Sagavanirktok River west to Barrow and beyond to the Chukchi Sea. Spectacled eiders have been reported during migration in the offshore waters of the Beaufort Sea near the mouth of the Colville River, Harrison Bay, and Smith Bay, and near the coast in the area northwest of Teshekpuk Lake. Arrival onto molting areas, departure from molting areas to winter areas, and arrival onto wintering areas follow a similar pattern; males are followed by unsuccessful females which are followed by successfully breeding females (Petersen et al. 1999). More female than male spectacled eiders may migrate through the offshore marine waters of the Beaufort Sea because more open water exists in offshore areas when females depart than earlier in the year when males migrate which allows for more extensive use of marine habitats by later migrating birds. TERA (1999) reported that the average distance offshore for migrating males was 10.1 km compared to 21.8 km for migrating females.

Non-breeding season

Most of the spectacled eider world population winters in the Bering Sea south of St. Lawrence Island (Petersen et al. 1999). Based on counts and photography from aerial surveys, this population may number around 360-375,000 (Larned and Tiplady 1999). The birds congregate in this area to forage for invertebrates at depths of 45-70 m in areas of open leads. Petersen et al. (1998) reported that spectacled eider stomach samples from birds collected near St. Lawrence Island included snails, clams, barnacles, amphipods, and crabs. The samples were collected during May-June of 1987 and 1992 and the primary species group consumed was the clam *Macoma* sp. However, Lovvorn et al. (2003) reported that esophagi of spectacled eiders collected on the wintering grounds southwest of St. Lawrence Island contained only clams, mostly *Nuculana*, without a trace of *Macoma*. The difference in diet at the two locations likely reflects differences in prey availability. Global climate regime shifts have the potential to alter prey communities that could impact the spectacled eider population.

Factors affecting population status

The reasons behind declines in spectacled eider breeding populations are unknown. On the ACP, historical data are lacking and the extent of declines there, if any, are difficult to assess. On the Y-K delta, a number of potential factors that may have contributed to the spectacled eider population decline there have been identified but the relative importance of each has not been determined. Possible factors that may affect spectacled eider are discussed below. It is possible that a single factor alone may not be the cause of the spectacled eider population decline, and that the decline may have resulted from a combination of factors.

Lead shot ingestion. Extensive research has been conducted on the effects of ingestion of lead shot by foraging birds and lead poisoning has been confirmed to be a cause of mortality for spectacled eiders on the Y-K delta. The first reports of lead poisoning in spectacled eiders came from 4 birds found dead or moribund on the Yukon Delta National Wildlife Refuge from 1992 to 1994 (Franson et al. 1995). Ingested lead shot was found in the lower esophagus of one bird, and analyses revealed higher than normal lead concentrations in the livers of dead eiders. Subsequent studies examined lead-exposure rates of Y-K delta spectacled eiders (Flint et al. 1997). Ingested lead shot was detected in the gizzards of 11.6% of the birds sampled. During the brood-rearing period, 13.0% of the adult females and 6.6% of the adult males sampled had elevated blood lead levels, and during the brood-rearing period, 35.8% of the adult females and 12.2% of the ducklings had been exposed to lead. Flint and Grand (1997) also reported mortality of female spectacled eiders due to lead poisoning resulting from ingestion of lead shot and speculated that lower adult female survival during the breeding season may be contributing to the overall population decline. Franson et al. (1998) collected 342 blood samples from spectacled eiders in the Y-K delta and reported detectable lead in 58% of the samples. Detectable concentrations of lead occurred more frequently in females than in males upon arrival, and maximum lead concentrations in the blood of females was greater than that of males and ducklings. Grand et al. (1998) reported that female spectacled eiders on the Y-K delta exposed to lead prior to hatching their eggs survived at a much lower rate than females not exposed to lead before hatch. During a study of spectacled eider brood survival in the Y-K delta, Flint et al. (2000a) reported detectable concentrations of lead in 73.7% of the bones of depredated female spectacled eiders and 21.1% of the duckling bone samples. Flint (1998) established experimental plots to determine the settlement rates of lead shot in wetland types commonly used by foraging waterfowl. There was no change in the proportion of lead shot collected in the surface layer of the habitats sampled over a 3 year period suggesting that spent lead shot persists in waterfowl foraging habitat for many years.

Predation pressure. Tundra nesting birds are subjected to predation pressure from arctic (*Alopex lagopus*) and red (*Vulpes vulpes*) foxes, grizzly bears (*Urus arctos*), gulls, jaegers (*Stercorarius* sp.), common ravens (*Corvus corax*), and snowy owls (*Nyctea scandiaca*; Day 1998). Some predators, such as ravens, gulls, arctic fox, and bears may be attracted to areas of human activity where they find anthropogenic sources of food and denning or nesting sites (Eberhardt et al. 1982; Day 1998; Burgess 2000). The availability of anthropogenic food sources associated with villages or North Slope development, particularly during the winter, may increase winter survival of arctic foxes and contribute to increases in the arctic fox population. Anthropogenic sources of food at dumpsters and refuse sites may also help to increase populations of gulls and ravens above natural levels. Major negative impacts have occurred at the Howe Island goose colony in the Sagavanirktok River delta from predation by arctic fox and grizzly bears during some years (Johnson 2000), and arctic foxes and glaucous gulls (*Larus hyperboreus*) are predators of common eider and brant (*Branta bernicla*) eggs and young on the barrier islands (Noel et al. 2002). Increased levels of predation due to elevated numbers of predators could impact nesting and brood-rearing spectacled eiders.

Subsistence hunting. Subsistence harvest of eider eggs and adults occurs in coastal areas during the spring and fall. Subsistence harvest reports with information on spectacled eider harvest are available primarily for the Y-K delta, Bristol Bay, Alaska Peninsula (AMBCC 2006). Few data are available from the North Slope villages however, Braund (1993) reported 155 spectacled eiders taken at Wainwright during 1988-1989, and 2 reported from Barrow.

Contaminants. Exposure to contaminants, including petroleum-related compounds, organochlorinne compounds, and heavy metals, has also been proposed as a possible contributing factor in the decline of the spectacled eider population. Trust et al. (2000)

sampled male spectacled eiders from St. Lawrence Island and reported that a few contained trace concentrations of chlorinated organic compounds. However, levels of copper, cadmium, and selenium were elevated when compared to literature values for other marine birds. Other elements that could potentially impact eiders include mercury and zinc (Stout 1998; Stout et al. 2002). However, the birds sampled by Trust et al. (2000) appeared to be in good health and if the presence of contaminants is a factor involved in the spectacled eider population decline, it may act by reducing fecundity or survival of young rather than via direct health impacts on adults.

Effects of research activities. There has been speculation that researchers conducting studies on avian nest density and success may inadvertently affect the results by attracting predators to nests and broods (Bart 1977; Götmark 1992). Birds that are flushed from their nests during surveys may be more susceptible to nest predation than undisturbed birds. Ongoing activities by researchers could cause some mortality to spectacled eider eggs and chicks. The collection of birds for dietary or contaminant studies obviously impacts small numbers of spectacled eiders. Implantation of satellite transmitters has provided the best information available on spectacled eider movements and locations of molting and winter areas, but the invasive nature of the surgery may impact the survival of a small number of birds.

Other factors. Spectacled eider survival may also be affected by habitat loss and disturbance related to development, disease, parasites, potential changes in availability of prey related to global climate change, and the potential for fishing industry activities to impact benthic feeding areas in molting and/or wintering areas. The overall impact of the individual sources of take and their cumulative effects on spectacled eiders are unknown. Petersen and Douglas (2004) suggested that annual population estimates on the breeding grounds can be negatively affected by extended periods of dense sea-ice concentration and weather on the wintering grounds in the Bering Sea. However, their study did not support the hypothesis that changes in the benthic community in the wintering area had contributed to the decline or inhibited the recovery of the spectacled eider breeding population.

Critical habitat

The USFWS has established spectacled eider critical habitat for molting areas in Ledyard Bay and Norton Sound, for breeding areas in the Y-K Delta, and for wintering areas in the Bering Sea south of St. Lawrence Island (USFWS 2004). No critical habitat for spectacled eiders has been declared on the ACP.

Steller's Eider

Population status

Steller's eiders breed across coastal eastern Siberia and the ACP of Alaska. A smaller population also breeds in western Russia and winters in northern Europe (Fredrichson 2001). Steller's eiders were formerly common breeders in the Y-K delta but numbers there declined drastically and Kertell (1991) reported that Steller's eider was apparently extinct as a breeding species on the Y-K delta. However, Flint and Herzog

(1999) reported single Steller's eiders nests in the Y-K delta in 1994, 1996 and 1997, and 3 nests in 1998. Steller's eiders continue to nest in extremely low numbers in the Y-K delta (MMS 2006). Steller's eider density on the ACP is low and the largest population that may include over 128,000 birds is located in eastern Russia (Hodges and Eldridge 2001). Steller's eider was federally listed as a threatened species in 1997 (62 *FR* 31748-31757) due to a reduction in the number of breeding birds and suspected reduction in the breeding range in Alaska.

The historical range of Steller's eider on Alaska's ACP apparently extended from Wainwright east into the Canadian Northwest Territories (Johnson and Herter 1989, Quakenbush et al. 2002, and references therein). Steller's eiders are currently reported east at least to Prudhoe Bay where it is considered to be rare (TERA 1997) but no recent records have been reported east of the Sagavanirktok River (Quakenbush et al. 2002). Steller's eider has not been recorded nesting east of Cape Halkett other than one recent record inland near the Colville River (Quakenbush et al. 2002). Aerial surveys conducted by USFWS indicate that Steller's eiders are widely distributed across the ACP in low densities (0.01 birds/km^2 in 2006, Larned et al. in 2006) from Point Lay to the Sagavanirktok River with very few sightings east of the Colville River. The highest concentrations occur near Barrow (Quakenbush et al; 1995, 2002; Ritchie et al. 2006) although breeding there does not occur every year and may be related to predator/prey cycles (Quakenbush and Suydam 1999). During the 1990s, Steller's eider breeding at Barrow coincided with highs in the lemming population.

Mallek et al. (2006) reported lower than average population indices for Steller's eiders on the North Slope for the period 2000-2005 when the indices ranged from 0 to 563 birds. The long-term average for the index had been 968 birds for the period 1986-2001 (Mallek et al. 2003). However, Larned et al. (2006) reported an increasing growth rate for Steller's eiders during eider breeding pair surveys on the North Slope during the last 7 years (2000-2006). Differences in the two trends may be related to survey timing and variability within the surveys is high. However, based on comparisons of historical and recent data, Quakenbush et al. (2002) suggested that a reduction in both occurrence and breeding frequency of Steller's eiders had occurred on the ACP with the exception of the Barrow area. Larned (2005) also reported a declining trend during annual spring surveys for Steller's eiders in the Bristol Bay area.

Spring migration

In the spring the majority of the world population migrates along the Bristol Bay coast of the Alaska Peninsula, crosses Bristol Bay toward Cape Pierce, and continues northward along the Bering Sea coast (Larned 2005). Most of these birds migrate to breeding grounds in Siberia with small numbers moving to the Arctic Coastal Plain of Alaska. Small numbers of Steller's eiders may also breed in the Y-K delta.

Nesting

Steller's eiders arrive on the ACP in early June and evidence from the Barrow area suggests that nesting effort may vary from year to year (Quakenbush and Suydam 1999). At Barrow, Steller's eiders apparently nest during high lemming years when predators, such as snowy owl and pomarine jaeger (*Stercorarius pomarinus*) that feed on lemmings, are also nesting. Steller's eiders, as well as snowy owls and pomarine jaegers, may not nest at all during low lemming years. This cycle has been consistent since the initiation of intensive studies of Steller's eider nesting biology in the Barrow area in 1991 and has continued through 2006 (Quakenbush et al. 1995; Obritschkewitsch et al. 2001; Obritschkewitsch and Martin 2002 a, b; Rojek and Martin 2003; Rojek 2007). Theoretically, an ample supply of lemmings may divert potential predators away from eider eggs and chicks thus making it more advantageous for eiders to nest during years of high lemming populations. Some evidence also suggests that Steller's eiders may benefit by nesting close to nests of avian predators such as jaegers and snowy owls. These aggressive birds defend their own nests against other predators, and eider nests located nearby may benefit when potential predators are driven from the area. Other variables, such as weather and snow conditions did not explain the inter-annual variability of eider nesting. Although intensive studies of Steller's eider breeding biology have been conducted in the Barrow area, little information is available for other portions of the ACP where most information consists of scattered sightings during aerial surveys.

Steller's eiders nests are located on tundra habitats often associated with polygonal ground both near the coast and at inland locations. Emergent *Carex* and *Arctophila* provide import areas for feeding and cover. Males may remain on the breeding grounds for two weeks after the onset of the 24 day incubation period (Fredrichsen 2001). Clutch size ranges from 3 to 8, but averages 5 to 6 eggs. Nest success is variable and ranged from approximately 14 to 71% at Barrow in the 1990s (Quakenbush and Suydam 1999). Nest predators include jaegers, common ravens, glaucous gulls, and arctic foxes. Avian predators including snowy owls, and peregrine and gyrfalcons, have been the predominant natural cause of adult Steller's eider mortality. Steller's eider broods apparently are less mobile than those of spectacled eiders and remain in ponds with emergent *Carex* and *Arctophila* within a few hundred meters of the nest site.

Post-nesting period

Male departure from the breeding grounds begins in late June or early July. Most of the available information on migration comes from Barrow where birds disperse across the area from Admiralty Inlet to Wainwright and enter marine waters during the first week of July. They make use of coastal areas along the Chukchi Sea coast from Barrow to Cape Lisburne, and also use bays and lagoons of Chukotka (USDOI/BLM 2003). Females that fail in breeding attempts may remain in the Barrow area into late summer (USDOI/BLM 2003). Females and fledged young depart the breeding grounds in early to mid-September. Male and non- or failed breeding Steller's eiders concentrate in several lagoons on the Alaska Peninsula in August and September to molt (Flint et al. 2000b).

Non-breeding season

Steller's eiders spend most of the year in shallow marine habitats along the Alaska Peninsula and the eastern Aleutian Islands to lower Cook Inlet with stragglers south to British Columbia. In Eurasia they winter from Scandinavia and northern Siberia south to the Baltic Sea, southern Kamchatka, and the Commander and Kurile islands (Johnson and Herter 1989).

Factors affecting population status

Causes for the decline of the Steller's eider population in Alaska are unknown but may include increased predation pressure on the North Slope and Y-K delta breeding grounds, subsistence harvest, ingestion of lead shot, and contaminants (Henry et al. 1995). Bustnes and Systad (2001) also suggested that Steller's eiders may have specialized feeding behavior that may limit the availability of winter foraging habitat. Steller's eiders could be affected by global climate regime shifts that cause changes in prey communities.

Critical habitat

The USFWS has established Steller's eider critical habitat in the Y-K Delta nesting area, the Kuskokwim Shoals, and at the Seal Island, Nelson Lagoon, and Izembek Lagoon units on the Alaska Peninsula (USFWS 2004). No Steller's eider critical habitat has been established on the ACP.

4. AVENUES OF TAKE FOR LISTED EIDER SPECIES RESULTING FROM ACTIVITIES IN THE LIBERTY PROJECT AREA

Development activities on the North Slope have the potential to impact bird species in both positive and negative ways. Various types of development activities are discussed below in terms of their potential to impact spectacled and Steller's eiders. The focus of the discussion below is oriented toward spectacled eider which occurs regularly in low densities within the project area. Steller's eider is a rare species within the project area that is likely to occur only sporadically.

Habitat Loss

Habitat loss for tundra nesting birds during oil field development on the North Slope has resulted primarily from the placement of gravel during construction of infrastructure and from gravel mining. Tundra covered by gravel fill during the construction of roads and pads is lost as nesting habitat for tundra birds, and gravel mine sites that were once covered by tundra cannot be used for nesting by most bird species. Loss of nesting habitat through gravel placement and mining is permanent unless these areas are rehabilitated after abandonment of the field.

Gravel placement

After examining several onshore and offshore options for development of the Liberty reservoir, BP determined that the most practical development option would be to use extended-reach drilling from SDI to access the offshore reservoir. This option will require expansion of the existing pad at SDI from ~11 acres to 31 acres (working surface) which will require ~860,000 yd^3 of gravel fill. Gravel placement during the expansion of SDI will be confined to the waters surrounding SDI and will not impact tundra habitats. The placement of gravel for expansion should not have any impact on spectacled eider nesting habitat.

For the current construction option which calls for the use of sheet piling during the SDI expansion process, the footprint of the SDI expansion on the seabed will increase from ~20 acres to 40 acres. The SDI extension will be located in ~4-11 ft of water and could result in the loss of ~20 acres of potential feeding habitat for eiders or other diving waterfowl species. The abundance of mollusks and other invertebrates in this area that may be utilized as a food source by eiders is unknown. Due to the low densities of spectacled eiders in the general area, it is unlikely that many eiders would be impacted by this loss of feeding habitat. Due to their low density in the project area, few spectacled eiders would likely be affected by loss of feeding habitat. Eiders that may have used this area for feeding would be able to move to adjacent habitats.

Gravel mining

Gravel mining would have the potential to result in the loss of spectacled eider nesting habitat. BPXA has selected a site adjacent to the existing Duck Island Mine Site along the Endicott road (Fig. 3) as a gravel source for the Liberty project. Small numbers of spectacled eiders may nest in wetlands near this proposed gravel mine site. The site is located in the Sagavanirktok River delta along the Endicott road near locations where spectacled eiders have been reported during aerial surveys (TERA 1996). TERA (1996) reported spectacled eider density in this area ranging between 0.04 and 0.32 eiders/km^2. Larned et al. (2006) reported spectacled eider densities ranging from 0.01 to 0.61 birds/ km^2 in the same general area.

The proposed gravel mine site is located in upland habitats that are suitable for gravel mining and do not attract spectacled eiders. The proposed boundary area of the gravel mine site covers approximately 63 acres including the excavation area (18 acres), a viable soil overburden stockpile (3 acres), a non-viable overburden stockpile (8 acres), a safety berm (3 acres), and access roads (2 acres). Prior to development, a vegetation map will be prepared for the mine site and the site will be surveyed to determine its suitability as spectacled eider habitat. Based on the greater density of 0.6 birds/ km^2 reported by Larned et al. (2006), habitat for ~0.15 spectacled eiders would potentially be eliminated by the development of the 63 acres proposed for the gravel mine site. This figure assumes that the habitat value of the proposed mine site for spectacled eiders is the same as that of the general area. However, spectacled eiders are probably more likely to use wetland habitats associated with lakes or ponds than the upland habitat found at the mine site, and the number of eiders potentially affected by the mine site development will likely be reduced compared to the calculated figure based on eider density in the general area.

Damage to tundra from winter activities

In addition to permanent habitat loss associated with gravel placement and mining, temporary loss of habitat associated with gravel placement can occur on tundra adjacent to gravel structures. Accumulated snow from plowing activities or snow drifts can become compacted and cause delayed snow melt. Dust deposition can result in early green-up on tundra adjacent to roads and pads (Walker and Everett 1987; Auerbach et al. 1997). Rolligons and track vehicles used during seismic exploration leave tracks on tundra habitats that can affect vegetation, soil chemistry, soil invertebrates, soil thaw characteristics, and small-scale hydrologic changes (Kevan et al. 1995). For the Liberty Development Project, no new gravel roads will be constructed and the SDI pad expansion will be surrounded by water rather than tundra. Development-related impacts to tundra such as snow compaction will not be likely to affect tundra habitats beyond current levels. No land-based seismic activities are planned for the Liberty project and there will be no impacts to tundra habitats associated seismic activities.

Winter ice roads constructed for hauling gravel from the chosen mine site to SDI could cause compaction of vegetation (Walker 1996), which could temporarily affect the availability of cover for nesting eiders in the ice road footprint. BPXA is evaluating ice-road routes for the gravel haul along a channel of the Sagavanirtok River which would avoid traversing much of the tundra. Tundra affected by ice-road construction would likely recover within one to two years and any potential habitat alteration resulting from ice-road construction and use would be temporary.

Withdrawal of fresh water from lakes and ponds

Ice roads will be required to transport gravel from the chosen mine site to SDI. Construction of ice-roads involves water withdrawal from deep lakes in the areas adjacent to road locations. Bergman et al. (1977) reported that spectacled eiders at Point Storkerson used deep *Arctophila* lakes during pre-nesting, nesting, and post-nesting periods, and Derksen et al. (1981) reported that some spectacled eider brood-rearing occurred on deep open and deep *Arctophila* lakes in the NPR-A. Spectacled eider nests are often located within several feet of lake shorelines, and water withdrawal from lakes during ice-road construction that lowered the level of lakes could have the potential to affect spectacled eider nesting habitat. Changes in the surface levels of lakes as a result of water withdrawal would be dependent on the amount of water withdrawn, the size of the lake, and the recharge rate. The State of Alaska places restrictions on the amount of water that may be withdrawn from individual lakes and lakes must be permitted before being used as water-sources. Lake studies would be conducted prior to water withdrawal for ice road construction for any lakes that had not already been permitted as water sources. Most lakes would likely return to pre-withdrawal levels during spring flooding (Rovansek et al. 1996).

During winter water withdrawal operations, care should be taken to minimize or eliminate water withdrawal from deep open and deep *Arctophila* lakes that may be used by spectacled or Steller's eiders if other sources are available. Aerial and/or ground-based surveys of potential water withdrawal lakes conducted during the summer breeding and post-breeding season could identify lakes used by threatened eiders, and help to determine which lakes would be most suitable for water withdrawal activities to minimize potential impacts on threatened eiders. The existing Duck Island mine site located near the proposed mine sites contains fresh water and BPXA proposes to use this water for most of the onshore portion of the gravel-haul ice road. This should minimize water extraction from naturally occurring lakes as a water source during ice-road construction. However, water usage at all source lakes will be regulated by State issued Temporary Water Use Permits.

Disruption/alteration of hydrology

Impoundments created by gravel structures could cause temporary or permanent flooding on adjacent tundra. Impoundments could be ephemeral and dry up early during the summer, or they could become permanent water bodies that persist from year to year (Walker et al. 1987; Walker 1996). Tundra covered by impounded water may be lost as nesting habitat for some birds. However, impoundments could also create new feeding and brood-rearing habitat that would be beneficial to some bird species (Kertell 1993a,b; Noel et al. 1994). For the Liberty Project, no new roads or pads except a short access road to the mine site will be constructed on tundra habitats and the potential positive or negative effects of impoundments on spectacled eiders will not be relevant.

Disturbance

Activities that are typically related to oil development and production, such as vehicle, aircraft, pedestrian and boat traffic, routine maintenance activities, heavy equipment use, and oil-spill clean-up activities, could cause disturbances that adversely affect threatened eiders. These disturbances could result in decreased nest attendance or nest abandonment, and increased energy expenditures that could affect the physiological condition of birds and their rate of survival or reproduction. BPXA intends to use extended-reach drilling techniques from an existing pad to access the Liberty oil reservoir and some of the oilfield activities that typically are sources of disturbance for eiders or other tundra nesting birds will not be implemented for the Liberty project. The various sources of disturbance related to oil field development and their relevance to the Liberty project are discussed below.

Construction period (pads, pipelines and the Sag River Bridge)

Installation of pipelines and gravel placement for typical oil field infrastructure (e.g., roads, airstrips, and pads associated with wells, camps, staging areas, and processing facilities) has the potential to cause disturbance to eiders. No new roads or airstrips are proposed for the Liberty project. However, BPXA proposes to expand the existing SDI pad. Gravel placement during expansion of the SDI pad will occur during the winter months when eiders are on wintering grounds and construction activities at the gravel mine site and transport and placement of gravel at SDI would not have any disturbance effects on eiders.

At present the SDI design is based on sheet pile slope protection. The project schedule calls for installation of the sheet piles during winter of 2009. Installation of sheet piles will likely require the use of a vibratory and an impact pile driver. Eiders are absent from the North Slope during the winter months, therefore this activity will not have any effect on the birds.

No new pipelines will be constructed on tundra habitats however two new pipelines ~3 mi in length (a water injection pipeline and a high pressure gas pipeline) will be constructed along the Endicott causeway adjacent to existing pipelines from SDI to the Endicott processing facility. These pipelines will be elevated on industry standard vertical support members (VSMs) along the causeway at the same elevation as the existing adjacent pipelines. These pipelines are scheduled to be installed during winter of 2012 although there will be no seasonal constraints on pipeline construction. Winter construction of the pipelines would not cause any disturbance or other impacts to spectacled eiders.

BPXA is evaluating whether to upgrade the West Sag River Bridge or to construct a new bridge with up to two lanes upstream of the existing bridge. The bridge work will be done to accommodate increased traffic and vehicular loads. These winter construction activities would not cause disturbances that would impact spectacled eiders.

Pad activity

Various types of disturbances that are associated with oil and gas operations, such as vehicular traffic, machinery, facility noise, and pedestrian traffic may occur on the SDI pad during the construction period and after construction during the production phase of the project. Disturbance from facility noise and activity could affect activity and energy budgets of spectacled eiders.

Few studies have documented responses of spectacled eiders to oil field disturbances. Anderson et al. (1992) reported that during the nesting period, spectacled eiders near the GHX-1 facility in the Prudhoe Bay area appeared to adjust their use of the area to locations further from the facility in response to noise. TERA (1996) reported no conspicuous avoidance of facilities in the Prudhoe Bay oil field by brood-rearing spectacled eiders. Brood movement was extensive during the first few days after hatching, and broods often spent a portion of their time within 200 meters of facilities, including high-noise areas such as gathering centers and the Deadhorse airport. Spectacled eiders may be able to acclimate to periodic but regularly occurring disturbances related to oil field activities on roads and pads. A potentially more serious situation could develop if spectacled eiders nested near pads where little or no activity occurred early during the nesting period, but activity later in the summer causes nest failure or abandonment by eiders that had not become acclimated to oil field activities.

Some evidence suggests that pedestrian traffic may have a greater negative impact than vehicular traffic on some birds. Pedestrian traffic is likely to occur on well pads during well maintenance activities. During a study of the effects of disturbance related to the Lisburne Development in the Prudhoe Bay oil field, Murphy and Anderson (1993) reported that of the more common sources of disturbance, humans on foot elicited the strongest reactions from geese and swans. Ritchie (1987) reported that pedestrians caused greater disturbance to nesting raptors than other sources of disturbance.

Disturbances from oil field activities on the SDI pad would not affect nesting spectacled eiders because SDI is surrounded by water and removed from tundra nesting habitat. Spectacled eiders using the SDI shore for resting or nearby marine habitats for feeding would likely become acclimated to pad activities or move to adjacent habitats. Due to the low density of spectacled eiders in the general area of the SDI pad, the number of spectacled eiders likely to be affected by pad activities is low.

Aircraft

Disturbance from aircraft activity in support of oil field development and operation has the potential to impact birds by causing nest abandonment, or by disrupting normal activities that affect energy budgets (Ward and Stehn 1989; Derksen et al. 1992). After expansion of the SDI pad is completed, most drill rig and facility construction, maintenance, and operational activities will be supported using existing infrastructure along the Endicott Road system. Construction of new airstrips will not be required for support of the Liberty project and there will be no increase in aircraft traffic in the vicinity of the Liberty Development in support of construction, maintenance, and operation. There should not be any impacts to threatened eiders from aircraft traffic related to support for development of the Liberty project.

Year-round helicopter access to the Liberty project area is not planned, although there will be sufficient area for helicopter landings. In general, helicopter access to the Liberty Development will be used only for emergency evacuation of personnel. Helicopters will avoid direct overflights of Howe Island during the snow goose nesting and brood-rearing period. In addition, helicopters will fly at an altitude of at least 1500 ft except during landings and take-offs consistent with safe operation.

Like aircraft activity in support of oil field development, aircraft activity in support of research activities also has the potential to disturb spectacled eiders and other waterfowl. Aerial surveys using fixed-wing or helicopter aircraft are frequently used in support of wildlife monitoring studies. These studies sometimes result from development stipulations and may be required prior to or during development scenarios. No specific aerial surveys are expected to be required in support of the Liberty Development Project and there should be no impacts to threatened eiders related to aerial survey activity for research or monitoring purposes beyond those existing from current survey activity.

Roads

Spectacled eiders could be subjected to disturbances related to vehicular and pedestrian traffic and noise from equipment on roads. Increased vehicular traffic in support of the Liberty project, including large trucks hauling cranes and other equipment and road maintenance equipment could impact threatened eiders along the Endicott Road during summer activities. In the North Slope oilfields, these types of disturbances have been documented for brant, and Canada and white-fronted geese, and have been shown to have greater effects on geese feeding close to roads than on geese feeding further away (Murphy et al. 1988; Murphy and Anderson 1993). Disturbances occur most often during the pre-nesting period when these birds gather to feed in open areas near roads, and during brood-rearing and fall staging when some geese exhibit higher rates of disturbance (e.g., “heads up” behavior) in areas near roads than do birds in undisturbed areas. A small percentage of birds may walk, run, or fly to avoid vehicular disturbances (Murphy and Anderson 1993). Disturbance occurs most often within 50 meters of roads. However, some disturbance has been reported for birds as far as 150 to 210 meters from roads (Murphy and Anderson 1993).

The effects of disturbance to threatened eiders near roads would likely differ depending on the reproductive stage. Anderson et al. (2003) reported that pre-nesting pairs of spectacled eiders in the Kuparuk oil field were located nearer to roads than nesting females. However, both Anderson et al. (2003) and TERA (1996) reported locations of spectacled eider nests that were within a few hundred meters of oil field facilities. Anderson et al. (2003) also reported that there was no significant difference in the distance of failed vs. successful spectacled eider nests from oil field facilities.

There has been concern that the presence of gravel roads which are elevated structures 1 to 2 m above the tundra, may obstruct the movements of spectacled eiders. Gravel roads and pads could present some temporary obstructions during brood-rearing and molting periods when birds are flightless, particularly if traffic levels are high (Murphy and Anderson 1993). However, TERA (1996) reported that spectacled eider broods moved extensively averaging 0.53 km per day during the first week after hatch and that some of the longest movements occurred during the first day or two after hatch. Spectacled eider broods did not avoid facilities, and broods were known to cross roads repeatedly (TERA 1996).

No new roads would be constructed for the Liberty Development and there would be no increase in the physical presence of roads to obstruct the movements of spectacled eiders. Increased traffic on the road system between Deadhorse and SDI during summer construction and in support of drilling activities could increase the potential for obstruction of eider movements. Obstruction of movement may be most significant for eider broods which are flightless are known to walk across oil field roads. Reducing speed limits on oil field roads may help to reduce potential impacts to eider movement.

Watercraft based support

Barge traffic associated with the transportation of equipment during the construction period for the Liberty project could occur during the open-water season from mid-July to early October. A ***LoSal***™ enhanced oil recovery process plant and supporting facility are scheduled for fabrication during 2011 and 2012 and will be sealifted to the Endicott MPI. Barge routes may pass through shallow, nearshore habitats of the Beaufort Sea that are known to be used by spectacled eiders (TERA 1999; Fischer et al. 2002; Troy 2003). Failed nesting females and females with young would be the spectacled eider groups most likely to encounter vessel traffic. Most males would have departed the area by late June or early July before the onset of vessel traffic. Spectacled eiders are uncommon in the offshore waters of the Beaufort Sea but Fischer et al. (2002) reported that when spectacled eiders were sighted they occurred in relatively large flocks. The mean spectacled eider flock size during surveys in 1999 and 2000 was 21.1 eiders. Small numbers of Steller’s eiders could also occur in this area. Vessel traffic could cause temporary disturbance to feeding eiders if barges were to pass through eider feeding habitat. The disturbance would be short-term, and eiders would be able to swim or fly to avoid oncoming vessel traffic. The low number of barges involved would also minimize disturbance to eiders. Due to the low density of spectacled and Steller’s eiders in the offshore waters of the Beaufort Sea, barges would be likely to cause minimal disturbances to eiders.

Oil spill response training activities for the Liberty project using small boats will likely be conducted in the vicinity of SDI and the Endicott facilities. These activities would have the potential to disturb foraging or brood-rearing eiders in marine habitats adjacent to the Endicott causeway and SDI. We know of no studies that have addressed the potential impacts of boat disturbance on spectacled eiders, but boat activity can cause alerted postures, disruption of feeding behavior, and flight in other waterfowl, shorebirds, and raptors (Burger 1986; Belanger and Bedard 1989; Steidl and Anthony 2000). Rodgers and Smith (1995) and Rodgers and Schwikert (2001) determined set-back distances for boat activity for various bird groups to minimize the potential for boat disturbance, ranging from 100 meters for shorebirds to 180 meters for wading birds. Due to the small number of spectacled eiders expected to occur in the area where oil spill response training activities will occur, few eiders are likely to be affected.

Pipeline maintenance

The only new pipelines to be constructed for the Liberty development are a high pressure gas line and a water injection pipeline which will be located along the Endicott causeway between SDI and the Endicott production facility. The pipelines will be accessed and maintained from the causeway road and maintenance activities will not cause disturbance to eiders or other waterfowl on tundra habitats. If routine maintenance activities are required, spectacled eiders that may be using the causeway shore or adjacent marine habitats may be temporarily disturbed. Due to the small number of spectacled eiders expected to occur in the area, few spectacled eiders are likely to be affected. Spectacled eiders or other waterfowl that are disturbed by routine maintenance activities would likely move to adjacent habitats.

Tower maintenance

There has been concern that construction of towers for powerlines or cellular telephone towers associated with oil field development may negatively impact threatened eiders and other tundra nesting birds. Summer maintenance activities at powerline or cellular telephone towers could cause disturbances that impact nesting or brood-rearing eiders. No new powerlines or communication towers will be associated with the Liberty project and there should be no impacts to spectacled eiders related to powerlines or cellular telephone towers.

Gravel mining/transport

Gravel mining and transport during expansion of the expanded SDI pad would occur during the winter when threatened eiders are on wintering grounds. Gravel mining and transport would not cause disturbances that affect spectacled eiders.

Oil spill response activity

Should an oil spill occur, oil spill response and clean-up activities would be immediate and could not be planned to avoid disturbance to eiders. Clean-up activities would involve the use of vehicles, equipment, and ground personnel, and the disturbance effects of clean-up activities would be similar to those described for other activities associated with gravel roads and pads. Depending on the location and activity of eiders in relation to the spill, eider response could include anything from alert responses to abandonment of the area. Disturbance during oil spill response activities that caused spectacled eiders or other waterfowl to abandon the immediate area of the spill could help to reduce impacts of the spill on birds in the affected area. Although common and king eiders, long-tailed ducks, scoters, other waterfowl, and loons can sometimes be abundant in the marine habitats adjacent to the Endicott causeway, few spectacled eiders are likely to occur in this area. Impacts from disturbance related to oil spill response activities would depend on the timing, size and location of the spill which would affect the equipment used and the level of the response effort.

Collisions (Strikes)

Numerous authors have reported on bird mortality due to collisions with various types of man-made structures including powerlines, wind turbines, towers and associated guy wires, lighthouses, vessels, and buildings (e.g., Crawford 1981; Verheijen 1981; Day et al. 2002; Wiese et al. 2005). Day et al. (2005) reported collisions of 36 eiders (all common or king eiders) with facilities at Northstar Island or Endicott over a 4-year period. Gas flares and lights on some offshore oil platforms have also been reported to attract seabirds and passerines that sometimes result in bird mortality due to collision or incineration (Jones 1980; Wallis 1981; Wiese et al. 2005).

Structures and equipment associated with oil development and production for the Liberty project that could represent potential collision hazards to spectacled eiders include the drill rig, production and support facilities, pipelines, vehicles (trucks, heavy equipment), barges and other vessels, and bridges. TERA (1999) suggested that most spectacled eiders probably arrive on the breeding grounds using overland routes across the ACP. Good visibility associated with extended day length during the summer breeding season would minimize the potential for eider mortality due to collisions with any of these structures.

After arrival onto the breeding grounds most spectacled eiders remain primarily on tundra habitats. The greatest potential for eider collisions would occur during periods of reduced visibility such as rain or foggy conditions during fall migration. At this time flocks of low-flying eiders migrating during periods of darkness could be particularly susceptible to mortality due to collisions with man-made structures. However, based on relatively small number of spectacled eiders with satellite transmitters, TERA (1999) suggested that male and female spectacled eiders average 10 and 20 km, respectively, offshore during fall migration. If this is the case most spectacled eiders would be migrating well offshore of the Liberty facilities thus reducing the potential of collision with Liberty structures.

Drill rig

Quakenbush and Snyder-Conn (1993) reported that a Steller’s eider was apparently killed by collision with a tower near Nanvak Bay. Day et al. (2002) concluded that the probability of collisions of migrating eiders with existing structures at Barrow was low, but this finding was influenced by the offshore route followed by most eiders during fall migration. The drill rig that will be used for Liberty will be larger than any other drill rig on the North Slope and will likely be one of the largest (if not the largest) drill rigs in the world. The base of the eastern side of the drill rig will be ~350 ft wide by ~44 ft high, and the top of the derrick will be ~230 ft above ground level (vs. 170-205 feet for other North Slope Drill rigs) (Figure 6). A trunk ~250 ft long by 29 ft high will extend north from the drilling rig toward the existing well house.

Day et al. (2005) reported that the mean elevation of migrating eiders (predominantly common and king eiders) near Northstar Island was 6 m above ground or sea level and ranged from 1-50 m. Although most eider flight paths near the drill rig at SDI would likely be near the pad and the lower portions of the drill rig, some eiders could fly in the vicinity of the upper portion of the rig and the tower. Eiders could collide with any portion of the drill rig. Collisions would be most likely to occur during fall for eiders migrating near shore, and during periods of poor visibility such as under foggy conditions and at night. Due to the low densities of spectacled and Steller's eiders in the project area, few threatened eiders would likely collide with the drill rig.

Production/support facilities

Surface facilities that will be located on SDI include a pipe rack and well tie-in piping, fuel-gas conditioning skid, booster pumps for high-salinity water injection, electrical transformer and switchgear, control room, transformer module for the electrical submersible pump, ***LoSal***™ pipeline pig launcher, and ***LoSal***™ EOR process injection pumps. Excluding the drill rig, these facilities relatively small in size compared to existing facilities on MPI. Threatened eiders would have the potential to collide with these production and support facilities. Human activity in the vicinity of facilities such as vehicle and pedestrian traffic could help to deter eiders from using habitats near this area. Due to the low density of threatened eiders in the project area, few spectacled or Steller's eiders would be likely to collide with production and support facilities. The potential for eider collisions with proposed facilities on SDI is likely reduced compared to that which may have resulted from the offshore development for the Liberty project as proposed in the 2002 FEIS (USDOI/MMS 2002).

Two new pipelines will be constructed from the SDI facilities for approximately 3 miles to the Endicott MPI facilities. One pipeline will be used to transport water for injection, and the other will be a high pressure gas line. The pipelines will be installed parallel to and west of the existing lines on the Endicott Road at the same elevation as the existing adjacent pipelines. Large pipelines such as those proposed for the Liberty Development Project are generally visible to waterfowl in flight. Eider collisions with elevated pipelines are probably infrequent but may be more likely to occur during periods of poor visibility such as at night or under foggy conditions. Since the proposed pipelines for the Liberty project will be constructed adjacent to the existing pipelines, the likelihood for eider collisions with the Liberty pipelines is probably no greater than the potential for collision with existing pipelines.

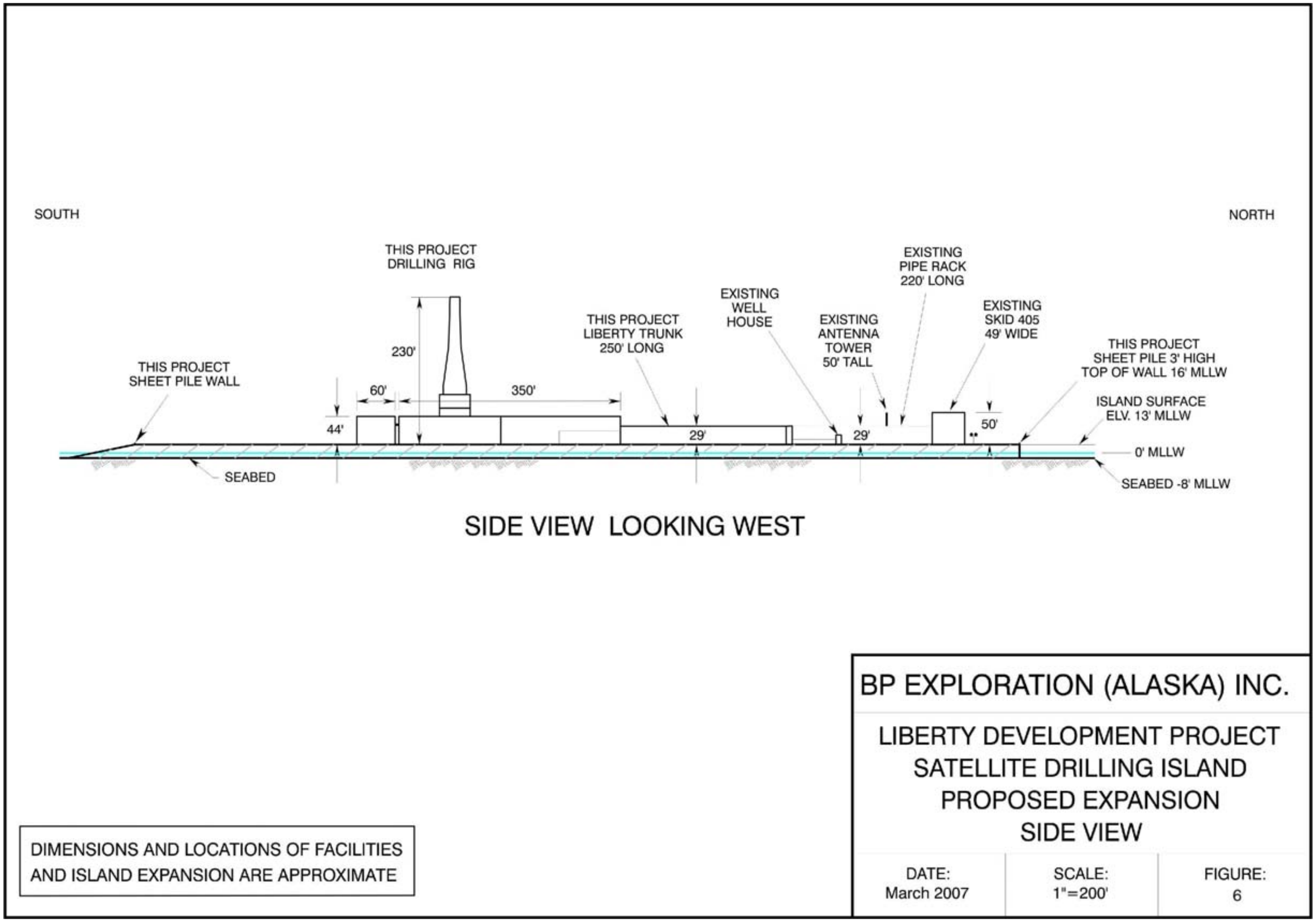

Figure 6. Configuration and dimensions of proposed Liberty project drill rig and facilities on SDI as viewed from the east.

Vehicles and equipment

Mortality to threatened eiders could result from collisions with vehicular traffic or equipment transiting the road system. This was the greatest source of bird mortality associated with the Trans Alaska Pipeline System, particularly along the Dalton Highway where dust shadows caused early green-up along the road that attracted birds (TAPSO 2001). The primary groups affected were grouse and passerines. Although the number of birds killed was not quantified, the level of mortality was probably low when compared to local populations. Dust deposition on tundra adjacent to gravel roads on the North Slope oil fields can cause early snow melt resulting in a snow-free band within 30 to 100 m of the road in early spring (Walker and Everett 1987). Waterfowl on the North Slope oil fields are known to congregate in these areas.

Levels of traffic (including vehicular traffic and machinery) are expected to be elevated during development of the Liberty project compared to that which has occurred in recent years. Since SDI is part of the existing oil field and connected to other oil field facilities and to Deadhorse by the road system, higher traffic levels are expected both during the winter and summer construction activities. Vehicular traffic during winter construction activities when eiders are not present on the North Slope would have no potential to result in collisions with eiders. Eiders could be susceptible to collisions with vehicles during the summer months, particularly during the early spring, if tundra habitats adjacent to roads become open earlier than habitats away from roads. Brood-rearing eiders with flightless young are known to cross North Slope oil field roads and could also be susceptible to vehicle collisions. Reduced speed limits along roads, particularly early in the season when eiders could be attracted to areas of early green-up near roads and pads, during periods of poor visibility, and during brood-rearing periods when flightless birds could cross gravel roads, would help to reduce the potential for eider collisions with vehicles.

Marine vessels

Since the SDI site is accessible by road there will be little need for marine traffic during development of the Liberty project. However, a sealift is scheduled for summer 2012 to transport the ***LoSal***™ process and power generation modules to the MPI dock. The sealift will transit the Chukchi and Beaufort seas where it may encounter spectacled eiders using open-water habitats after the breeding season. The sealift will avoid the critical habitat for spectacled eiders in Ledyard Bay.

There are few reports of collisions of eiders with marine vessel traffic. Lovvorn et al. (2003) salvaged 3 spectacled eiders that collided with a ship during predawn hours in the Bering Sea. Spectacled or Steller's eiders staging in the Beaufort and Chukchi seas along the route of the proposed sealift could potentially collide with vessel traffic during mid-July to September. Inexperienced young-of-the-year, which may be at higher risk for collisions with vessels, may occupy these marine habitats during August and September. However, good visibility associated with the long hours of daylight during much of this period could reduce the potential for eider collisions with vessel traffic. In addition, the number of barges transiting these offshore waters would be low.

West Sag River Bridge

BPXA plans an upgrade or construct a new bridge across the west channel of the Sagavanirktok River to accommodate increased traffic and vehicular loads. Threatened eiders and other waterfowl would have the potential to collide with the new or upgraded structure however the risk of collision would likely not be greater than any existing collision risk. Due to the low density of threatened eiders in the project area few spectacled or Steller's eiders would be likely to collide with the new or upgraded West Sag River Bridge.

Powerlines and communication towers

Some bird species have been victims of collisions with elevated power and communication lines or communication towers. Quakenbush and Snyder-Conn (1993) reported that a Steller's eider was apparently killed by collision with a tower near Nanvak Bay, and local residents on St. Lawrence Island have reported eider collisions with wires associated with the FAA tower (Day et al. 2003). Anderson and Murphy (1988) reported locating the remains of 15 and 16 birds in 1986 and 1987, respectively that had been killed as a result of collisions with the Lisburne Development powerline in the Prudhoe Bay area. None of the birds was identified as spectacled or Steller's eiders, although one unidentified eider was reported along with several other waterfowl species. No elevated power or communication lines, or communication towers will be constructed in support of the Liberty Development. There will be no additional risk to threatened eiders in relation to potential collisions with power or communication lines or towers.

Effects of light on bird movements

Numerous studies have attempted to determine how environmental and anthropogenic factors affect bird collisions with various types of structures. Lighting sources have been suggested as a possible mitigation tool to help reduce the risk of bird collisions with man-made structures, although there are a number of studies or observations of birds being attracted to lighting on various types of structures (e.g., Cochran 1958; Verheijen 1981; Jehl 1993). Birds are often attracted to lights and may collide with lighted man-made structures if they are blinded by the light and lose their ability to navigate. Strobe lights may affect birds differently than continuous light, and some evidence suggests that red lights may be more attractive to night-migrating birds than white lights.

Recently, Day et al. (2005) conducted a 4-yr radar and visual-based study of eiders and other waterfowl migrating in the fall past Northstar Island, located approximately 35 km northeast of SDI. Most of the birds recorded as eiders were likely common or king eiders although small numbers of spectacled, and possibly Steller's, eiders could have been in the area. Fourteen white strobe lights were mounted at ~14 m elevation on structures around the perimeter of the island to provide a visual deterrent to migrating birds during the fall. The lights were set to operate at a flash rate of 40/min and to fire asynchronously both with adjacent lights and with lights on other sides of the island. Visual and radar-based observations were made with the lighting system "on" and "off" to determine what effect the system might have on migrating eiders and other waterfowl.

Overall results of the Day et al. (2005) experiment were not conclusive however, eider flight velocity was significantly reduced during periods when the lights were on, which would allow eiders a better opportunity to avoid collisions with structures as they approached the island. The lighting system also appeared to result in a spatial redistribution of eiders away from the island during periods when sea ice was present around the island. However, the avoidance response was small and the lights explained only ~4% of the variation suggesting that other factors had a greater effect on the spatial distribution of migrating eiders than did the lighting. However, there appeared to be a weak attracting of non-eiders species toward the island during periods when the lights were on. It is noteworthy that a gas flaring event appeared to attract long-tailed ducks and glaucous gulls to the island resulting in some near collisions.

Day et al. (2005) reported information on 36 downed eiders (20 from Northstar Island and 16 from Endicott) that were discovered during the fall migration 2001-2004. There appeared to be a tendency for eiders to be downed during periods of a full or waxing moon, and during nights with a weakly changing barometer. All eiders about which information was available were downed on nights with foggy conditions. The sample size of downed eiders was small and no information appeared to be available to compare the numbers of collisions during period with the lights on vs. off.

The results of the Northstar study by Day et al. (2005) suggest that it may be possible to use anti-collision lighting system as a deterrent to migrating eiders. However, numerous studies and observations document collision mortality to birds attracted to lights near towers and buildings (Manville 2005). BPXA rig engineers will discuss lighting options with Fish and Wildlife Service biologists during rig design.

Increased Predation

There is evidence that some predators may be attracted to anthropogenic sources of food or denning/nesting sites associated with oilfield development (Eberhardt et al. 1982, 1983a, b; Garrott et al. 1983; Martin 1997; Day 1998; Burgess 2000). Increased predation pressure could impact threatened eiders and other tundra nesting birds. Potential predators of adult eiders and their eggs and young that could be attracted to anthropogenic sources of food or denning/nesting sites include arctic fox, red fox, grizzly bear, glaucous gull and common raven. Jaegers might also prey on eider eggs and young, but would probably not be attracted by human activities associated with development.

Major negative impacts have occurred at the Howe Island brant and snow goose (*Chen caerulescens*) colony in the Sagavanirktok River delta from predation by common ravens, arctic foxes, and grizzly bears (Johnson 2000). Arctic foxes and glaucous gulls are also predators of common eider and brant eggs and young on the barrier islands (Noel et al. 2002). Increased levels of predation due to elevated numbers of predators could impact nesting and brood-rearing spectacled and Steller's eiders.

Increased food availability

The availability of anthropogenic food sources, particularly during the winter, could increase winter survival of arctic and red foxes and contribute to increases in the fox population. Anthropogenic sources of food at dumpsters and refuse sites could cause populations of foxes, gulls and ravens to increase above natural levels. In recent years, oil field operators have installed predator-proof dumpsters at camps and implemented new refuse handling techniques to minimize the attraction of predators to the North Slope Borough landfill and areas of oil field development. In addition, oil field workers undergo training designed in part to mitigate the effects of increased levels of predation by educating workers about the problems associated with feeding wildlife. The numbers of foxes and most avian predators at the existing Alpine development did not appear to increase during construction of the project with the exception of common ravens, which nested on buildings at the Alpine site (Johnson et al. 2003b). There was also no evidence that predation pressure on tundra nesting birds increased during construction and early operation of the Alpine development. Current oil field policy includes measures to help control the numbers of predators in the oil field by reducing attraction of predators to anthropogenic sources of food. If necessary these mitigation measures will be implemented at Liberty project facilities.

Increased den/nesting sites

Foxes in the Prudhoe Bay area have used spaces under buildings as dens sites, and common ravens that were uncommon visitors on the North Slope prior to development use buildings, towers, and other structures for nest sites (Johnson and Herter 1989; Johnson et al. 2003b). In addition, gyrfalcons have been reported nesting on pipelines (Ritchie 1991). Mitigation measures have been successful in preventing predator use of structures for denning sites, although it is difficult to deter common ravens use of structures for nest sites (Johnson et al. 2003b). Common ravens have also nested on the Endicott facilities and at the Alpine development. However, Johnson et al. (2003b) reported no increase in predation levels on tundra-nesting birds when comparing pre- and post-development nest success at Alpine. BPXA engineers will discuss methods to prevent raven nesting on the drilling rig with biologists from Fish and Wildlife Service during rig design.

Additional landfills

No additional landfill sites will be required for operation of the Liberty project. All garbage will be removed from development sites and transported to landfill sites currently in operation.

Increased anthropogenic perch/hunting sites

Building, towers, pipelines and other structures provide perching sites that may be used by avian predators such as raptors, jaegers, snowy owls, and glaucous gulls. These perches may have the potential to increase predator efficiency that could impact spectacled or Steller’s eiders. The potential for impacts from anthropogenic sources of hunting perches for avian predators to affect eiders may be greatest during the brood-rearing period when hens with broods are moving across tundra habitats.

Oil Spills

Oil spills or leaks onto tundra or marine habitats could negatively impact spectacled or Steller's eiders in numerous ways. Oil can come in contact with and adhere to feathers, causing the feathers to lose their insulating capabilities resulting in hypothermia (Patten et al. 1991). The consequences would be most severe for aquatic habitats when feather integrity to maintain water repellency and buoyancy is lost due to contact with oil. Birds can suffer toxic effects from ingestion of oil by consuming food contaminated by an oil spill or by preening oiled feathers (Hansen 1981). Oil that comes in contact with bird eggs can cause toxic effects to embryos (Patten and Patten 1979; Stickel and Dieter 1979). Oil could come in contact with eggs directly as a result of a spill, or indirectly from the oiled feathers of incubating adults. Oil can also contaminate food sources. Oil spills can occur on terrestrial, river/delta, and offshore habitats.

Terrestrial

Oil spills or leaks from a pipeline located in terrestrial habitats would be confined by topographical features. Spilled oil could also enter a lake or pond and be contained by the banks of these water bodies. However, for a tapped lake or during spring flooding, an oil spill could spread to a much larger area depending on the amount of oil spilled, the surface topography, and the extent and duration of flooding. Oil entering a river or stream could spread into delta or coastal areas, where impacts to birds would likely be more severe. No new pipelines will be constructed to transport produced oil for the Liberty project and there would be no increase in the potential for a terrestrial oil spill to impact threatened eiders above that which currently exists.

Riverine/intertidal

A small spill entering a riverine or intertidal area would be diluted and would be unlikely to affect threatened eiders. Larger spills would have the potential to spread to intertidal or offshore areas where staging eiders could be affected. The greatest potential for impacts to eiders would occur during the fall staging period when eider flocks are molting. No new pipelines will be constructed to transport produced oil for the Liberty project and there would be no increase in the potential for an oil spill in river or intertidal habitats to impact threatened eiders above that which currently exists.

Offshore

Wind and currents in marine habitats could potentially spread an oil spill over a larger area than would be likely under most terrestrial scenarios. Therefore, birds residing in marine habitats could be particularly at risk for negative impacts from an oil spill. An oil spill occurring during the summer breeding and staging seasons would have a greater impact on threatened eiders than a spill occurring during the winter, when eiders are on wintering grounds. However, the lingering effects from a winter spill could impact returning birds during the following breeding season if clean-up activities did not adequately remove contaminants from bird habitats and food sources.

An oil spill that spread into offshore waters during the fall molting/staging period may have a greater potential to affect spectacled eiders than a nearshore spill (Fischer et al 2002). Stehn and Platte (2000) developed an oil spill scenario for the central Beaufort Sea based on a spill size of 5,912 barrels. When taking spectacled eider densities in the Beaufort Sea into consideration, the highest mean number of spectacled eiders exposed to oil was 2 birds. However, since there is some evidence that spectacled eiders may occur in flocks in offshore Beaufort Sea habitats (Fischer et al 2002), an offshore spill could potentially impact more birds than proposed in the analysis of Stehn and Platte (2000). The average flock size reported during aerial surveys in the offshore waters of Harrison Bay was 21.1 (Fischer et al 2002). An oil spill would be unlikely to contact eiders due to the low density of spectacled eiders in offshore waters, however, a spill that did contact spectacled eiders could impact 20 or more birds.

Based on a small number of spectacled eiders fitted with satellite transmitters, TERA (1999) reported that there appeared to be little spectacled eider use of the Beaufort Sea offshore habitats east of Spy and Pingok islands located offshore of Oliktok Point, approximately 60 km west of SDI. No other information is available on spectacled eider use of marine habitats east of Pingok Island or the marine habitats offshore of SDI. The Liberty project is located near the eastern edge of the breeding range of spectacled eider where densities are relative low, and few spectacled eiders would be likely to be affected by an offshore spill from the Liberty project unless a massive spill spread to the west of SDI.

Toxics

Organic pollutants and metals can be found in various types of environments throughout the world. The availability of these contaminants and their effects on waterfowl are becoming popular topics of study for researchers (e.g., Franson et al. 1995; Henry et al. 1995; Stout 1998; Trust et al. 2000; Stout et al. 2002; Grand et al. 2002). Contaminants are sometimes spilled during oil and gas exploration and development activities. Some types of contaminants include drilling mud, waste water, used crankcase oil, dust-control chemicals, reserve pit fluids, diesel fuel, glycol, crude oil, and salt water (Walker 1996). Current policies in North Slope oil fields require that any spills of toxic materials, including small quantities of material, be reported and cleaned up as soon as possible. In addition, current and future development practices have eliminated hazardous reserve pits that may have been a source of contaminants for threatened eiders in the past.

5. POSSIBLE MITIGATION OPTIONS AND SUGGESTED STIPULATIONS

The types of activities generally associated with oil field development on the North Slope and the potential impacts that may result from those activities are expected to be reduced or eliminated for the Liberty SDI alternative compared to other options that had been proposed for the Liberty development. Loss of tundra habitat resulting from the Liberty Development Project will be limited to the footprint of the mine site development along the Endicott road. No new gravel roads (except a short access road to the mine site), pads or airstrips will be constructed for the Liberty Development. Although temporary disturbance to tundra habitats along the route of the ice road may occur, impacts are expected to be short term and effects are not likely to persist beyond 1 or 2 growing seasons. Further, BPXA plans to maximize use of a channel of the Sagavanirktok River for the onshore portion of the ice road.

Disturbance activities that typically occur on gravel infrastructure, such as vehicular, pedestrian, and aircraft traffic, and noise resulting from construction, production, and maintenance activities will also be reduced compared to that which often occurs at new development sites. The SDI is not located near potential nesting habitat for spectacled eiders, and pad activities would not be expected to affect nesting eiders. However, increased vehicular traffic along the Endicott road during the construction period could have the potential to affect spectacled eiders during the pre-nesting, nesting, and brood-rearing periods. Traffic along the Endicott road would likely return to pre-construction levels during the production phase of the development and road disturbance would likely be no greater than that which currently exists.

Many types of mitigation that are required for North Slope oil field development will not be necessary for development of the Liberty Development Project. However, mitigation will be relevant for several aspects of the project including mine-site development, ice-road construction and use, and potential disturbance along the road system during the construction period. Potential mitigation for these aspects of the Liberty development are discussed below. In addition, standard North Slope practices established to reduce the availability of anthropogenic sources of food to predators must be continued for the Liberty development.

Mitigation Options

Mine-site Development

A vegetation map of the mine site will be prepared prior to development of the mine to aid in the identification of potential eider habitats. A ground-based survey to determine the suitability of the mine site as potential spectacled eider nesting habitat will be conducted during the pre-nesting period to determine the level of use of the site by spectacled eiders.

The DPP contains details of a rehabilitation plan developed by BP for the mine site. The goal for the mine site preparation, operation, and subsequent closure and rehabilitation is to minimize tundra disturbance. The rehabilitation plan describes methods and procedures for rehabilitating the Liberty mine site and is subject to confirmation based on a biological assessment of the site prior to mining operations. The plan may be amended when more site-specific information is available and as the rehabilitation progresses over time.

The excavated area will be prepared for restoration when it is no longer required for the Liberty Project Development (i.e., after the second winter season). Inorganic overburden will be placed over the stepped benches in the excavated area side walls and allowed to form side slopes with the natural angle of repose expected to be between 2:1 and 3:1 H:V. These side slopes would be consistent with those at the nearby Duck Island Mine Site. The inorganic material, except for a flood protection berm, will be replaced in the excavated area to moderate the side slopes. The harvested organic material stockpile will be used to encourage natural species revegetation on the flood protection berm.

Excess organic material that is not used on the fold protection berm will remain stockpiled for potential use elsewhere to be done in consultation with regulatory agencies.

The goal after mining is completed is to replace the stockpiled overburden back into the excavated area to create shallow sloping excavated side walls to the extent practicable. In response to comments on the Mining and Rehabilitation Plan, BPXA has agreed to provide a breech to the excavated area to connect to the ephemeral Duck Island Creek after closure of the mine site. The excavated area will be allowed to fold gradually over time from locally occurring run-off waters.

In consultation with the U.S. Army Corp of Engineers, BPXA has established a practice of defining clear goals, objectives, and performance standards as part of their current approach to rehabilitation. The quantitative measures associated with BS's rehabilitation goals, objectives, and performance standards typically focus on percent vascular cover, species composition, and available nutrients. Additional quantitative measures often include monitoring the site for wildlife activity, and significant areas of subsidence or thermokarst. Specific time frames for completion of various stages of the rehabilitation process for the Liberty mine site and BPXA's reporting schedule are included in Attachment D to the DPP.

Ice-road Construction and Use

Ice roads have the potential to crush tundra vegetation causing temporary disturbance to the vegetation that may affect nesting eiders. Thickened areas of ice may linger into the nesting season reducing the availability of tundra habitats to spectacled eiders. Potential impacts to spectacled eiders from ice-roads may be reduced by avoiding routes near known eider nesting locations, and by routing ice roads over habitats not preferred by eiders (such as river channels). Such routing is currently being investigated by the project team to maximize use if feasible of a channel of the Sagavanirktok River.

Road Disturbance

Reduced speed limits along the road system, particularly during the pre-nesting period when eiders and other waterfowl may be attracted to areas of open tundra near roads may help to reduce the potential for collisions of spectacled eiders with vehicles or equipment. Reduced speed limits during the brood-rearing period would reduce any negative impacts associated with potential obstruction of eider movements or bird collisions with vehicles during the brood-rearing period. Reduced speed limits were used as mitigation to minimize impacts to snow geese in brood-rearing areas adjacent to the Endicott road during the mid-1980s.

Suggested Stipulations

BPXA has an active long-term environmental studies program designed to understand the impacts of its operations and develop appropriate environmental mitigation. In support of this program BPXA recently began production of an annual, long-term monitoring report which highlights the results of ongoing ecological studies on the North Slope and the long-term status of various environmental factors. Some chapters in the long-term monitoring report summarize information gathered over many years, while others present information on recently launched efforts. The intent of the report is to add data to the report sections each year and to increase the scope of the report over time. At this time the report discusses a number of topics including but not limited to weather, plant communities, tundra-nesting birds, fox denning activity, polar bear and seal sightings, and nearshore fish.

Possible topics for inclusion in future editions of the report include studies that have been conducted intermittently in the Liberty project area but that could be resumed on an annual basis. Common eiders are known to use nest sites located on the Endicott causeway and on the man-made Duck Island located south of SDI. Common eider nesting activity has been monitored on the Endicott causeway during some years beginning a few years after construction of the causeway when eiders were first observed nesting in the area. However common eider nesting along the causeway has been monitored only sporadically since 1992. Monitoring of common eider nesting activity along the Endicott causeway and Duck Island that would continue for the life of the project could be continued on an annual basis as a permitting stipulation for the Liberty development with reporting to be included in BP's annual long-term monitoring report. Other studies that could be initiated in the general area of the Liberty project include monitoring of long-tailed duck use of the lagoon formed by the Endicott causeway, monitoring of raven nesting in the Endicott/Liberty area, and monitoring of bird mortality that may result from collision with structures at the Liberty development site. Results of these monitoring efforts could also be included in the long-term monitoring report through the life of the Liberty project.

The potential stipulations for the proposed Liberty development which could be conducted for the life of the project include:

- monitoring of common eiders along the Endicott causeway and the man-made Duck Island south of SDI,
- monitoring of long-tailed duck (and other waterbird) use of the Endicott lagoon, and
- monitoring of collision mortality at the Liberty facilities.
- BPXA consultation with the USFWS during design of the drilling rig and SDI facilities with respect to raven nesting and facility lighting

6. CUMULATIVE EFFECTS ON SPECTACLED AND STELLER'S EIDERS

Cumulative effects are defined in 50 CFR 402.02 (Interagency Cooperation on the Endangered Species Act of 1973, as amended) as "…those effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation." The cumulative effects described in this section relate to potential effects to spectacled and Steller's eiders that may result from State or private actions reasonably certain to occur within or near the Liberty Project area. These actions relate primarily to future oil development.

Continued Oil Field Development

The initial development work for the Prudhoe Bay oil fields began around 1968. Since then the number of production pads increased from 16 in 1973 to 115 in 2001 (NRC 2003). The number of miles of gravel road increased from 100 in 1973 to 400 in 2001. The developed area, which was originally confined to the Prudhoe Bay area, currently extends from the Colville to the Sagavanirktok River. In addition, production facilities for the Badami Unit, located about 30 miles east of the Sagavainrktok River, are connected to the Endicott development by a pipeline, and further oil field expansion is planned west of the Colville River into the National Petroleum Reserve—Alaska.

Recent and future negotiations between the State of Alaska and various industry groups regarding development of a gas pipeline from Prudhoe Bay to Canadian and U.S. markets could result in future development of the Point Thomson Unit located about 50 miles east of Prudhoe Bay. Other exploratory activities which could lead to future development are proposed for offshore areas east of the Liberty Project area during 2007. Recent and future seismic exploration in the Chukchi Sea could also result in future development that would have the potential to affect spectacled and Steller's eiders. The types of impacts that could result from future development would be similar to those discussed above in Chapter 4 including potential impacts resulting from habitat loss, effects of disturbance and increased predation, and oil spills.

The need for developers and wildlife managers to address all of the issues related to the potential impacts of future oil field development will continue. Many stipulations and required operating procedures which have helped mitigate the effects of North Slope oil field development are included in various permitting and EIS documents. Continued oversight of North Slope development will help to insure that the impacts of future development on spectacled and Steller's eiders and other wildlife are minimized.

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RD

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

MAY 25 2007

Memorandum

To: Regional Director, FWS, Region 7

From: Regional Director

Subject: Endangered Species Act Section 7 Consultation Request for Proposed Liberty Development and Production Plan

The Minerals Management Service (MMS), in cooperation with the U.S. Army Corps of Engineers, is completing a draft Environmental Assessment for the proposed Liberty Development and Production Plan in the Beaufort Sea. The Steller's and spectacled eider, both threatened species, occur in the project area. The Kittlitz's murrelet, a candidate species, may also occur there as well.

Section 402.08 of the Endangered Species Act (ESA) states that a Federal agency may designate a non-Federal representative to conduct informal consultation or prepare a biological assessment (BA) by giving written notice to the Director of the U.S. Fish and Wildlife Service (FWS) of such designation. The MMS notified the FWS that it had designated British Petroleum Exploration (Alaska) Inc. (BPXA) as the non-Federal representative on February 17, 2006, and BPXA submitted a BA to MMS on May 8, 2007. The BPXA BA was prepared by LGL, Alaska Research Associates, Inc. (Attachment 1). The ultimate responsibility for Section 7 consultation under the ESA, however, remains with the MMS. Section 402.08 of the ESA requires MMS to independently review and evaluate the scope and contents of the BPXA BA.

The MMS has completed its review of the BPXA BA (Attachment 2). This review supersedes conclusions in the BPXA BA. We believe the MMS review and BA satisfy the information requirements specified in 50 CFR 402.12 and 402.14 and consequently constitute a complete consultation package for your review and preparation of a biological opinion. The MMS determined that the proposed Liberty Development and Production Plan activities would likely have the following level of effects on Steller's and spectacled eiders and Kittlitz's murrelets:

- Listed and Candidate Species
  - The Liberty Development and Production Plan activities *are likely to adversely affect* spectacled eiders.
  - The Liberty Development and Production Plan activities *are not likely to adversely affect* Steller's eiders.

    - The Liberty Development and Production Plan activities *are not likely to adversely affect* Kittlitz's murrelets.

- Critical Habitat Area
    - The Liberty Development and Production Plan activities are *not likely to adversely modify* the Ledyard Bay Critical Habitat Unit.

We request your concurrence on these findings. If you determine a jeopardy situation may exist for all or any part of the proposed action, we ask that you notify us as early as possible, according to 50 CFR 402.14(g)(5), to allow the MMS and FWS staff time to jointly discuss the findings. We believe that such discussions will facilitate the consultation and ensure protection of listed species. These discussions will also ensure that any proposed alternatives are within our authority to control and implement, and are feasible, prudent, and effective. To facilitate timely completion of this consultation, we are sending a copy of this memorandum to the Fish and Wildlife Service, Field Office in Fairbanks, Alaska.

The BPXA is also designated the non-federal representative to evaluate potential project impacts on the polar bear, a species proposed for listing as threatened under the ESA. Although it does not appear that the Liberty Development and Production Plan activities are likely to jeopardize the continued existence of the polar bear, the MMS would like to conference on this species. We request the conference be conducted in accordance with the procedures for formal consultation in 50 CFR 402.14 so that the conference opinion may be adopted as a biological opinion if the polar bear is listed. BPXA has agreed to prepare a BA, which MMS will use as the basis for the conference. We intend to initiate conferencing when the BA is complete. We prefer to keep the conference separate from the Section 7 consultation process on ESA-listed birds.

If you have any questions on these consultations or require additional information, please contact Mr. Mark Schroeder (907-334-5247) or Mr. Casey Buechler (907-334-5265).

Attachments

cc: (w / attachments)

Supervisor, Fairbanks Fish and Wildlife Field Office
Cash Fay, BPXA

bcc: Official File (1001-03a)
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RSLE Chron
EAS Chron
Author (Schroeder) MAS

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Field Office Supervisor
U.S. Fish and Wildlife Service
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

Cash Fay
BP Exploration (Alaska) Inc.
P.O. Box 196612
Anchorage, Alaska 99519-6612

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701
June 20, 2007

Memorandum

To: Regional Director, MMS – Alaska OCS Region

From: Fairbanks Fish and Wildlife Field Office Supervisor Jerry Bright

Subject: BP Alaska's Liberty Project: Endangered Species Act Section 7 Consultation

We received a Biological Assessment and cover memo requesting initiation of section 7 consultation under the Endangered Species Act (Act) for BP Exploration (Alaska) Inc.'s (BP Alaska) proposed Liberty Development and Production Plan on May 31, 2007. The consultation concerns the possible effects of the proposed action on spectacled (*Somateria fischeri*) and Alaska-breeding Steller's *(Polysticta stelleri*) eiders, which are listed as threatened under the Act and the candidate species Kittlitz's murrelet (*Brachyramphus brevirostris*). We understand that MMS intends to request a separate conference opinion on the potential effects of the project on Polar Bears (*Ursus maritimus*), which are proposed for listing.

After reviewing the BA we have determined that the proposed action may adversely affect listed species and will therefore require formal consultation. All the information required to initiate formal consultation was either included in the BE, or is otherwise accessible for our consideration and reference. However, it is likely that we will identify additional information needs, or require clarification on aspects of the proposed action as consultation progresses.

As a reminder, section 7 allows the Fish and Wildlife Service (Service) 90 calendar days to conclude formal consultation with your agency and an additional 45 calendar days to prepare our biological opinion (unless we mutually agree upon an extension).

This consultation will be conducted by the Endangered Species Branch of the Fairbanks Field Office. In order to expedite communication please address future documents or requests concerning this consultation to Ted Swem, Branch Chief, Fairbanks Fish & Wildlife Field Office, 101 12th Ave, Room 110, Fairbanks, AK 99701.

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701
October 3, 2007

RECEIVED
OCT 11 2007
REGIONAL DIRECTOR, ALASKA OCS
MINERALS MANAGEMENT SERVICE
ANCHORAGE, ALASKA

Memorandum

To: Regional Director, MMS – Alaska OCS Region

From: Fairbanks Fish & Wildlife Field Supervisor D. Roy

Subject: BP Alaska's Liberty Development Project: Endangered Species Act Section 7 Consultation

This document transmits the U.S. Fish and Wildlife Service's (Service's) Final Biological Opinion (BO) based on our review of the Mineral Management Service's (MMS's) Biological Assessment (BA) and supplemental materials on BP Alaska Inc.'s proposed Liberty Development Project. The BO documents effects of the action on threatened spectacled (*Somateria fischeri*), and Alaska-breeding Steller's (*Polysticta stelleri)* eiders, and the candidate species Kittlitz's murrelets (*Brachyramphus brevirostris*) in accordance with section 7 of the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 et seq.). A separate conference opinion is being prepared for the proposed species polar bear (*Ursus maritimus*).

The Liberty field is located offshore in the Beaufort Sea Outer Continental Shelf (OCS) region. Originally BP Alaska intended to develop the field from a stand-alone offshore island with a subsea pipeline. However, the current proposal would expand the Endicott Satellite Drilling Island to house ultra extended reach wells to extract oil from this field. Products from the Liberty field will move through existing Endicott pipelines and production infrastructure. This new design, use of state-of-the-art technology, and co-location with existing infrastructure, significantly reduces the environmental impacts of the project and the Service commends BP Alaska for this new approach.

After reviewing the information provided, the status of the species, the environmental baseline, and cumulative effects, the Service concludes the proposed activities will not violate section 7(a)(2) of the Act by jeopardizing the continued existence of any listed species or adversely modify designated critical habitat. Adverse effects to listed species are, however, predicted to occur. The incidental take statement for this non-jeopardy BO includes reasonable and prudent measures, and terms and conditions that are non-discretionary for MMS and their agents, BP Alaska, to implement.

A complete administrative record of this consultation is on file at the Fairbanks Fish and Wildlife Field Office, 101 12th Ave., Room 110, Fairbanks, Alaska 99701, and a chronology of the consultation history is provided in Appendix 1.

We look forward to working collaboratively with the MMS and BP Alaska to implement the terms and conditions of the BO. If you have any comments or concerns regarding this BO, please contact Ted Swem, Endangered Species Branch Chief, at (907) 456-0441.

CC: Mr. Cash Fay, Permits Coordinator, BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK 99519-6612

FINAL BIOLOGICAL OPINION

for

Minerals Management Service

and their agents

BP Exploration (Alaska) Inc.

LIBERTY DEVELOPMENT PROJECT

OCTOBER 2007

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1. INTRODUCTION

This document is the U.S. Fish and Wildlife Service's (Service) Biological Opinion (BO) on the Minerals Management Service's (MMS) proposal to authorize BP Exploration (Alaska) Inc.'s (BP Alaska) Liberty Development Project. This project will use Ultra Extended Reach Drilling (uERD) technology to extract hydrocarbons from the Liberty field in the Beaufort Outer Continental Shelf (Beaufort OCS) region. The project will involve the expansion of the existing Endicott Satellite Drilling Island (Endicott SDI) to house the drill rig and associated equipment, and development of a new material site. The project will utilize existing roads, pipelines, and Endicott production facilities.

This BO describes the effects of these actions on spectacled (*Somateria fischeri*) and Alaska-breeding Steller's *(Polysticta stelleri)* eiders, which are listed as threatened under the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et. seq.). As requested by MMS, effects to the candidate species Kittlitz's murrelet *(Brachyramphus brevirostris)* have also been considered. Polar bears (*Ursus maritima*), a proposed species, are being considered in a separate conference.

This BO was prepared using information in the "Biological Assessment for Spectacled and Steller's Eiders the Liberty Development Project" (BP Alaska 2007), supplemental information from MMS, BP Alaska's Environmental Impact Assessment (EIA), and the Liberty Development and Production Plan. MMS's letter requesting formal consultation, and designating BP Alaska as their non-Federal representative, was received on May 31, 2007. On June 20, 2007 the Service confirmed that sufficient information to begin formal consultation had been provided. The complete administrative record of this consultation is on file at the Service's Fairbanks Fish and Wildlife Field Office.

Section 7(a)(2) of the Act states that Federal agencies must ensure their activities are not likely to:

- Jeopardize the continued existence of any listed species; or
- Result in the destruction or adverse modification of designated critical habitat.

After reviewing the information provided, the status of the species, the environmental baseline, and cumulative effects, the Service concludes that the proposed activities may adversely affect listed eiders but will not jeopardize either species or adversely modify critical habitat. The Service has determined that it is unlikely that the action will violate section 7(a)(2) of the Act. To arrive at this non-jeopardy determination, we used a four-step approach for applying section 7(a)(2) standards. These steps were:

1. Define the biological requirements and current status of listed eiders;
2. Evaluate the relevance of the environmental baseline to the current status of listed eider populations;
3. Determine the effects of the proposed or continuing action on the species; and
4. Determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the effects of the environmental baseline, and any cumulative effects, and considering measures for survival and recovery specific to other life stages.

Although limited information currently exists regarding the specific distribution of Kittlitz's murrelets, this species does not regularly occur in the action area. Hence the Service concludes the Liberty project is not likely to pose a significant threat for this species.

In addition to listed eiders, the Beaufort OCS, and Alaska's North Slope may now or hereafter contain plants, animals, or their habitats determined to be threatened or endangered. The Service, through future consultation may recommend alternatives to future developments within this area to prevent activity that will contribute to a need to list such a species or their habitat. The Service may require alternatives to proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species or result in the destruction or adverse modification of designated or proposed critical habitat. MMS should not approve any activity that may affect any such species or critical habitat until it completes its obligations under applicable requirements of the Act, including completion of any required procedure for conference or consultation.

2. DESCRIPTION OF THE PROPOSED ACTION

2.1 Background

Section 7(a)(2) of the Act requires Federal agencies to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any threatened or endangered species, or result in the destruction or adverse modification of critical habitat. When actions of a Federal agency may adversely affect a protected species, that agency (i.e., the action agency) is required to consult with either the National Marine Fisheries Service (NMFS) or the Service, depending upon the protected species that may be affected.

For the actions described in this document, the action agency is the Minerals Management Service (MMS). MMS will be authorizing activities described in this BO, which is the federal nexus for consultation. This BO focuses on the potential effects of the proposed project on the threatened Alaska-breeding Steller's (*Polysticta stelleri*) and spectacled (*Somateria fischeri*) eiders, and the candidate species Kittlitz's murrelet (*Brachyramphus brevirostris*).

2.2 Action Area

The action area is the area in which direct and indirect effects of the proposed action may occur. Liberty project activities, and hence direct effects, will occur at the Endicott Satellite Drilling Island (Endicott SDI), the Endicott Main Production Island (Endicott MPI), along the causeway that joins these two facilities, at a new mine site near Duck Island Material site, and along transportation routes (ice and gravel roads) connecting these facilities (Figure 2.1). No indirect effects outside the immediate construction and operations areas and along transportation corridors are anticipated.

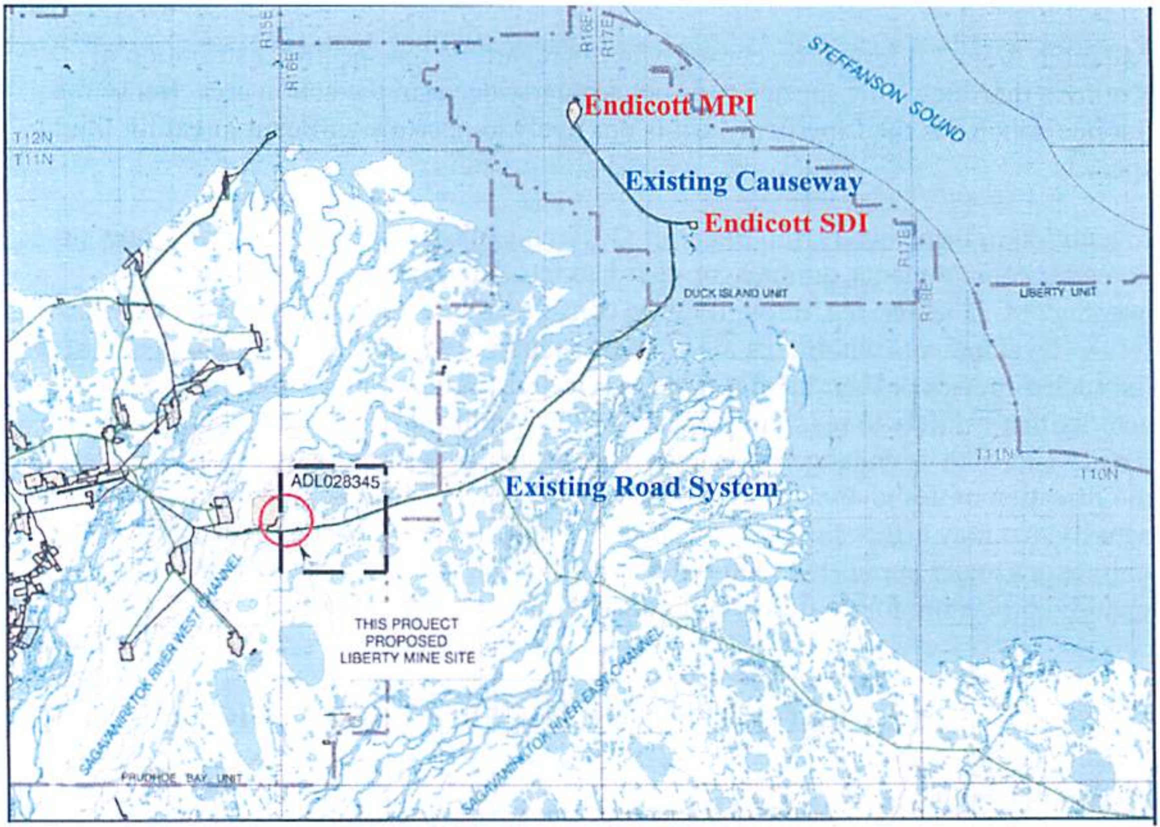

Figure 2.1 – Map of the Project Area

2.3 Project Actions

The project will develop infrastructure to extract an estimated 105 million barrels of hydrocarbons from the Liberty oilfield in federal waters of the Beaufort Sea. The project will involve:

- Development of a material site to supply gravel for expansion of Endicott SDI, and transportation of gravel via ice roads;
- Upgrades to the existing West Sag River Bridge;
- Construction of a purpose-built drill rig;
- Expansion of the Endicott SDI to accommodate the drill rig and associated facilities;
- Construction of pipelines, a LoSal™ facility, and upgrades to existing facilities in the Endicott area;
- Drilling production and injection wells using uERD methods;
- Hydrocarbon production; and
- Abandonment.

BP Alaska anticipates construction will commence in January 2009 with development of the material site. Snow and overburden will be cleared and stockpiled at the site, before gravel is mined and transported to the Endicott SDI expansion area via a specially constructed ice road. Mine site activities are expected to disturb 37 acres of habitat through the extraction of 870,000 cy of gravel. Gravel hauling will continue through April, with compaction of the gravels at Endicott SDI commencing in June/July. A new sheet pile wall for slope protection will then be placed from the north side of the island around to the southeastern corner for ice and erosion protection.

The Liberty project would expand the 11 acre Endicott SDI on its eastern and southern sides adding an additional 20 acres of working area. Located in waters 4-11 feet deep, the seafloor footprint of the island will increase from 20 to 40 acres. Drilling supplies and equipment will be stored on the expansion area in support of a single row of wells and the uERD drill rig (Figure 2.2).

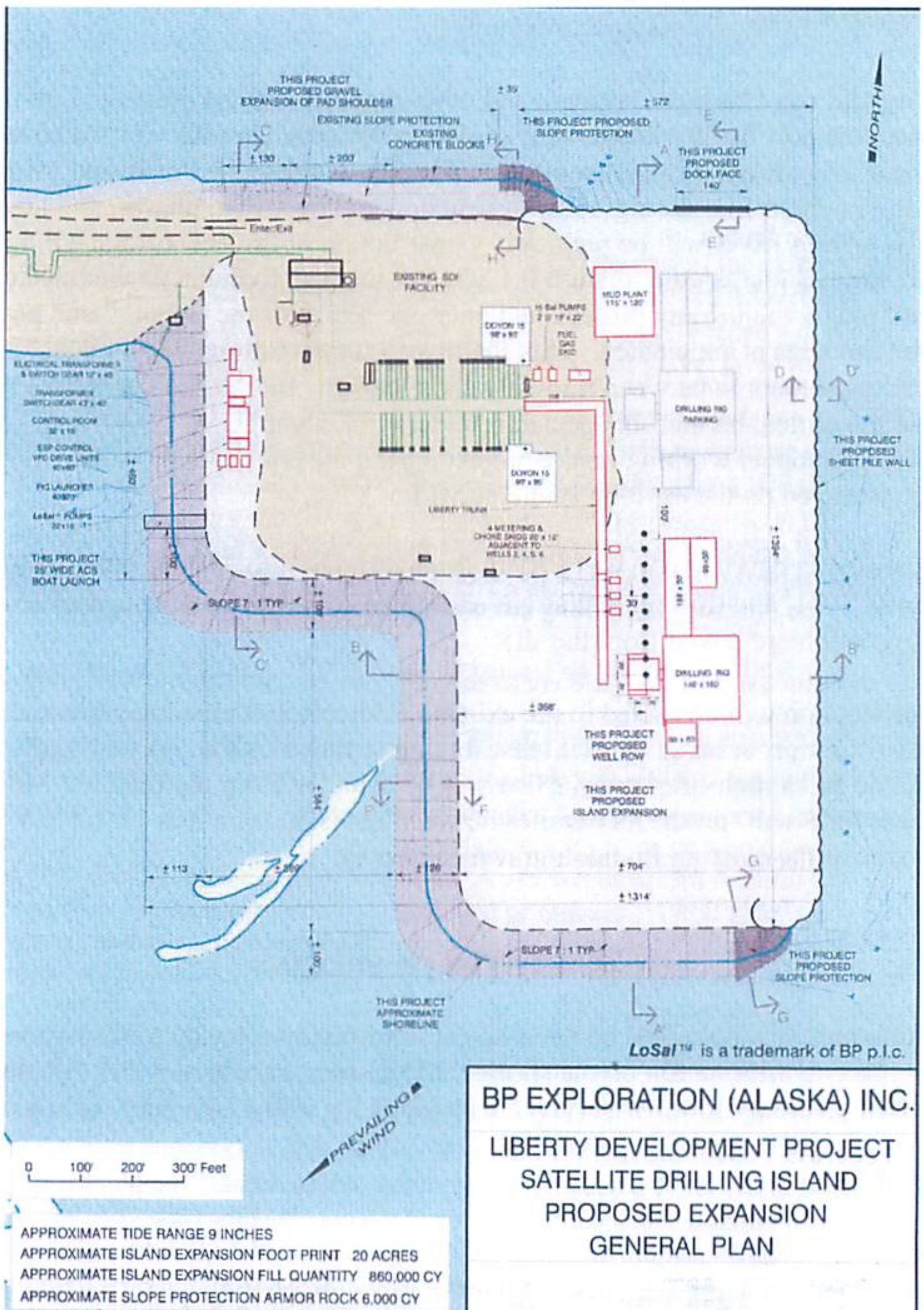

Figure 2.2 – Layout of the Expanded Endicott SDI

Surface facilities on the island will include:
- Pipe rack and well tie-in piping;
- Fuel-gas conditioning unit;
- Booster pumps for high-salinity water injection;
- Electrical transformer and switchgear;
- Control room;
- Transformer module for the electrical submersible pump variable frequency drive (ESP VFD);
- LoSal^{TM} pipeline pig-launcher module; and
- LoSal^{TM} EOR process injection pumps.

The piping, dill rig, LowSal^{TM} system, and other modules will be fabricated offsite and transported to a port facility in southern Alaska, before each module is trucked to the project site. The Liberty project would significantly increase the traffic and vehicular loads to the Endicott SDI during both construction and operation phases, and the bridge over the West Sag River will be replaced. Construction of the new bridge will take place in winter, and is anticipated to disturb 0.1 acres of tundra. Regularly scheduled air traffic is not required by the Liberty project, and only one sealift of the LoSal^{TM} and power generation modules is anticipated. This sealift will transit through the Chukchi and Beaufort Seas sometime between mid-July and October. BP Alaska states "the sealift will avoid the critical habitat for spectacled eiders in Ledyard Bay." Additional camp facilities for personnel working on the project during the construction and drilling phases will be constructed on the existing Endicott MPI.

Drilling is expected to begin in early 2010. Production will follow the hook up of the first well in early 2011, and drilling operations should be completed by the end of 2013, when the drill rig will be removed from the site.

Liberty production will be routed to the existing Endicott SDI pipeline system and on to Endicott MPI for processing and final distribution to the sales line. A new LoSal^{TM} water injection line and a high-pressure gas line will be installed from the Endicott MPI to the SDI. These lines will run the three miles between the islands on new elevated VSMs on the west side of the existing Endicott gravel causeway.

3. STATUS OF SPECIES

This section presents biological and ecological information relevant to formation of the BO. Appropriate information on the species' life history, habitat and distribution, and other factors necessary for their survival is included for analysis in later sections.

Spectacled Eider

Physical Appearance
Spectacled eiders are large sea ducks. Males in breeding plumage have a white back, black breast, and pale green head with large white "spectacles" around the eyes. In late

summer and autumn males molt into a mottled brown plumage that lasts until late fall, when they re-acquire breeding plumage. Females are mottled brown year round, with pale tan spectacles. Juveniles attain breeding plumage in their second (female) or third (male) year; until then they are mottled brown (Petersen et al. 2000). Both males and females have long sloped bills, giving them a characteristic profile (Figure 3.1).

Figure 3.1 - Male and female spectacled eiders in breeding plumage.

Distribution and Status

Spectacled eiders inhabit the North Pacific. There are three primary breeding populations; those on Alaska's North Slope, the Yukon-Kuskokwim Delta (Y-K Delta), and northern Russia. The entire species was listed as threatened on May 10, 1993 (Federal Register 58(88):27474-27480) because of documented population declines. The Y-K Delta population had declined 96% between the 1970s and early 1990s (Stehn et al. 1993, Ely et al. 1994), and anecdotal information indicated that populations in the other two primary breeding areas had also declined (USFWS 1996).

Birds from all three breeding populations molt in a number of discrete areas (Figure 3.2), with birds from the different populations and genders apparently favoring different molting areas (Petersen et al. 1999). After molting, spectacled eiders migrate to openings in pack ice of the central Bering Sea south/southwest of St. Lawrence Island (Petersen et al. 1999) (Figure 3.2). Spectacled eiders depart from the wintering area in March and April to begin migration back to their breeding grounds (Lovvorn et al. 2003).

Distribution of spectacled eiders. Molting areas (green) are used July through October. Wintering areas (yellow) are used October through April. The full extent of molting and wintering areas is not yet known, and may extend beyond the boundaries shown.

Figure 3.2 - Distribution of spectacled eiders (USFWS 2002a).

North Slope Breeding Population

Spectacled eiders arrive on their North Slope breeding grounds in late May and early June. Nest initiation is thought to occur in the third week of June (Petersen et al. 2000). Incubation lasts 20-25 days (Kondratev and Zadorina 1992, Harwood and Moran 1993, Moran and Harwood 1994, Moran 1995), and hatching occurs from mid-to late July (Warnock and Troy 1992). Ducklings leave the nest 1-2 days after hatching (Petersen et al. 2000).

On the nesting grounds, spectacled eiders feed on mollusks, insect larvae (craneflies and caddisflies), midges, small freshwater crustaceans, and plants and seeds (Kondratev and Zadorina 1992) in shallow freshwater or brackish ponds, or on flooded tundra. Young fledge approximately 50 days after hatch, when females with broods move directly from freshwater to marine habitats.

Spectacled eider density varies across the North Slope (Figure 3.3). Aerial surveys targeting eiders have been conducted annually by the Service since 1992. Data from these surveys suggests the population was stable between 1993 and 2006, with an average (n=14) annual growth rate of 0.997 (0.978-1.016 90% C.I.). The most recent (2002-2006) population index[1] for North Slope breeding spectacled eiders is 6,458 (5,471-7,445 95% CI). This index was adjusted by a factor that accounts for the number of nests missed during aerial surveys[2] (developed for the Y-K Delta) and used to calculate a North Slope breeding spectacled eider population estimate of 12,916 (10,942-14,890 95% CI) (Stehn et al. 2006). Of these birds only an estimated 1.93% were observed east of the Endicott SDI (Service data).

Molt Migration

Males generally depart breeding areas when the females begin incubation in late June (Anderson and Cooper 1994, Bart and Earnst 2005). Use of the Beaufort Sea by departing males is variable. Some appear to move directly to the Chukchi Sea over land, while the majority moved rapidly (average travel of 1.75 days), over nearshore waters from breeding grounds to the Chukchi Sea (TERA 2002). Of 14 males implanted with satellite transmitters, only four spent an extended period of time (11–30 days), in the Beaufort Sea (TERA 2002). Preferred areas for males appeared to be near large river deltas such as the Colville River where open water is more prevalent.

Females generally depart the breeding grounds later, when much more of the Beaufort Sea is ice-free, allowing for more extensive use of the area. Females spent an average of two weeks in the Beaufort Sea (range 6-30 days) with the western Beaufort Sea the most heavily used (TERA 2002). Females also appeared to migrate through the Beaufort Sea an average of 10 km further offshore than the males (Peterson et al. 1999). This migration route and the greater use of the Beaufort Sea by females were attributed to ice extent by Peterson et al. (1999) and TERA (2002). The more prolonged use and greater distance offshore were thought to result from the decreased sea ice later in summer when females migrate through the region (Peterson et al. 1999, TERA 2002).

Causes of Population Decline

Although causes of spectacled eider population decline are unknown, factors that affect adult survival may be the most influential on population growth rate. These include lead poisoning from ingested spent shotgun pellets, which may have contributed to the rapid decline observed in the Y-K Delta (Franson et al. 1995, Grand et al. 1998), and other factors such as over harvest, disturbance, and collisions with human-built structures. Productivity may also be impaired by habitat loss and increased nest predation.

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[1] A standard index used to monitor waterfowl populations based on the number of birds seen during aerial surveys and adjusted for cryptic females that are presumably missed when single males are detected (USFWS and Canadian Wildlife Service 1987).

[2] The detection correction factor compares the number of eiders observed during aerial surveys with the number of nests located on ground surveys in order to presume actual population size from the number detected in aerial surveys.

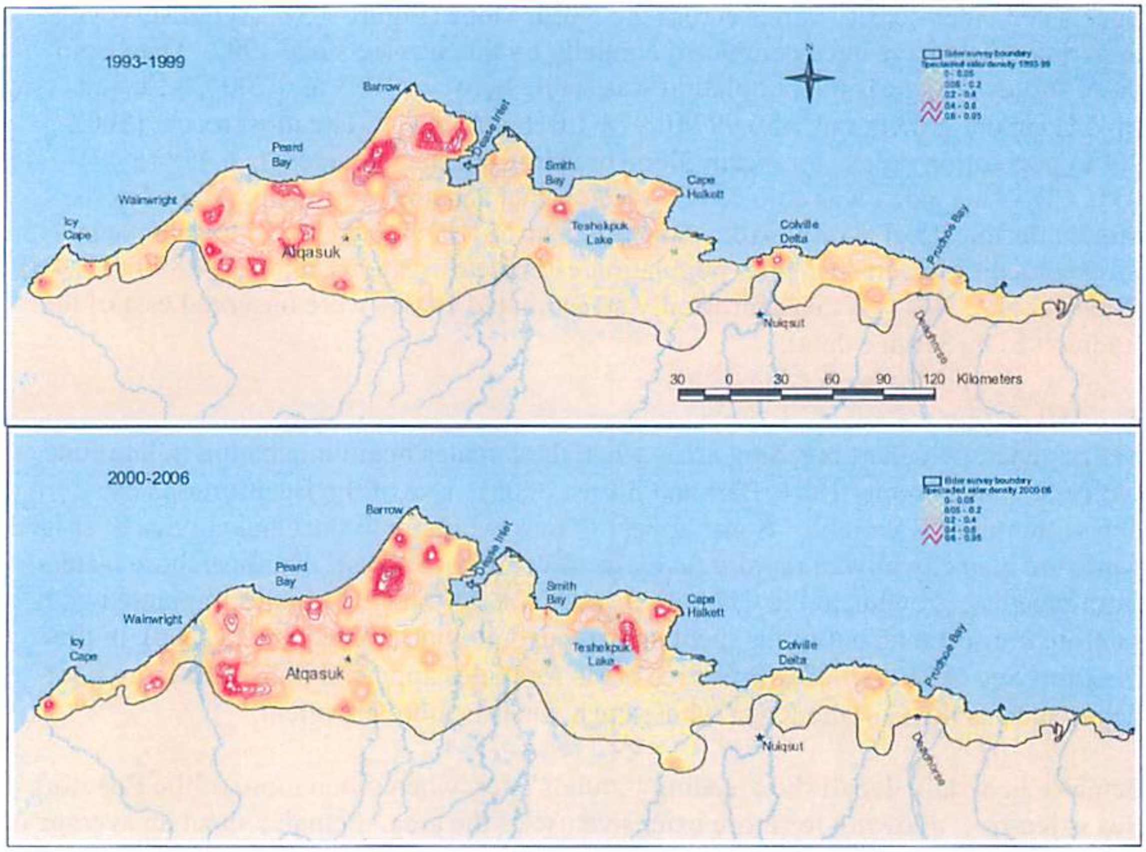

Figure 3.3 - Spectacled eider density on the Alaska ACP from 1993-1999 and 2000-2006 (Larned et al. 2006).

Steller's Eider

Physical Appearance

The Steller's eider is the smallest of the four eider species. From early winter until mid-summer males are in breeding plumage - black back, white shoulders and sides, chestnut breast, white head with black eye patches and a greenish tuft (Figure 3.4). During late summer and fall, males molt to dark brown with a white-bordered blue wing speculum; this plumage is replaced during the autumn molt when males re-acquire breeding plumage, which lasts through the next summer. Females are dark mottled brown with a blue wing speculum year round. Juveniles are dark mottled brown until the fall of their second year, when they acquire breeding plumage (Fredrickson 2001).

Figure 3.4 - Male and female Steller's eider in breeding plumage.

Distribution and Status

Steller's eiders are a circumpolar sea duck with both Atlantic and Pacific populations. The Pacific population is further divided into the Russian-breeding population and the Alaska-breeding population. On June 11, 1997, the Alaska-breeding population of Steller's eiders was listed as threatened based on a substantial decrease in this population's breeding range and the increased vulnerability of the remaining Alaska-breeding population to extirpation (Federal Register 62(112):31748-31757). Although population size estimates for the Alaska-breeding population were imprecise, it was clear Steller's eiders had essentially disappeared as a breeding species from the Y-K Delta, where they had historically occurred in significant numbers, and that their Arctic Coastal Plain (North Slope) breeding range was much reduced. On the North Slope they historically occurred east to the Canada border (Brooks 1915), but have not been observed on the eastern North Slope in recent decades (USFWS 2002b). The Alaska-breeding population of Steller's eiders now nests primarily on the North Slope, particularly around Barrow and at very low densities from Wainwright to at least as far east as Prudhoe Bay (Figure 3.5). A few pairs remain on the Y-K Delta, with 9 nests found in the last 14 years (Service, unpublished data).

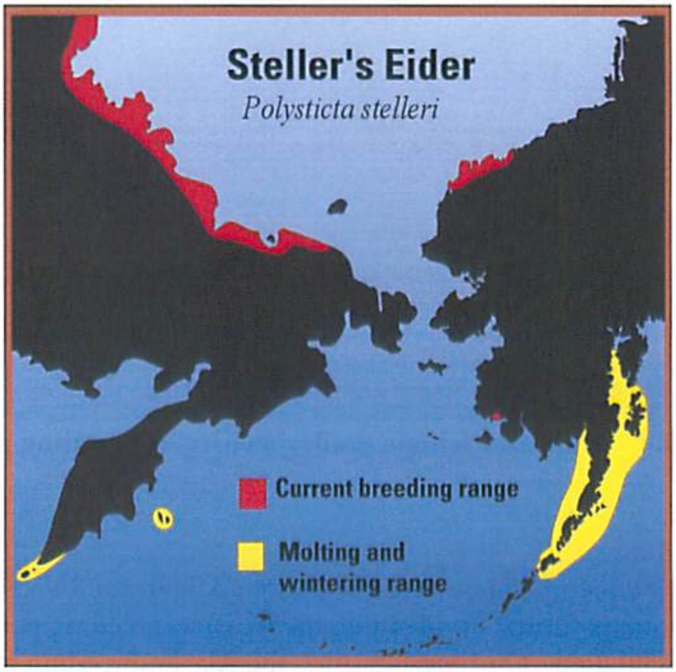

Figure 3.5 - Steller's eider distribution in the Bering and Chukchi Seas (USFWS 2002b).

After the breeding season, Steller's eiders move to marine waters where they undergo a complete flightless molt for about 3 weeks. The combined Pacific wintering population (which includes populations that breed in eastern Russia and Alaska) molts in numerous locations in southwest Alaska, with exceptional concentrations in four areas along the north side of the Alaska Peninsula: Izembek Lagoon, Nelson Lagoon, Port Heiden, and Seal Islands (Gill et al. 1981, Petersen 1981, Metzner 1993). After molting, many of the Pacific-wintering population of Steller's eiders disperse to the eastern Aleutian Islands, the south side of the Alaska Peninsula, and as far east as Cook Inlet, although thousands may remain in lagoons used for molt unless or until freezing conditions force them to move (USFWS 2002b). Prior to spring migration, thousands of Steller's eiders stage in estuaries along the north side of the Alaska Peninsula, including some molting lagoons, and at the Kuskokwim Shoals near the mouth of the Kuskokwim River in late May (Larned 2005, Martin et al. *in prep.*).

North Slope Breeding Population
Steller's eiders arrive in pairs on Alaska's North Slope in early June, but may be episodic breeders; since 1991, Steller's eiders near Barrow apparently nested in 9 years but did not nest in 7 years (Rojek 2006). Non-breeding years are common in long-lived eider species and are typically related to inadequate body condition (Coulson 1984), but reasons for Steller's eiders non-breeding may be more complex. In the Barrow area, Steller's eider nesting has been related to lemming numbers and other environmental cues; nest success could be enhanced in years of lemming abundance because mammalian predators are less likely to prey-switch to eider eggs and young, or because avian predators such as pomarine jaegers (*Stercorarius pomarinus*) and snowy owls (*Nyctea scandiaca*) that nest nearby (and consume abundant lemmings) may protect eider nests from mammalian

predators such as arctic fox (Quakenbush and Suydam 1999, and summarized by Rojek 2006).

Nest initiation dates for Steller's eiders at Barrow between 1991 and 2006 ranged from June 6 to June 28 (Rojek and Martin 2003, Rojek 2005, Rojek 2006). Male Steller's eiders typically leave the breeding grounds once females begin incubating. Incubation lasts between 24 (USFWS et al. 2002c) and 27 days (Fredrickson 2001), with hatching occurring from July 7 to August 3 (Quakenbush et al. 1998).

Hens move their broods to ponds with emergent vegetation, particularly *Carex* spp. (Rojek 2005) and *Arctophila fulva* (Quakenbush et al. 1998) soon after hatching. Here they feed on insect larvae and other wetland invertebrates. Fledging occurs 32-37 days after hatching (Obritschkewitsch et al. 2001, Rojek 2005). Females and fledged young depart the breeding grounds in early to mid-September.

Aerial surveys indicate that Steller's eiders occur at extremely low densities across most of the North Slope (Larned et al. 2006), with the highest densities occurring near Barrow (Figure 3.6). Because Alaska-breeding Steller's eiders occur at very low densities, there is not sufficient information to estimate population size or detect population trends. The mean 1992-2006 aerial-survey generated population index[3] was 116 (n=15, standard deviation [sd] = 204), but the range of indices in these years ranged from 20 (calculated in a year when no birds were seen) to 785 (Larned et al. 2006). The most recent index (2002-2006) was 112 (n=5, sd=98). However, aerial surveys likely undercount Steller's eiders for several reasons. An unknown number are simply missed when observers count from aircraft; this proportion varies by species and is unknown for Steller's eiders. Additionally, because observations at Barrow indicate that many Steller's eiders vacate nesting habitat early in non-nesting years, it is possible that aerial surveys fail to detect some individuals that were present early in the season, at least in some years. Further, the concentration near Barrow, which contains a significant proportion of Steller's eiders detected on the entire North Slope in most years, may be under-sampled because: 1) the scale of the concentration is too small to be adequately represented in the sampling regime; and 2) a portion of the concentration area is excluded from surveys because the area near the Barrow airport cannot be flown due to aviation safety concerns. Due to these biases, we cannot precisely estimate Steller's eider abundance on the North Slope, but the best available information leads the Service to estimate that roughly several hundred Steller's eiders occupy the North Slope in most years.

[3] We present only an index (no population abundance estimate, as with spectacled eiders) because no aerial survey-ground survey correction factor has been created for Steller's eiders on the North Slope.

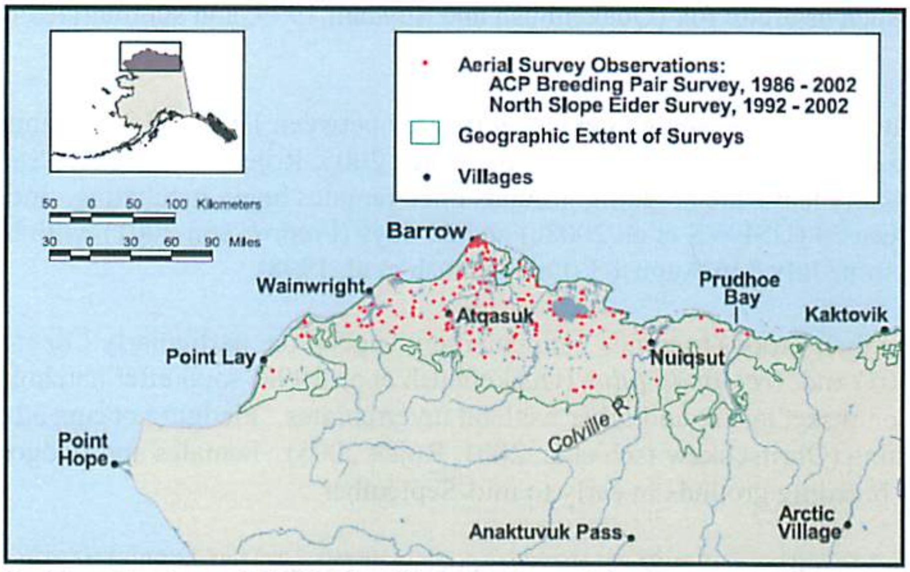

Figure 3.6 - Distribution of Steller's eiders from aerial surveys on the Arctic Coastal Plain, Alaska (USFWS 2002b).

Causes of Population Decline

When the Alaska-breeding population was listed as threatened, factors causing the decline were unknown, but potential causes identified were predation, over hunting, ingestion of spent shot in wetlands, and changes in the marine environment. Since listing, other potential threats have been identified; including exposure to oil or other contaminants near fish processing facilities in southwest Alaska, but causes of decline and obstacles to recovery remain poorly understood.

Kittlitz's Murrelet

Physical Appearance

Kittlitz's murrelets are small diving seabirds in the family Alcidae (including puffins, guillemots, and murres) which inhabit Alaskan coastal waters. Breeding plumage is mottled golden-brown and winter non-breeding plumage is more distinct, with a white underbelly and face and dark back and chest band.

Distribution and Status

Kittlitz's murrelets are often found in association with marine tidewater glaciers and glacial-influenced water and in protected fiords (Kuletz and Piatt 1992, Day and Nigro 1998). In the eastern Pacific and Arctic areas they range from Taku Inlet in Southeast Alaska north to about Point Barrow in the Chukchi Sea. The species has not been recorded in the Beaufort Sea (Divoky 1984, Johnson and Herter 1989), but it is possible they occur there in small numbers. The entire North American population occurs in Alaskan waters, migrating between offshore waters in winter and nearshore waters in summer, which are presumably near breeding areas (Fig. 3.7). Kittlitz's murrelets possibly nest as far north as Cape Sabine and Cape Beaufort on the Chukchi Sea coast.

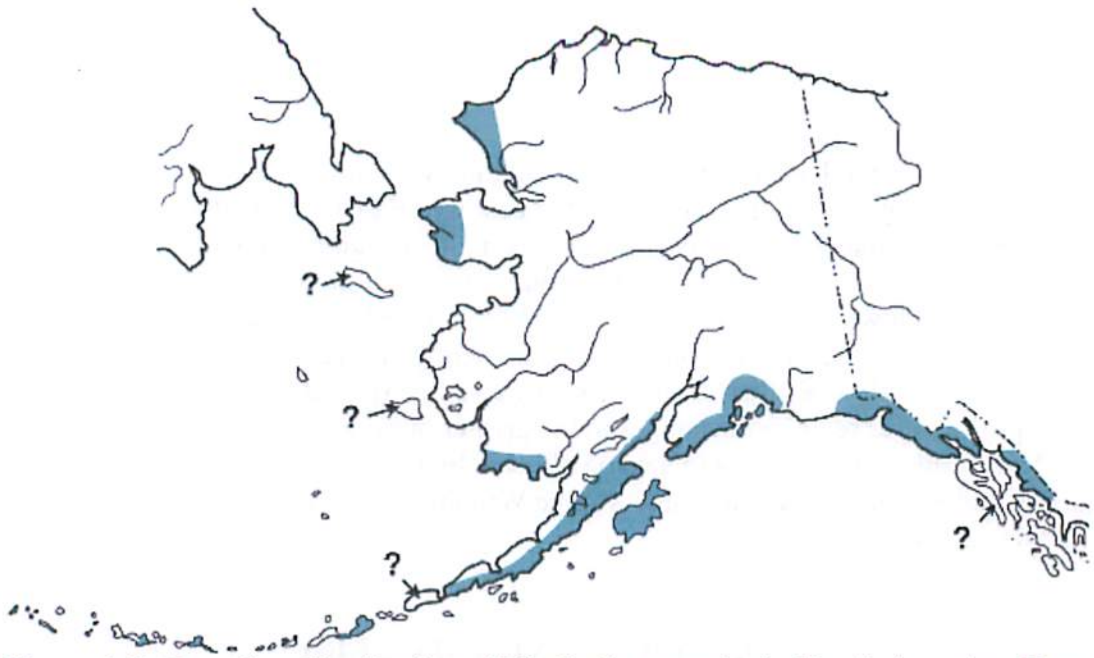

Figure 3.7. Breeding distribution of Kittlitz's murrelet in North America (Day et al. 1999).

Suitable nesting habitat is lacking north of Cape Beaufort, so the species rarely occurs and probably does not breed north of there (Huey 1931, Bailey et al 1933, Bailey 1948, Pitelka 1974).

Both the timing and migration routes to and from the breeding grounds are unknown. It is likely that Kittlitz's murrelets follow the retreating ice edge, feeding on invertebrates associated with ice plankton blooms. There is no information on migration routes.

The Kittlitz's murrelet's winter range is poorly known. Only 31 have been seen on Alaska Christmas Bird Counts from 1967 to 1997, suggesting most leave protected bays and go to sea during winter.

The Kittlitz's murrelet is thought to be one of the rarest seabirds in North America, with a total population estimate of 9,000-25,000 birds. Surveys indicate significant population declines have occurred in three core areas: 84% in Prince William Sound since 1989; 38-75% near Malaspina Glacier; and a rate of decline that could result in extinction in 40 years in Glacier Bay. On May 4, 2004, the Kittlitz's murrelet was designated a candidate for protection under the Act because of its sharply declining numbers, indicating the species warrants listing as threatened or endangered (Federal Register 69(86):24875-24904).

Diet and Feeding

Principle summer foods are thought to be small fishes and macro-zooplankton; winter foods are unknown, although the stomach of one museum specimen contained macro-zooplankton (Day et al. 1999). This species has been documented to forage extensively in turbid waters near tidewater glaciers and near glacier-fed streams as well as within clear water areas. Kittlitz's murrelets forage singly or in small groups during the day and night (Day et al. 1999).

Population and Causes of Decline
The causes of decline in Kittlitz's murrelets are not known, but may be related to the retreat of tidewater glaciers since the turn of the century. Exactly how glacier retreat might affect the murrelets is unknown, but studies in other regions have recorded low biological productivity in fjords with receding glaciers as a result of increased sedimentation and lowered salinity (Day et al. 1999). Lowered productivity could result in fewer forage fish, or sedimentation that affects feeding efficiency. In addition to changes in fjord habitats, Kittlitz's murrelets may also be affected by changes in their available prey species relative to changes in the greater marine environment (Kuletz 2004). The Kittlitz's murrelet could also be affected by increased marine traffic and tourist helicopter flights in Kenai Fjords, Prince William Sound, and Yakatak and Glacier bays (Kuletz 2004).

4. ENVIRONMENTAL BASELINE

The environmental baseline provides an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, their habitat, and ecosystem in the action area.

Spectacled and Steller's Eiders

Spectacled and Steller's eiders may be present in the action area from late May through approximately late October. Both species nest on Alaska's North Slope between early June and September, and individuals migrate through the Beaufort Sea from May through the end of October. Both species have undergone significant, poorly explained declines in their Alaska-breeding populations. Factors in the action area that may have contributed to the current status of spectacled and Steller's eiders are discussed below and include, but are not limited to, toxic contamination of habitat, increase in predation, and habitat loss through development and disturbance.

Toxic Contamination of Habitat
The deposit of lead shot in tundra or nearshore habitats used for foraging is a threat for spectacled and Steller's eiders. Lead poisoning of spectacled eiders has been documented on the Y-K Delta (Franson et al. 1995, Grand et al. 1998) and in Steller's eiders on the North Slope (Trust et al 1997; Service unpublished data). Use of lead shot for hunting waterfowl is prohibited statewide, and for hunting all birds on the North Slope. Outreach programs are being undertaken to reduce any lingering illicit use of lead shot that may be occurring on the North Slope, and hunting does not occur in the action area due to the proximity of oil field infrastructure.

Water birds in arctic regions are also exposed to global contamination, including radiation and industrial and agricultural chemicals that can be transported by atmospheric and marine transport. Twenty male spectacled eiders wintering near St. Lawrence Island examined for the presence and effects of contaminants apparently were in good condition, but had high concentrations of metals and subtle biochemical changes that may have long term effects (Trust et al. 2000).

Increase in Predator Populations
It has been speculated that anthropogenic influences on predator populations or predation rates may have affected eider populations, but this has not been substantiated. Steller's eider studies at Barrow suggest that high predation rates explain poor breeding success (Quakenbush et al. 1995, Obritschkewitsch et al. 2001). Researchers have proposed that reduced fox trapping, increased anthropogenic food sources in villages and oil fields, and nesting sites on human-built structures have increased fox, gull, and raven numbers (R. Suydam and D. Troy pers. comm., Day 1998), but the connection between these factors and increased predation rates has not been proven.

Habitat Loss through Development and Disturbance
With the exception of contamination by lead shot, destruction or modification of nesting habitat is not thought to have played a major role in the decline of spectacled or Steller's eiders. Until recently eider breeding habitat on the North Slope was largely unaltered by humans, but now limited portions of each species' breeding habitat has been altered by community and industry growth leading to wetland fill, material site development, the presence of structures that present collision risk, and other human activities that may disturb birds or increase populations of predators.

Kittlitz's Murrelet

Kittlitz's murrelets are closely associated with marine tidewater glaciers, and their decline may be related to the retreat of glaciers and decreased foraging habitat. Boat tours of tidewater glaciers have increased substantially in southeast Alaska, and this may be increasing disturbance of Kittlitz's murrelets in foraging areas. The primary distribution and breeding range of Kittlitz's murrelets occurs in southeast Alaska, outside of the action area. Activities in the action area are not thought to be impacting the decline, or recovery, of this species.

5. EFFECTS OF ACTION ON LISTED SPECIES

This section of the BO provides an analysis of effects of the action on listed species and critical habitat. Both direct effects, i.e., those immediately attributable to the action; and indirect effects, i.e., those caused by the action but which will occur later in time, are considered. Finally, interrelated and interdependent effects of the action are discussed.

Direct Effects
MMS identified the following potential impacts to listed eiders from the Liberty project:

A. Habitat Loss
B. Disturbance
C. Collisions
D. Increased Predation
E. Oil Spills

A. Habitat Loss
The Liberty project would expand the seafloor footprint of Endicott SDI by approximately 20 acres. The expansion area is located in water with a depth of 4 to 11 feet which is within the depth range for eiders feeding on mollusks and other invertebrates. Although the expansion may result in the loss of some marine feeding and staging habitat, the Service does not consider this type of habitat to be limiting for listed eiders in the Beaufort Sea. In addition, available satellite telemetry data do not suggest this area is heavily used by listed eiders (TERA 2002, Peterson 1999). Therefore, the loss of this small area of habitat is not likely to adversely affect listed eiders.

Gravel mining and transportation will result in the loss of nesting habitat for spectacled and Steller's eiders. BP Alaska intends to mine an estimated 860,000 cy of gravel from a new material site adjacent to the Duck Island Mine Site. Organic and non-organic overburden will be stripped and stockpiled separately. Gravel will then be removed and transported to the construction sites via ice and gravel roads. A berm will be constructed around the excavated area to prevent flooding during spring and summer while the pit remains active. MMS estimates activities at the material site will disturb 37 acres.

The new mine site is on a raised gravel bench close to the Sagavanirtok River, adjacent to the existing Endicott Road (Figure 5.1). Multiple years of Service aerial survey data indicate the proposed material site is in an area that supports a relatively low density of spectacled eiders (<0.1-0.6 birds/km^2) (Figure 5.2). Aerial photography suggests the proposed mine site is relatively dry, with polygonal ground and small ponds favored by nesting Steller's and spectacled eiders only present in the extreme northeast of the mine site. The proposed site is adjacent to the existing Endicott Road and Duck Island Material Site and is impacted by human activities in these areas, further reducing the habitat quality for eider nesting.

Figure 5.1 – Aerial photograph of the proposed material site, the existing Duck Island mine site, and the Endicott Road.

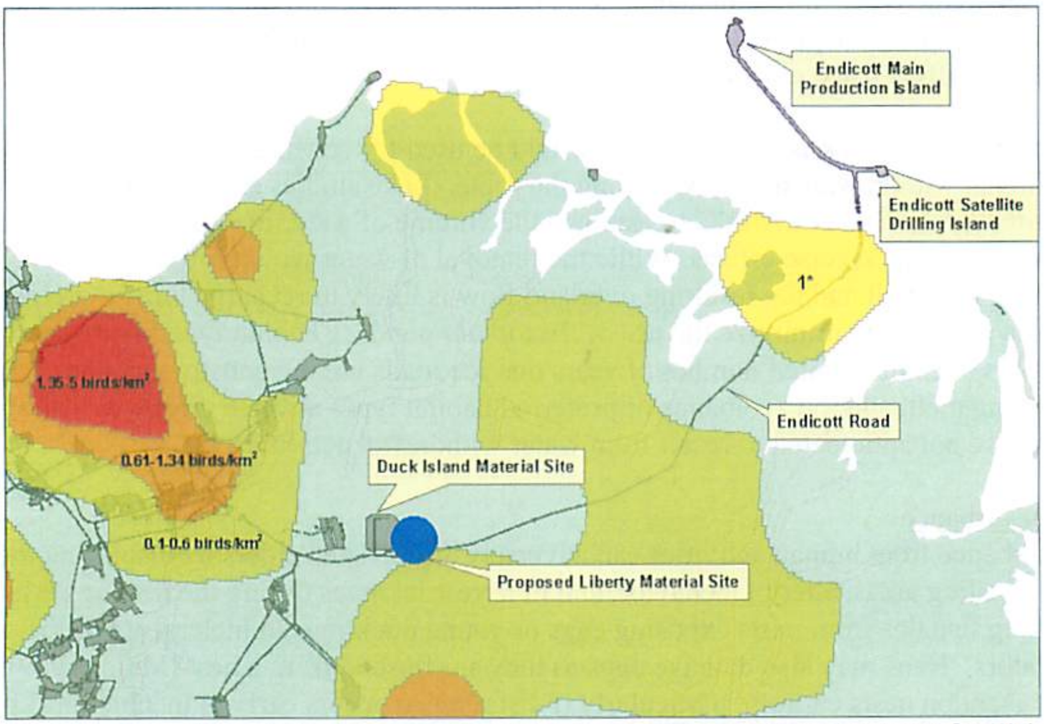

Figure 5.2 – Location of the proposed material site and existing Endicott facilities in relation to the average density of spectacled eiders/km^2 (Service data).

1* - The polygons were constructed using a kernel analysis technique and are intended to illustrate the approximate density of spectacled eiders over a large scale landscape.

BP Alaska has developed a preliminary reclamation plan for the material site. Overburden from the site will be used to form side slopes around the excavation area, the berm will be breached allowing the pit to slowly flood. Disturbed areas may have a layer of organic overburden placed over them before seeding with native grass. The rehabilitation plan aims to restore the area to functioning wetland habitat. Much of the site will be a deep water pond, with the remaining area vegetated slopes. Based on the proposed plan it is not clear if the reclaimed site will support nesting spectacled or Steller's eiders in the future.

BP Alaska intends to construct an ice road from the material site to the Endicott SDI. This road will allow the gravel-haul trucks direct access to the SDI without impacting normal traffic on the existing road system.

There have been several studies on the impacts of ice road construction to different tundra types. Overall, these studies have found that impacts from ice roads are low, with occasional areas of moderate level impacts (Pullman et. al. 2003). In one survey, damage occurred on higher, drier sites with little or no damage observed in wet or moist tundra areas (Payne et al. 2003, cited by Pullman et. al. 2003). Jorgenson (1999) found impacts were limited to isolated patches of scuffed high microsites and crushed tussocks. McKendrick (2003) studied several riparian willow areas and found that while branches were damaged the plants remained viable. As ice roads do not appear to cause significant damage to the types of tundra habitat used by listed eiders, and they will only be used for two years during the project construction phase, significant impacts to habitat that could adversely affect listed eiders are not anticipated.

Water from the Duck Island Mine Site would be used for constructing the ice road, with additional withdrawals from lakes along the route. Lake studies and permitting are required by the State of Alaska to estimate the volume of water that can be withdrawn without causing adverse effects. While the removal of water would lower water levels in lakes, spring melt and the resulting overland flow is likely to recharge these systems. BP Alaska proposes to minimize the use of *Arctophila* ponds, a habitat type favored by listed eiders. Given the limited number of years that ice roads will be constructed, the recharge by spring melt, and the avoidance of preferred habitat types adverse effects to listed eiders are not anticipated to result from water withdrawal activities.

<u>B. Disturbance</u>

Disturbance from human activities can adversely affect listed eiders by displacing them from feeding areas, altering behavior, and in terrestrial areas during the nesting period, flushing females from nests exposing eggs or young ducklings to inclement weather and predators. Hens may also damage eggs as they are flushed from a nest (Major 1989); and may abandon nests entirely, particularly if disturbance occurs early in incubation (Livezy 1980, Götmark and Åhlund 1984).

Terrestrial
The majority of construction activities are scheduled to occur in winter when listed eiders are not present, so disturbance will not occur.

The Liberty development is likely to increase vehicle traffic on roads and the Endicott causeway system during all phases of the project. The behavioral response and tolerance of Steller's and spectacled eiders to disturbance likely varies by individual. Steller's eiders have been observed nesting and raising broods close to the Barrow airport, and spectacled eiders are known to nest close to the Deadhorse airport (Service data). Studies of spectacled eider responses to aircraft and construction activities at the Alpine oilfield suggests broods can be raised successfully close to areas with significant levels of disturbance (Johnson et al. 2006). Disturbance from the road system is regular and ongoing, possibly allowing sensitive individuals to move to other locations, and less sensitive individuals to become habituated. Therefore, the Service believes that disturbance from increased traffic and activity in the terrestrial portion of the action area is unlikely to result in adverse effects.

Marine
Disturbance from Liberty-associated traffic, machinery, facility noise, and pedestrians will occur on the Endicott SDI, expansion area, Endicott MPI, and along the causeway. While this on-going disturbance may displace listed eiders from an area around the Endicott/Liberty facilities, the impacted area is likely small in relation the size of the available marine habitat in the Beaufort Sea. The disturbance is relatively constant in intensity and space, possibly allowing birds to habituate to it, and is not anticipated to result in measurable adverse effects on either a population or individual level.

BP Alaska intends to conduct at least one sealift of equipment and supplies for the Liberty project. A barge would traverse the Chukchi and Beaufort Seas en route to the Endicott SDI, potentially disturbing listed eiders in these areas. The severity of a disturbance and displacement effect depends upon the duration, frequency, and timing of the disturbing activity. Along most of the route, barges may encounter small numbers of listed eiders and could temporarily displace them as the vessels move through the area. BP Alaska has committed to ensuring vessels do not enter the Ledyard Bay Critical Habitat Unit (LBCHU), where large numbers of flightless spectacled eiders molt. By avoiding the LBCHU, and given the very low number of vessel journeys through the area, no adverse effects are anticipated from the sea lift.

Oil spill response training activities using small boats may also be conducted in the vicinity of the SDI and other Endicott facilities. These activities may displace eiders from the immediate area, but other comparable habitat is available in the area.

As disturbance at Endicott SDI is on-going and there is comparable habitat available in the area, adverse impacts to the few listed eiders that may utilize the area are not anticipated.

C. Collisions

Migratory birds suffer substantial mortality from collisions with man-made structures (Manville 2004). Birds are particularly at risk of collision with objects in their path when visibility is impaired during darkness or inclement weather, such as rain, drizzle, or fog (Weir 1976). In a study of avian interactions with offshore oil platforms in the Gulf of Mexico, Russell (2005) found collision events were more common, and more severe (by number of birds) during poor weather. Certain types of lights (such as steady-state red) on structures increase collision risk (Reed et al. 1985, Russell 2005, numerous authors cited by Manville 2000). This is particularly apparent in poor weather when migrating birds appeared to get into circulation patterns around structures after being attracted to lights and becoming unable to escape the "cone of light" (Russell 2005, Gauthreaux & Belser 2002, Federal Communications Commission 2004). BP Alaska has offered to discuss lighting options for the rig structures with the Service.

Day et al. (2005) suggested that eider species may be particularly susceptible to collisions with offshore structures as they fly low and at relatively high speed (~ 45 mph) over water. Johnson and Richardson (1982), in their study of migratory behavior along the Beaufort Sea coast, reported that 88% of eiders flew below an altitude of 10 m and >50 % flew below 5 m.

The Liberty project would involve the construction and operation of a large drill rig (350' wide x 44' high with a 230' high derrick), pipe racks, LoSal™ plant and other equipment, control room, and support facilities on the expanded Endicott SDI and Endicott MPI. The expansion area will be protected by a vertical sheet pile wall. The wall and structures on the pad all pose a collision risk for listed eiders.

Two new pipelines will be constructed between the Endicott MPI and SDI; however, these pipes will run in parallel and at the same height as existing pipelines and should not increase avian collision risk. No additional collision risk is anticipated to result from construction and operation of a camp facility on the Endicott MPI as these buildings would be surrounded by existing buildings and structures.

BP Alaska and MMS also note that spectacled eider females with broods are known to cross roads (TERA 1996). BP Alaska anticipates an unspecified increase in traffic on the road, which increases the potential of vehicle/eider collisions. However, there is a very low density of listed eiders in the area, and many of the nests that are present fail before hatching. There is also an absence of data suggesting eider / vehicle collisions are occurring. Further, between July 1 and August 15 the speed limits on the Endicott road system are reduced from 45 mph to 35 mph to protect snow geese (BP Alaska 2007), likely decreasing collision risk for eiders. Therefore, given the low numbers of birds, the absence of data, and the additional protection of reduced vehicle speed, the Service concludes that collisions are unlikely to occur and adverse effects are not anticipated.

D. Increased Predation

No actions described in MMS's development scenario are likely to increase marine-based predators of either listed eider species.

In the terrestrial environment predator and scavenger populations may be increasing near sites of human habitation, such as villages and industrial infrastructure. Day (1998) conducted a comprehensive literature review examining four key predators of tundra-nesting birds. Day concluded that individual glaucous gulls, grizzly bears, arctic foxes, and common ravens had increased survival and reproductive success when additional anthropogenic food sources such as garbage dumps were available. A population increase in these species could affect listed eiders and other ground nesting avifauna through egg, young, and even adult predation.

Solid waste and garbage will be generated throughout the project. Although practices in the existing North Slope oil fields have not prevented predators and scavengers from accessing human wastes, recently oil-field operators have installed predator proof dumpsters, implemented new refuse handling techniques, and are educating their workforce on problems associated with feeding wildlife in an attempt to eliminate anthropogenic food sources that can support predators in the area. BP Alaska intends to implement these techniques to prevent wildlife accessing anthropogenic food and waste (BP Alaska 2007).

New infrastructure may also lead to an increase in the number of ravens in the area by providing suitable nesting substrate. Ravens appear to have expanded their breeding range on the North Slope by utilizing buildings and other manmade structures for nest sites (Day 1998). While there is little data describing ravens regularly depredating tundra-nesting birds, Day (1998) interviewed a number of biologists who work on the North Slope and many felt that ravens may be highly efficient egg predators. The Liberty project may create additional artificial nesting habitat on the drill rig, pipe-racks, and other structures on the expanded Endicott SDI and MPI. BP Alaska has committed to search Liberty structures for raven nesting activities from March 1 through June 30 each year. Monitoring would take place every four days and if nesting materials are found they will be removed and disposed of to prevent their reuse by ravens. An annual report summarizing monitoring efforts will be provided to the Service by BP Alaska via MMS before December 31 each year.

Similarly, the flood protection berm, and stockpiles of organic overburden at the material site could provide den sites for foxes, conceivably allowing an increase in nest depredation. To ensure that predators of tundra-nesting birds do not benefit from these structures, BP Alaska intends to monitor the berm and stockpiles weekly from April 15 through June 15. If denning activities are observed the Alaska Department of Fish and Game and Service will be contacted to develop a plan to prevent further activity. An annual report summarizing monitoring efforts will be provided to the Service by BP Alaska via MMS before December 31 each year.

Based on the proposed operation and monitoring methods, the Service concludes that the Liberty Development Project will not result in an increase in the number or fitness of predators of listed eiders.

E. Oil Spills

The Service was not able to evaluate the Liberty Oil Discharge Prevention and Contingency Plan for this BO because it will not be completed until the end of 2007, when BPXA will submit an amended Endicott and Badami Oil Discharge Prevention and Contingency Plan. In the absence of a specific spill response plan, the Service made worst case-assumptions that predicted oil spills will be uncontrolled and unremediated, and that all listed eiders exposed to an oil spill will be killed.

Accidental hydrocarbon releases and associated clean-up activities could result from the proposed project. Oil or fuel products entering the environment can have significant impacts on waterfowl, including the listed eider species. Exposure to oil affects waterfowl in several ways. Waterbirds that have direct contact with even small amounts of oil or fuel products oil usually lose the water-proof properties of their feathers and become wet. They then become hypothermic and can die, particularly in cold environments (Hunt 1987, Piatt et al. 1990). Bird embryos are highly sensitive to petroleum. Mortality of embryos in incubating eggs and nestlings has also been documented by exposure to small amounts of hydrocarbon contamination (light fuel oil, certain crude oil, and weathered oil) transferred by adults with lightly oiled plumage (Parnell et al. 1984, Hoffman 1990, Szaro et al. 1980, and Stubblefield et al. 1995). Birds that ingest hydrocarbon contaminated food can experience both sublethal and lethal toxicological effects (Albers 2003, Peakall1982). Birds that feed on invertebrates or other organisms that can bioaccumulate or biomagnify hydrocarbons are vulnerable to both direct and sublethal toxic effects from a contaminated food supply (Albers 2003). As described previously in this BO, Steller's eiders and spectacled eiders feed on invertebrates in both marine and freshwater environments on the North Slope.

Several sources of fuel and crude oil spills are possible throughout the life of the Liberty project. These include small spills of refined product spills or crude oil, and large crude oil spills. The Liberty EIA (BP Alaska 2006) describes the risk and possible outcome of each type of spill, and the potential effect on listed eiders is evaluated below.

Small Crude Oil and Refined Product Spills

Using historical Alaska North Slope (ANS) data on small spills of crude oil and refined product from 1985 to 2006 (1,662 small crude oil spills, average volume 2.1 bbl; 5,456 product spills, average volume 0.8 bbls), the Liberty EIA predicts there will be approximately 16 small crude oil spills totaling 34 bbls (6-100 bbls 95% C.I.) over the life of the project, and 42 bbls of refined product will be spilled (10-125 bbls 95% C. I.), making no explicit prediction for the number of small product spills. The Liberty EIA also describes the ANS experience handling small spills (compared to large spills) indicating:

- Small spills are more likely to be contained on site;
- Small spills are more likely to be fully recovered;
- Small spills have a lower potential to produce significant adverse environmental impacts; and

- Small spills collectively account for only a small proportion of the total volume spilled.

In general the Service agrees the relative cumulative risk to listed eiders from exposure to small spills is likely to be very low.

Because small spills on land are usually more easily detected and contained, and the terrestrial density of spectacled eiders is relatively low in the project area, few individual spectacled eiders are likely to be exposed to oil if a small terrestrial spill were to occur. If a small spill were to occur in the marine environment, spectacled eider density in the marine environment is also very low; density in an aerial offshore survey (including the Liberty project area) was 0.04 birds per km^2 (Stehn and Platte 2000).

Likewise, annual eider aerial surveys suggest extremely low numbers of Steller's eiders nest on the eastern North Slope. During the 1999 and 2000 aerial surveys of the Liberty project area, no Steller's eiders were observed (Stehn and Platte 2000), so there is no indication that a large proportion of the Alaska-breeding Steller's eider population would encounter a small spill originating from the Liberty project.

Therefore, because small spills are low volume, and the density of both spectacled and Steller's eiders in the project area is very low, there is a correspondingly low likelihood that listed eiders would be affected by small spills in the marine environment. Thus the remainder of this evaluation focuses on large spills in the marine environment.

<u>Large Crude Oil Spills</u>
To conclude whether large marine spills might jeopardize the survival and/or recovery of spectacled eiders, the Service must consider the likelihood of one or more large spills occurring, and the likelihood that the spill(s) would affect or kill enough spectacled eiders to appreciably reduce the survival and recovery of the species.

The risk of large oil spills (defined for this analysis as >200[4] bbl) for the Liberty project was estimated based upon historical ANS crude and product spills for 1985 to 2006. There have been nine large (>200 bbl) spills on Alaska North Slope during the production of 11 billion bbls of crude oil. The Liberty project is expected to produce 105 million bbl over its lifetime. MMS provides estimated probabilities there will be 1, 2, or 3 large (200 bbl) crude oil spill over the life of the Liberty project as 7.8%, 0.3%, and <0.01%, respectively. Therefore, it can be concluded there is approximately an 8% probability that at least one large crude oil spill will occur during the Liberty project. The Liberty EIA analysis addressed the occurrence of a large crude oil spill anywhere on the facility and made no assumption regarding whether or not the spill reaches the water. The analysis also indicated the most likely volume of a large crude spill would be approximately 1,000 bbl (225 to 4,786 bbl, 95% confidence interval).

[4] MMS has frequently used 1,000 bbl as the threshold for a large spill. However, only one spill of that size has occurred on Alaska's North Slope since 1997. The Liberty FEIS used 500 bbl as the threshold of a large spill. Here 200 bbl was used to provide a statistically adequate sample size of large spills.

Stehn and Platte (2000) evaluated the exposure risk of birds to assumed oil spills from the Liberty project as it was previously designed (MMS and BP Alaska 2001). At that time BP Alaska proposed developing an offshore production island and a 4.6 mile subsea pipeline. Stehn and Platte's analysis estimated the average number of birds exposed to oil, and the proportion of the total bird population exposed to 500 modeled trajectories in July and August of a 5,912 bbl spill, and a 1,580 bbl spill from the Liberty project site. Although the current Liberty project presents even less risk of spill to the marine environment with the elimination of the production island and subsea pipeline, the analysis remains useful because it evaluates the potential exposure of marine birds to the current estimate of likely large spill volumes (up to about 4,786 bbl) in the immediate vicinity of the newly proposed project.

Stehn and Platte (2000) used bird studies in the Beaufort Sea for distribution information on sea ducks (including spectacled eiders), loons, and gulls during July and August in 1999 and 2000. These data were combined with simulated oil spill trajectories provided by MMS in a geographic information system to construct a spatial model overlaying bird density estimates with predicted trajectories of oil spill originating at the Liberty project. In the analysis, two chronic spill scenarios were modeled: a 1,580 bbl spill from a 30-day leak, and a 5,912 bbl spill resulting from a 60-day leak. No spectacled eiders were exposed to oil in 451 out of 500 simulated spills. In five of 500 simulated spills, 39 to 41 eiders were exposed for the 1,580 bbl spill, and 48 to 52 eiders were exposed for the 5,912 bbl spill. The average number of spectacled eiders exposed was 1.1 (maximum 41) for the 1,580 bbl spill in July, and 1.7 (maximum 52) for the 5,912 bbl spill in July.

Given that the estimated population size of spectacled eiders within the survey area during July was 540, the model predicts that, of those, the average (and maximum) proportions likely to be affected are 0.20 (7.6) percent, and 0.37 (9.6) percent for the 1,580 and 5,912 bbl spills, respectively.

As data suggests the North Slope breeding population of spectacled eiders has remained relatively stable since 2000 (Stehn et al. 2006), and the effects analysis is in the same geographic area, and uses a comparable volume of oil in the spill analysis, the Service concludes that the analysis is still relevant for the current Liberty project. The model predicts if a large spill were to occur in the summer, when listed eiders are present in the area, a maximum of 52 spectacled eiders may be killed. This equates to <1% of the estimated 12,916 North Slope population (Stehn et al. 2006). Therefore, we conclude a large spill event, such as the one modeled, is not likely to jeopardize spectacled eiders.

Annual eider aerial surveys suggest extremely low numbers of Steller's eiders nest on the eastern North Slope. During the 1999 and 2000 aerial surveys of the Liberty project area no Steller's eiders were observed (Stehn and Platte 2000), and there is no indication that a large proportion of the Alaska-breeding Steller's eider population would encounter a spill that originated from the Liberty project. Therefore, we conclude a spill from the Liberty project would not jeopardize listed Steller's eiders.

Indirect Effects
Indirect effects of the action are defined as "those effects that are caused by or will result from the proposed action and are later in time, but are still reasonably certain to occur" (50 CFR §402.02). After reviewing the project the Service concludes no indirect effects to listed eiders are reasonably certain to occur.

Interrelated and Interdependent Actions
Interdependent actions are defined as "actions having no independent utility apart for the proposed action," while interrelated actions are defined as "actions that are part of a larger action and depend upon the larger action for their justification" (50 CFR §402.02). The Service has not identified any interdependent or interrelated actions that may result from the proposed activities that could result in additional effects to listed eiders.

6. CUMULATIVE EFFECTS

Under the Act, cumulative effects are the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this BO. Future Federal actions that are unrelated to the proposed action are not considered because they require separate consultation under the Act.

Although further oil-related development or expansion of the material site may occur in the action area, the Service is not aware of planned developments. Furthermore, the action area and its surroundings are classified as wetlands or marine waters, so future development would presumably require a Section 404 permit. The issuance of this permit would serve as a federal nexus and section 7 consultation would be required. Hence, no cumulative effects are anticipated as a result of this project.

7. CONCLUSIONS

After reviewing the current status of spectacled and Alaska-breeding Steller's eiders, the environmental baseline, effects of the proposed activities, and cumulative effects, it is the Service's biological opinion that activities associated with the Liberty project are not likely to jeopardize the continued existence of either species, and are not likely to destroy or adversely modify designated critical habitat.

In evaluating the impacts of the proposed project to Steller's and spectacled eiders, the Service concludes that the direct adverse impacts could result through habitat loss, collisions, an increase in predators, and through crude and refined oil spills if they occur.

Using methods and logic explained in the Incidental Take Statement below, we estimate an incidental take of two spectacled eider eggs/chicks and one adult, and less than one Steller's eider egg/chick. The population of North Slope-breeding spectacled eiders is estimated at 12,916 birds, while our estimate of Steller's eider population size is roughly 500. Hence, the predicted incidental take should not have significant population-level effects. The Service therefore believes that this level of take will not significantly affect the likelihood of survival and recovery of either species.

Although the Act does not require consultation for candidate species, by mutual agreement with the MMS, we have evaluated potential impacts to Kittlitz's murrelets in anticipation of possible future listing. Although limited information currently exists regarding the specific distribution of the species, Kittlitz's murrelets do not appear to regularly occur in action area, and hence we conclude the Liberty project is not likely to pose a significant threat for this species. We appreciate the willingness of MMS to proactively consider the conservation needs of Kittlitz's murrelets.

8. INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. "Harm" is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, but not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement (ITS).

The measures described below are non-discretionary, and must be undertaken by MMS so that they become binding conditions of any permit or authorization issued to BP Alaska for the exemption in section 7(o)(2) to apply. MMS has a continuing duty to regulate activities covered by this incidental take statement. If the MMS (1) fails to assume and implement the terms and conditions, or (2) fails to require any applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse.

As described in Section 5 - *Effects of the Action*, the activities described and assessed in this BO may adversely affect Steller's and spectacled eiders through habitat loss at the material site, collision with structures, an increase in predators in the area, and oil spills.

Habitat Loss
Work at the material site will result in the loss of 37 acres (0.15 km^2) of potential eider nesting habitat. Incidental take that may result from this loss was estimated by multiplying the area of habitat loss by the estimated density of listed eiders. Spectacled

eider density in the material site area is estimated to be <0.1 birds/km^2 (Figure 5.2). Steller's eider density across the North Slope aerial survey area during 2002-2006 averaged 0.0045 birds/km^2 (Larned et al. 2003, 2005a, 2005b, 2006), and in the absence of site specific data, this average was used.

The density estimates were multiplied by the average clutch size for each species [5.5 eggs for Steller's (Service data), and 3 eggs for spectacled eiders (Petersen et al. 2000)], and project life. As it is not clear if the material site rehabilitation plan will restore any acreage to habitat suitable for eider nesting, a 100-year project life was used. Using this methodology an incidental take of 2 spectacled eider eggs/chicks and <1 Steller's eider egg/chick was estimated.

Collisions

The Liberty project would involve the construction and operation of a large drill rig and associated facilities on the expanded Endicott SDI. The proposed expansion would present a 1,394-foot sheet pile wall and 660 feet of buildings and structures across the east-west migration axis, posing a collision risk for birds. Although the project will involve construction of additional facilities on Endicott MPI, they will be sited between and beside existing structures, and should not significantly increase collision risk.

The Service anticipates that threatened eiders may collide with Liberty structures. However, estimating the number of collisions is difficult due to a lack of information on migration routes, behavior, and vulnerability to collisions with obstructions.

Migration routes of the species are not fully understood and may have considerable inter- and intra-annual variation. However, we assume that only birds nesting east of Liberty project structures are at risk. Service data from the 1993 – 2006 aerial surveys for breeding eiders on the North Slope was combined to provide a longitudinal distribution of spectacled eider observations. We estimate 1.93% of the population nest east of the action area. Using this information and the long-term population mean of 12,916 for spectacled eiders (Stehn et al. 2006), we estimate 250 spectacled eiders may migrate past Liberty each year.

A strike rate is required to estimate collision risk, but no specific data on spectacled or Steller's eider collision rates are available. We therefore used recorded numbers of common eider (*Somateria mollissima*) collisions at Northstar Island as a surrogate. Northstar Island is located north of Prudhoe Bay in the Beaufort Sea Outer Continental Shelf (OCS), and has a 560-meter north/south profile (i.e., the cross section of the island on a north-south axis). In 2000-2004, respectively, 6, 8, 0, 4, and 3 common eiders were known to strike Northstar, for an average of 4.3/year (2000 data reported by BP Alaska to the Service; 2001-2004 data from Day et al. 2005).

A collision risk (percent of population killed per year) was then calculated as the annual average of Northstar Island common eider strikes divided by the number of birds which presumably migrate past the island (176,109, the most recent population estimate of common eiders migrating over the Beaufort Sea (Quakenbush & Suydam 2004), according to the following formula:

$$\frac{\text{Annual average number of strikes}}{\text{Population estimate}} \times 100 = \text{Percent of population killed each year by collisions (strike rate)}$$

or:

$$\frac{4.3}{176{,}109} \times 100 = 0.0024\ \%$$

Assuming that spectacled and Steller's eider collision risk is similar to that of common eiders, the following mortality rate was estimated for spectacled eiders:

0.0024% (collision rate) of 500 birds (population of 250 birds passing through the area x 2 migrations, spring and molt) = 0.012 spectacled eiders/year.

The mortality rate was multiplied by 30, the life expectancy of the project, to give an estimated 0.36 (1) total spectacled eider killed by collisions with Liberty infrastructure.

Steller's eiders occur on the North Slope in extremely low densities, with very few recent observations in or east of the action area (Figure 3.6). Because so few Steller's eiders migrate through the action area, the Service considers it extremely unlikely that a Steller's eider will collide with any of the proposed structures, therefore no incidental take of Steller's eiders is anticipated as a result of collisions.

Oil Spills

There is always some risk of oil, fuel, or toxic spills associated with oil development. If a spill were to occur, particularly to marine waters, it is possible listed eiders could contact oil or oil products and die. However, as spills are not an otherwise legal activity, no incidental take is provided for oil or petroleum product spills.

9. REASONABLE AND PRUDENT MEASURES

These reasonable and prudent measures (RPMs) and their implementing terms and conditions aim to minimize the incidental take anticipated from BP Alaska's Liberty project. As described in Section 8 – *Incidental Take Statement*, project activities are anticipated to lead to incidental take of spectacled eiders through habitat loss and collisions.

To minimize the incidental take anticipated in this BO, MMS and their agents, BP Alaska, are required to undertake the following RPMs.

RPM A – Work with the Service to design, install, and operate strobe warning lights at Endicott SDI.

RPM B – Report all avian mortalities and collisions and their circumstances to the Service.

10. TERMS AND CONDITIONS

To be exempt from the prohibitions of Section 9 of the Act, MMS and their agent, BP Alaska, must comply with the following terms and conditions, which implement the RPM described above. These terms and conditions are non-discretionary.

RPM A – *Work with the Service to design, install, and operate strobe warning lights for the Endicott SDI.*

In cooperation with the Service, MMS and BP Alaska should develop and implement a system of strobe warning lights for the Endicott SDI.

Data from Northstar Island (Day et al. 2003) showed that the use of warning strobes significantly decreased eider flight speed at night. A net increase in the passing distance from eiders to Northstar was observed when the strobes were operating, and Day et al. (2005) concluded the lights caused some avoidance of the island.

Warning strobes should be placed outside the eastern sheet-pile wall in an effort to aid migrating eiders in avoiding the Endicott SDI. The lights should be synchronous, and not red in color. The Service recommends they be shaded in a manner that directs light outwards to the east, while minimizing their visibility to personnel on the island. The lights should operate from late June through the end of November when listed eiders may be moving east to west through the area. Their use can be temporarily suspended if required to ensure human safety (e.g., when aircraft are approaching).

RPM B – *Report all avian mortalities and collisions and their circumstances to the Service.*

Dead or injured birds observed in the project area, and any vehicle/avian collisions on the Endicott road system, should be reported to the Service. For purposes of this BO, the Endicott road system is defined as the road between the new material site, the Endicott SDI, and Endicott MPI. The date, time, location, and weather when the bird was observed should be included in the report. For vehicle collisions, a brief narrative describing the incident should be included. The Service does not recommend the collection of dead birds to avoid risk of avian influenza. However, a photograph should be taken to aid identification if possible. BP Alaska is responsible for transmitting this data to MMS within 7 days. As MMS is the federal agency with whom this consultation is being conducted, they are required to report all collisions to the Service and should do so as soon as practicable.

11. CONSERVATION RECCOMENDATIONS

Section 7(a)(1) of the Act directs federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. We recommend the following action be implemented:

MMS and BP Alaska are encouraged to:

- Continue to work with the Service to develop lighting designs and strategies that reduce collision risk for eiders at oilfield infrastructure.
- Continue to support research to improve our understanding of Steller's and spectacled eiders, the reasons for their decline, and assist in focusing and conducting recovery efforts.

In order for the Service to be kept informed of actions affecting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

12. REINITIATION NOTICE

This concludes formal consultation on the actions outlined in the Biological Assessment and other materials for the Liberty Development Project. As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

1) The amount or extent of incidental take is exceeded;
2) New information reveals effects of the action agency that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion;
3) The agency action is subsequently modified in a manner that causes an effect to listed or critical habitat not considered in this opinion; or
4) A new species is listed or critical habitat is designated that may be affected by the action.

Thank you for your cooperation in the development of this biological opinion. If you have any comments or require additional information, please contact Ted Swem, Endangered Species Branch Chief, Fairbanks Fish and Wildlife Field Office, 101 12th Ave., Fairbanks, Alaska, 99701.

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APPENDIX 1 – SUMMARY OF CONSULTATION ACTIVITIES

This summary of section 7 consultation activities refers only to the most recent project design (uERD with expansion of Endicott SDI). Details of consultation activities on previous Liberty project designs, and a full administrative record for the consultation, are available from the Fairbanks Fish and Wildlife Field Office.

12/11/06 - BP Alaska meets with Fairbanks Fish and Wildlife Field Office staff to provide an overview of the new design for the Liberty Development Project.

3/29/07 - FWS receives a species list request for the Liberty project from MMS.

4/3/07 - FWS sends the requested species list to MMS.

5/31/07 - FWS receives a Biological Assessment and supplemental information, and a memo requesting formal section 7 consultation be initiated.

6/20/07 - FWS responds that sufficient information has been received to allow consultation to begin.

7/2/07 - FWS receives the oil spill analysis for the Liberty project.

8/3/07 - Mr. John Goll (MMS Regional Director) telephone Mr. Thomas Melious (Service Regional Director) requesting that consultation be completed ahead of the statutory deadline.

8/8/07 - FWS requests clarification from BP Alaska on aspects of the project.

8/9/07 - BP Alaska responds to the request.

8/17/07 - FWS, MMS, BP Alaska and their consultants meet via teleconference to discuss the project and outstanding issues and possible terms and conditions.

8/20/07 - FWS distributes teleconference meeting notes, including a list of clarifications and descriptions required before the BO can be finalized.

8/28/07 - FWS distributes preliminary draft RPMs and terms and conditions for comment.

8/28/07 - MMS provides comments on draft RPMs and terms and conditions.

9/10/07 - BP Alaska submits additional information to support the BO.

9/18/07 - MMS and FWS discuss the additional information provided by BP Alaska.

9/18/07 - FWS requests clarification on some of the additional information provided in BP Alaska's September 10, 2007 letter.

9/19/07 - BP Alaska provides the necessary clarification.

10/1/07 - FWS e-mails the Draft BO to MMS.

10/2/07 - MMS provides minor comments on the Draft BO to the Service.

10/3/07 - FWS issues the Final BO.

Appendix D

Consultation with National Marine Fisheries Service (ESA Endangered Species)

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

FEB 17 2006

Dr. James Balsiger
Regional Administrator, Alaska Region
National Marine Fisheries Service
P.O. Box 21668
Juneau, AK 99802-1668

Dear Dr. Balsiger,

This letter serves as notification that pursuant to 50 CFR 402.08 and 600.920(c) the Minerals Management Service (MMS) has designated BP Exploration (Alaska) Inc. (BPXA) as the non-Federal representative for Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultations for the Liberty development project. The BPXA is also the applicant in the proposed federal action. As the designated non-Federal representative, BPXA will conduct informal consultations with the National Marine Fisheries Service (NMFS) and prepare any requisite Biological Assessment (BA) and EFH assessment.

In accordance with 50 CFR 402.07 and 600.920(b), we are also advising the NMFS that the MMS will be the lead agency for ESA and EFH consultations for the Liberty development project. As required, MMS will independently review and evaluate the scope and contents of the BA and EFH assessment and is ultimately responsible for compliance with section 7 of the ESA and sections 305(b) (2) and 305(b)(4)(B) of the Magnuson-Stevens Act.

Liberty is an oil field located about 5.5 miles offshore in the central Beaufort Sea. The BPXA is proposing to develop Liberty from onshore using extended reach drilling (ERD) technologies. The Liberty ERD project envisions an on-shore satellite with production sent by pipeline to an existing processing facility (Badami or Endicott).

Attached for your information is a copy of a Memorandum of Understanding (MOU), dated February 2, 2006, between the MMS, the Army Corp of Engineers (COE) and BPXA. This MOU sets forth responsibilities and a schedule to affect timely National Environmental Policy Act (NEPA) and permit evaluation processes for the Liberty development project. Attachment 2 to the MOU is a schedule for conducting the ESA and EFH consultations.

Jeff Walker with this office and Peter Hanley, BPXA Liberty HSE Manager briefed the Deputy Regional Administrator and the Director of the Protected Resource Division on the Liberty project last fall. We would be pleased to arrange an update briefing at your convenience. We would also appreciate information regarding your designated point of contact for both the ESA and EFH consultations.

We look forward to a working closely with your agency in a mutually beneficial regulatory process for the Liberty project. If there are any questions concerning the Liberty Project please contact Jeff Walker at 907-334-5303 or by e-mail Jeffery.Walker@mms.gov.

Sincerely,

John Goll
ACTING Regional Director

Enclosure: Liberty MOU

cc: Peter Hanley BPXA
Mike Holley

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

JUL 12 2007

Mr. Doug Mecum
Deputy Regional Administrator
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

Dear Mr. Mecum:

This letter is in regards to the Endangered Species Act Section 7 consultation request for the proposed Liberty Development and Production Plan-Bowhead Whale. The BP Exploration (Alaska) Inc. (BPXA) is proposing to develop the Liberty reservoir located southeast of the existing Endicott development. The project will utilize extended-reach drilling technology, and occur on a previously constructed satellite drilling island (SDI). The SDI will be expanded to accommodate this project, and remains connected to the mainland with a causeway.

The Mineral Management Service (MMS) Alaska Outer Continental Shelf (OCS) Region has entered into a Memorandum of Understanding with the US Army Corps of Engineers (USCOE); State of Alaska Department of Natural Resources; and BPXA to set forth the National Environmental Policy Act (NEPA) and permit evaluation responsibilities. An Environmental Assessment for the proposed action is being prepared by MMS, and is scheduled for completion in mid-August 2007.

The MMS recognized that the bowhead whale, an endangered species, occurs adjacent to the project area. On February 17, 2006, the MMS notified the Regional Administrator, Alaska Region, National Marine Fisheries Service (NMFS) it had designated BPXA as the non-Federal representative to conduct an informal consultation or prepare a biological assessment (BA) pursuant to Section 402.08 of the Endangered Species Act (ESA). The BPXA has coordinated with NMFS and submitted a transmittal letter (Enclosure 1) and a BA (Enclosure 2) to MMS on June 28, 2007.

The MMS and USCOE completed a review of the BA and coordinated subsequent modification of the BA with BPXA. The MMS and USCOE review and attached BA satisfy the information requirements specified in 50 CFR 402.12 and 402.14 and consequently constitute a complete consultation package for your review. The MMS determined that the proposed Liberty Development and Production Plan activities *are not likely to adversely affect* bowhead whales.

The MMS requests your concurrence on this finding and response indicating the same. If you determine that all or part of the proposed Liberty Development and Production Plan activities are likely to affect bowhead whales, we ask that you notify us as early as possible, according to 50 CFR 402.14(g)(5), to allow the MMS Alaska OCS Region and NMFS time to jointly discuss the findings. If necessary, such discussion would facilitate further consultation and ensure protection of bowhead whales. To facilitate timely completion of this consultation, we are sending a copy of this letter to Mr. Brad Smith, NMFS Anchorage Field Office, Marine Mammal Program.

If you have any questions on this consultation or require additional information, please contact Mr. Jeffrey Denton at (907) 334-5262.

Sincerely,

John Goll
Regional Director

Enclosure (s)

cc: (w/Enclosures)

Brad Smith, NMFS
Cash Fay, BPXA
Mike Holley, USACOE
Don Perrin, State of Alaska, DNR / OPMP

Enclosure 1

bp

BP Exploration (Alaska) Inc.
900 East Benson Boulevard
P.O. Box 196612
Anchorage, Alaska 99519-6612
(907) 561-5111

June 28, 2007

Mr. Jeffrey Walker
Regional Supervisor
U.S. Minerals Management Service
3801 Centerpoint Drive, Suite 500
Anchorage, AK 99503

Transmittal of Revised Letter Report
Biological Assessment (BA) for Section 7 Endangered Species Act Consultation for the National Marine Fisheries Service
Liberty Development Project

Dear Mr. Walker:

BP Exploration (Alaska) Inc. (BPXA) hereby transmits for your review and transmittal to the National Marine Fisheries Service (NMFS) a Letter Report Biological Assessment for the Liberty Development Project to support the Section 7 Endangered Species Act (ESA) consultation process. This report focuses on the endangered bowhead whale. This submittal has been revised to reflect proposed changes recommended by MMS from the original submittal of March 27, 2007.

Pursuant to 50 CFR 402.08, the Minerals Management Service designated BPXA as the non-federal representative for the ESA for the Liberty Development Project in a letter to Dr. Balsiger, Regional Administrator, National Marine Fisheries Service (NMFS) dated February 17, 2006.

BPXA is also the applicant in the proposed federal action. As the non-federal representative, BPXA has conducted informal consultations with the NMFS and has summarized potential project impacts to bowhead whales in the attached Letter Report (a format suggested by the NMFS).

If you have any questions or require further information, please contact me at (907) 339-5067.

Sincerely,

Cash E. Fay, Acting Liberty HSE Manager

Attachment

cc: Mike Holley, USACE
Don Perrin, OPMP

Liberty Development Project
Proposed Text of Letter Report to the National Marine Fisheries Service
Biological Assessment
Section 7 Endangered Species Act Consultation

Prepared by BP Exploration (Alaska) Inc.
For the Minerals Management Service
Pursuant to 50 CFR 402.08

June 2007

Background

BP Exploration (Alaska) Inc. (BPXA) is planning to develop the offshore Liberty reservoir located southeast of the existing Endicott development using extended-reach drilling technology from a shore-based pad rather than an offshore island as originally proposed. The location chosen for the drilling site is the Satellite Drilling Island (SDI) which is accessible by road from the Endicott causeway. SDI is located approximately 2.0 miles (3.2 km) offshore of the Sagavanirktok River delta well inside the barrier islands.

Request for Informal Consultation and Analysis

In accordance with the provisions of 50 CFR 402.10(c) and as discussed in a meeting between Brad Smith, NMFS, Dale Funk, LGL Alaska Research Associates and Dave Trudgen, OASIS Environmental, Inc. on December 6, 2006 the MMS requests an informal consultation, rather than a formal consultation that may include a Biological Assessment, regarding Section 7 requirements for threatened and endangered species. The bowhead whale, an endangered species which occurs in the general area of the proposed development activity, could potentially be affected by construction and oil production activities associated with the Liberty Project.

Most of the concerns related to the potential impacts to bowhead whales that may result from offshore development on the North Slope are related to the potential effects of noise on the bowhead whale migration corridor and potential effects on the subsistence bowhead whale hunt. Migrating bowhead whales that are deflected further offshore in response to industrial sounds may become less available to Native subsistence hunters who may be forced to hunt whales in more dangerous situations at locations further offshore. BPXA believes that the potential impacts to bowhead whales from the current development plan are reduced compared to the original (offshore) plan, and that impacts to bowhead whales from the SDI option will be negligible.

Most construction phase development activities for the Liberty SDI option would occur from approximately mid-November through March when the Beaufort Sea is ice covered and when bowhead whales are wintering in the Bering Sea. Winter activities would include gravel mining, ice-road construction and use, gravel placement at SDI, and potential replacement of the West Sag River Bridge. Installation of sheet pile wall along the northern and eastern sides of the expanded SDI would occur during the same period. Originally sheet pile wall construction was planned for the spring and early summer following gravel placement. However, BPXA has recently (March 2007) revised its construction plans to defer island expansion to the winter of 2009 and to install the sheetpile slope protection contemporaneous with the winter gravel placement. These activities would not have an impact to bowhead whales.

Noise-producing activities that could occur during the summer or fall when bowhead whales are migrating in the general vicinity of the Liberty development include drill-rig mobilization and drilling activity, well pad facility installation, pipeline construction, and installation of the *LoSal*™ process plant and other equipment at the Endicott facility. The results of numerous acoustical studies at Northstar Production Facility indicated that underwater sound produced from construction and oil production activities attenuate rapidly and reach background levels within a few kilometers of the sound source (Blackwell and Greene 2001, 2006). Underwater sound propagation is affected by numerous factors including bathymetry, seafloor substrate, and water depth (Richardson et al. 1995). Underwater sound propagation is reduced in locations where water is shallow compared to deep water locations. Underwater drilling noise could be audible up to 10 km during unusually calm periods (Green and Moore, 1995). Blackwell et al. (2004) indicated underwater broadband sound levels from drilling Northstar reached background levels about 9.4 km from the island. McDonald et al. (2006) reported subtle offshore displacement of the southern edge of the bowhead whale migratory corridor offshore from Northstar Island. The Northstar Island is 8 km from the migration corridor and outside of the barrier islands where as the SDI is approximately 13-15 km from the migratory corridor, inside the barrier islands and in shallower water.

The fall bowhead whale migration corridor along the Alaskan Beaufort Sea coast is located 15 km or more offshore. Bowheads typically begin their fall migration out of the Canadian Beaufort Sea in late August and early September and continue through the Alaska Beaufort Sea throughout October. The peak number in the Alaskan Beaufort Sea is typically in mid September (Schick and Urban, 2000). Eskimo whalers have infrequently observed individual and groups of a few whales in the bay mouths between the barrier islands and inside the barrier islands. These observations have ranges from between 8.8 and 10 km from the SDI. Results of the Northstar studies that describe the rapid attenuation of underwater industrial sounds suggest that, particularly in shallow waters similar to those surrounding the Liberty SDI development option, sounds resulting from construction and production at or near SDI are not likely to affect migrating bowhead whales (Blackwell and Greene 2006). Given that the Liberty development will occur entirely inside of the barrier islands (Endicott SDI is located in shallow water about 2 miles off the mouth of the Sagavanirktok River) it is less likely to affect migrating bowhead whales than Northstar, which is outside of the barrier islands. Impacts to individual whales or the bowhead population is considered negligible.

The greatest potential for activity related to construction of the Liberty SDI option to impact bowhead whales would result from a sealift of the *LoSal*™ process plant and other equipment to the MPI which is scheduled for summer 2012. Summer is defined here as the early portion of the open-water season from July through late-August. Bowhead whales are unlikely to occur in the project area prior to mid-August and summer sealift activities would be unlikely to affect bowhead whales. Small numbers of bowhead whales could be affected by the sealift activities should these activities extend beyond mid-August. Bowhead whales have been known to respond to vessel noise and activities, and the sealift could have the potential to cause a temporary deflection of some bowhead whales at the southern edge of the migration corridor. Any deflection to migrating bowheads would occur while the sealift vessel was transiting the near shore waters of the Beaufort Sea. The potential deflection effects to bowhead whales could occur over several days.

To the greatest extent possible, BPXA will plan all operations to avoid impacts to the bowhead migration and the annual bowhead hunt. Mitigation will, in all but exceptional cases, be achieved by scheduling sealift operations to avoid the migration timing and periods of the annual hunt. Typically, depending upon ice and weather conditions, sealifts in the central Beaufort Sea can be completed in August prior to the main migration of bowhead whale and subsistence whaling. Should the sealift be delayed for any reason, then BPXA would coordinate this activity with the Alaska Eskimo Whaling Commission (AEWC) and Barrow and Nuiqsut whaling Captains' Associations through a Conflict Avoidance Agreement (CAA) or other communication mechanisms. Consistent with safe navigation and ice conditions, the sealift may be routed inshore to avoid migrating bowhead whales and subsistence whaling.

As described in BPXA's *Liberty Development Project Development and Production Plan, Attachment A Environmental Impact Assessment (2007,)* the SDI alternative for development of the Liberty project would result in very low probability of oil spills reaching bowhead whales. Most small spills would be contained on the SDI pad and only a large spill that reached the ocean during migration would have the potential to impact large numbers of bowhead whales. Even with a large spill the likelihood that oil would move beyond the barrier islands before it was contained is small.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

October 19, 2007

John Goll
Director, Alaska Outer Continental Shelf Region
Minerals Management Service
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

Dear Mr. Goll:

The National Marine Fisheries Service (NMFS) has completed informal consultation regarding the Liberty project in the U.S. Beaufort Sea, Alaska. The Minerals Management Service (MMS) and Army Corps of Engineers are the Federal action agencies responsible for issuing permits to allow the operator, British Petroleum, to drill into Federal waters of the Alaskan Outer Continental Shelf. MMS is designated as the lead Federal action agency for this consultation.

The Corps of Engineers' public notice describes the proposed construction of an offshore oil facility in waters of the Beaufort Sea at Foggy Island Bay (POA-1998-1109-2, the Liberty project). This work would expand the existing Endicott drilling island with approximately 20 acres of marine fill, approximately 18 acres of fill associated with a gravel mine site adjacent to the Duck Island mine site, fill in 0.3 acres of marine waters to construct a boat launch at Endicott MPI, and renovate and expand the bridge over the West Saganavirktok River. The project's goal is to use Ultra-extended Reach Drilling to gain access to the Liberty oil prospect. Pressure will be maintained by a Low-Sal™ water injection technique. Using the existing Endicott SDI allows the project to avoid on-water drilling or construction of a new drilling island. It also avoids installing approximately 6.1 miles of buried pipeline to deliver the product. The Notice identifies the bowhead whale as the only species for which NMFS bears responsibility under the Endangered Species Act which may be affected by this project. No designated critical habitat occurs within the action area.

MMS and the Corps of Engineers have preliminarily determined that the described activity is not likely to adversely affect the bowhead whale. Based on an analysis of the information provided, NMFS concurs with this determination. This concurrence is based on information provided in the Submittal of Revised Oil Spill Risk Analysis Environmental Impact Analysis, the Biological Assessment (BPXA for MMS), the project proposal, the Corps of Engineers' Public Notice of Application for Permit, and other sources of information. A complete administrative record of this consultation is on file in this office. While the Liberty project may affect these whales, our assessment (described below) finds any such effects are insignificant (such effects could not be meaningfully measured or detected) or discountable (such effects would not reasonably be expected to occur).

Discussion
The potential for bowhead whales to be affected by this project will depend in large part on their occurrence in or near the project site. Bowhead whales are seasonally present in the Beaufort Sea. Beginning in late March, bowheads migrate north through the Bering Strait and into the Beaufort Sea, arriving in the Canadian Beaufort Sea from mid-May through June. They return in fall, migrating westward along the continental shelf of the Alaskan Beaufort Sea during September and October. Fall migrant bowhead whales generally migrate at least 18 to 20 km offshore in water depths exceeding 10 to 18 m. The satellite drilling island is approximately 13-15 km landward from this migration corridor (BPXA 2007).

Bowheads do not typically occur in the nearshore Beaufort Sea (i.e., inside the barrier island system) near the project area. During the spring migration eastward through the Alaskan Beaufort Sea, the nearshore waters of Prudhoe Bay are completely ice-covered and bowheads are far offshore of the Sagavanirktok River Delta, following open leads in the sea ice. During the fall, bowheads are usually more than 60 km offshore in heavy ice years, whereas in light or moderate ice years they generally occur more than 30 km from shore (BLM, 2004). In either type of ice year, this is far from the proposed project area.

During the fall migration, bowheads may occur closer to shore than in spring, depending on ice conditions. However, bowhead whales are rare nearshore in Prudhoe Bay. In years with light ice in the fall, surveys showed that bowheads occurred in waters deeper than 10 m while other studies have shown bowheads are generally restricted to waters 18 m deep. The area surrounding the project area is generally less than 3 m deep. Water depths of 10 m or greater occur at distances of about 20 km or more from the proposed development. Given that bowheads reportedly use water depths greater than 10 m; they are not likely to be found at the proposed Liberty project site. Although the presence of bowheads in the immediate project area is unlikely, bowheads occasionally use nearshore waters of the Beaufort Sea inside the barrier islands. Any bowhead whales that enter such waters could potentially be affected by this facility during construction or operation. Each of these phases of development is discussed.

Construction
Plans for the Liberty project facility call for the placement of gravel fill, a gravel mine, a boat-launch ramp on Endicott SDI, a bridge across the West Sagavanirktok River, and a sea-lift of equipment to the site. Proposed fill placement will occur in winter, and Bowhead whales would not be present in the Beaufort Sea during this time.
The existing satellite drilling island would be expanded by 20 acres of fill. Installation of infrastructure on the islands and well drilling would occur during open water periods of the next several years including times of bowhead whale migrations. This work would include construction of drilling modules and drilling of production and injection/disposal

wells. It is important to note that this work would predominantly or wholly consist of work on the newly expanded island, rather than in-water work. Offshore drilling from natural or man-made islands generally produces underwater sounds that are weak and do not propagate beyond a few kilometers (Richardson and Williams 2004). Continuing Liberty project facility work during the open-water season would involve shore protection (placement of gravel bags) and vessel support. Work extending into the fall migration, including the possibility of sea-lift work if needed, could expose bowhead whales to construction noise. However, most bowheads pass offshore of the barrier islands north of this project and would be unlikely to receive noise at this distance or the received levels of such noise would not be expected to cause significant change in whale behavior.

Bowhead whales receiving noise from the Liberty project might move further offshore, but would be expected to continue their migration. Monitoring studies of the Northstar Island facility in the Beaufort Sea found that offshore displacement of bowhead whales occurred at times of loudest noise occurring during construction in 2001 (predominately due to vessel activity). However, no significant displacement was observed in subsequent years. The 2001 displacement was evident only when sound was averaged over 70 minutes, and the effect decreased with distance (Richardson and Williams 2004). The applicant does anticipate a possibility of a sea-lift for this project. Most of this traffic would occur within Foggy Island Bay where distance and the presence of barrier islands can be expected to partially screen seaward-propagating vessel noise from reception by migrating bowheads. Again, few bowhead whales are likely to occur in the deeper portions of Foggy Island Bay during the fall migration. Monitoring studies for the Northstar facility found that vessel noises were the main contributor to the underwater sound field. This noise was detectable as much as 30km from the island. However, whales may not react to noise at such distances. Bowhead whales are known to avoid small boats at distances up to 4 km, but most reactions have been observed at ranges of less than 1.9 km (Richardson et al. 1985). Whales tend to show little response to larger vessels that move slowly and are not heading towards them. NMFS believes any effects on bowhead whales due to vessels associated with construction of this project would be insignificant.

Pile driving presents concerns regarding the noise introduced into the water and its potential to harass bowhead whales. Information provided by the Corps and the applicant indicate no pile driving is associated with construction. Our assessment of the effects of this project on bowhead whales assumes no pile driving would occur during open water periods. Any use of pile driving would be outside the scope of this consultation and would require reinitiation of consultation.

Operation

Operationally, the Liberty project facility may affect bowhead whales. Given that bowheads reportedly occur in water depths greater than 4.3 to 6m, and migrate in waters deeper than 10 m, it is unlikely a bowhead whale would approach the island drill sites.

During studies conducted on the Northstar project to the west of this site, combined in-water drilling and production noise during open water reached ambient levels at distances of 2-4 km. Northstar production noise presumably is greater than that potentially generated by Liberty because Northstar has on-island processing whereas Liberty will employ production-only drillsites with onshore processing. Therefore, the probability that bowheads will receive elevated drilling and production noise is low. At that point, drilling and production noise should be at the level of regular ambient noises. Regardless, it is not likely that noise emanating from Liberty would be detectable to offshore whales.

The potential for oil spills associated with the Liberty project and the delivery pipeline also has the potential to affect bowhead whales. This effect was considered in information provided by *BPXA's Liberty Development Project Development and Production Plan, Attachment A Environmental Impact Assessment (2007).* A spill that entered coastal waters in September or October could affect bowhead whales if the spill volume were large and the spill trajectory carried oil seaward of the barrier islands where fall-migrating whales can occur. However, the spill would have to travel long distances to reach migrating whales. Fall migrant bowhead whales generally use a migration corridor 13-15 km from the project site.

A number of small oil spills have occurred during oil and gas exploration in the Alaskan Beaufort Sea in past years. Only five spills have been greater than one barrel, and the total spill volume from drilling 52 exploration wells (1982 through 1991) was 45 barrels. Based on historical data, most oil spills would be less than one barrel, but a larger oil spill could also occur. Everett Consulting Associate's spill risk calculations project an estimated number of large spills form the Liberty project at about 0.09. Considering the number of days each year that bowhead whales may be present in or migrating through the area, the probability that a spill would occur, the probability for a spill to occur or persist during periods when whales are present, and the probability that oil would move into the migration corridor of the bowheads (at least that portion of the corridor outside of the barrier islands), it is unlikely that bowhead whales would be contacted by oil. Adverse affects would only be expected if all of these low probability events occurred at the same time; therefore NMFS considers these effects to be discountable.

Mitigation

The potential effects of this action on bowhead whales will be mitigated by the following factors as detailed in the project proposal submitted to the Corps of Engineers:

The project would be sited to provide a natural barrier to sound transmission into normal bowhead whale habitat.

Drilling muds, cuttings, and produced waters would not be discharged into the Beaufort Sea but re-injected into the underlying formations.

Mitigation is also already designed into the project in the site selection, and usage of pre-existing facilities, as discussed in the introduction.

Conclusion

NMFS has reviewed pertinent information regarding this project as noted above. We believe that project design, construction, and operation of the Liberty project is not likely to adversely affect the Bering-Chukchi-Beaufort Sea stock of bowhead whales for the reasons discussed above.

This concludes section 7 consultation. Reinitiation of consultation is required if: (1) take of a listed species occurs, (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not previously considered, or (4) a new species is listed or critical habitat designated that may be affected by the action.

Please direct any questions to Brad Smith at (907) 271-3023.

Sincerely,

Dr. James W. Balsiger
Administrator, Alaska Region

cc: John Goll, Minerals Management Service, Alaskan OCS Office

Appendix E

Consultation with National Marine Fisheries Service (Essential Fish Habitat)

RSLE ehkw

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

MAY 04 2007

Robert D. Mecum
Acting Administrator, Alaska Region
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

Re: EFH Consultation for Liberty Development Project

Dear Mr. Mecum:

BP Exploration (Alaska) Inc. (BPXA) is planning to develop the offshore Liberty reservoir located southeast of the existing Endicott development using extended-reach drilling technology. The project would occur on a previously constructed pad (connected to the mainland with a causeway) rather than an offshore island as originally proposed.

The Minerals Management Service (MMS) designated BPXA as the non-federal representative for Essential Fish Habitat (EFH) consultation for the Liberty Development Project, pursuant to 50 CFR 600.920(c). BPXA has delivered the enclosed document to fulfill MMS's responsibilities under the Magnuson-Stevens Fishery Conservation and Management Act of 1996 (Act). We consider the enclosed document to generally serve as the EFH Assessment for the Liberty Development Project. Despite designating BPXA as the non-federal representative, the MMS remains ultimately responsible for meeting sections 305 (b) (2) and 305 (b) (4) (B) of the Act. Therefore, the MMS must provide a conclusion regarding the effects of the proposed action on EFH.

The MMS and US Army Corps of Engineers have determined that the proposed action may adversely affect EFH identified under the Act. The primary difference between an EFH Assessment prepared by MMS and BPXA is that the MMS does not challenge the presumption that the waters of the Beaufort Sea constitute EFH for Pacific salmon and we have consistently treated these areas as if they were EFH. This difference in interpretation is largely inconsequential because we believe the proposed project is consistent with the NOAA document entitled Non-Fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures (2003). As a result, the MMS believes that while there may be minor adverse effects on EFH, those effects have been reduced to the maximum extent practicable.

Please provide any Recommended Conservation Measures on the Liberty Development Project to us within the next 30 days so that we may incorporate those measures into the authorization process, as appropriate. Please contact Mark Schroeder at (907) 334-5247 or at mark.schroeder@mms.gov if you have any questions or require additional information on this consultation.

Sincerely,

John Goll
Regional Director

Enclosure

cc: Mike Holly
Matt Eagleton
Brad Smith

Leasing &
Environment Office

- [x] RSLE
- [ ] Chief EAS
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Author (Buechler)
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cc:

Matthew Eagleton
National Marine Fisheries Service
222 West 7th Avenue, #43
Anchorage, Alaska 99513-7577

Brad Smith
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bp

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Anchorage, Alaska

REGIONAL SUPERVISOR
FIELD OPERATIONS
MINERALS MANAGEMENT SERVICE

BP Exploration (Alaska) Inc.
900 East Benson Boulevard
P.O. Box 196612
Anchorage, Alaska 99519-6612
(907) 561-5111

March 26, 2007

Mr. Jeffrey Walker
Regional Supervisor
U.S. Minerals Management Service
3801 Centerpoint Drive, Suite 500
Anchorage, AK 99503

Transmittal of Threatened and Endangered Species Essential Fish Habitat Brief for the National Marine Fisheries Service
Liberty Development Project

Dear Mr. Walker:

BP Exploration (Alaska) Inc. (BPXA) hereby transmits for your review and transmittal to the National Marine Fisheries Service (NMFS) *Threatened and Endangered Species Essential Fish Habitat Brief for the Liberty Development Project*. This Brief was prepared for BPXA by LGL Ecological Research Associates, Inc...

BP Exploration (Alaska) Inc. ((BPXA) is planning to develop the offshore Liberty reservoir located southeast of the existing Endicott development using extended-reach drilling technology from a shore-based pad rather than an offshore island as originally proposed. The location chosen for the drilling site is the Endicott Satellite Drilling Island (SDI) which is accessible by road from the Endicott causeway. SDI is located just offshore of the Sagavanirktok River delta. As you know, in a letter Dr. Balsiger, Regional Director, National Marine Fisheries Service (NMFS) dated February 17, 2006 pursuant to 50 CFR 402.08 and 600.920(c), the Minerals Management Service designated BPXA as the non-federal representative for Endangered Species Act (ESA) and Essential Fish Habitat (EFH) for the Liberty Development Project. BPXA is also the applicant in the proposed federal action. As the non-federal representative, BPXA has conducted informal consultations with the NMFS and has provided the information detailed in the attachment according those discussions with NMFS.

Please call me at 907-339-5024 if you have any questions or need more copies.

Sincerely,

Peter T. Hanley, Liberty HSE Manager

Attachment

cc: Mike Holley, U.S. Army Corps of Engineers

Liberty Development Project Proposed Endicott Satellite Drilling Island (SDI) Alternative

Threatened or Endangered Fish Species Essential Fish Habitat

A Brief

by

Robert G. Fechhelm Ph.D.
LGL Ecological Research Associates, Inc.
1410 Cavitt St.
Bryan Texas 77845

for

BP Exploration (Alaska) Inc.
P.O. Box 196612
Anchorage, Alaska 99519–6612

March 2007

LGL Ecological Research Associates Inc. (LGL) has been requested by BP Exploration (Alaska) Inc. to prepare a Biological Brief regarding the Liberty Development Project Satellite Drilling Island (SDI) Alternative. This brief addresses the issues of 1) threatened and endangered fish species and 2) Essential Fish Habitat (EFH).

Threatened and Endangered Fish Species

Presently, there are no fish species in the State of Alaska that are 1) listed as either endangered or threatened, 2) candidate species for listing as either endangered or threatened, or 3) proposed for listing as either endangered or threatened (USFW 2006).

Essential Fish Habitat

The Fishery Conservation and Management Act of 1976 established national standards for the conservation and management of exploited fish and shellfish stocks in U.S. Federal waters. Coastal waters extending 200 nautical miles seaward, but outside areas under State jurisdiction, were delineated as fisheries conservation zones for the U.S. and its possessions (later defined as the Exclusive Economic Zone [EEZ]). Fishery Management Councils were created to manage fish stocks within those conservation zones based upon the national standards. Councils were required to prepare Fishery Management Plans (FMPs) that would provide the basis for local administration and management of regional fisheries. FMP components generally address management objectives, alternatives and rationale; habitat issues; the benefits and adverse impacts of each alternative; and plans for the monitoring, review and possible amendments to any action.

The Fishery Conservation and Management Act was followed by the Magnuson-Stevens Fishery Conservation and Management Act of 1996 (MSA), as amended by the Sustainable Fisheries Act of 1996, which required that FMPs further include the identification and description of Essential Fish Habitat (EFH). The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA § 3(10)). The EFH Final Rule (50 CFR Part 600) further elaborates that "waters" include aquatic areas and their associated physical, chemical, and biological properties; "substrate" includes sediments underlying the waters; "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. EFH pertains to only commercially-exploited fish and shellfish species under Federal management. EFH includes areas that are under either Federal (offshore) or State (freshwater and coastal) management jurisdiction. The Act also requires Federal agencies to consult and comment on any activities that may adversely affect EFH. Under the National Environmental Policy Act (50 CFR 600.920[e]), in conjunction with stipulations of the MSA, Environmental Impact Statements are required to address issues pertaining to EFH.

Pursuant to NOAA, NMFS (2005), the Preliminary Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska, it is the current position of NMFS that the only two species of fish found in the Beaufort Sea that are amenable to EFH regulation and consideration are the pink salmon (*Oncorhynchus gorbuscha*) and the chum salmon (*O. keta*) (Jon Kurland, Director, NMFS Habitat Conservation Division, Juneau, pers. comm.; Lawrence Peltz, NMFS Habitat Conservation Division, Anchorage, pers. comm.). This is also the position of MMS (Jeff Childs, pers. comm.). Although all five species of Pacific salmon have been reported from the Beaufort Sea, three of these, chinook (*O. tshawytscha*), sockeye (*O. nerka*) and coho (*O. kisutch*) salmon are extremely rare and no known spawning stocks have been identified in the region (Craig and Haldorson 1986, Fechhelm and Griffiths 2001, Stephenson 2006).

Chum Salmon (*Oncorhynchus keta*)

The chum salmon ranges from the Sacramento River in California (and stray as far south as Baja California) north to the Arctic and east to the Mackenzie and Anderson Rivers, west along the Arctic coast of Siberia to the Lena River (Laptev Sea), and south along the coast of Asia to Korea and Japan (Scott and Crossman 1983, Morrow 1989, Salo 2003). In Arctic Canada, small runs of chum salmon have been reported within the Mackenzie River watershed in Great Bear Lake, below Fort Smith in the Slave River, and in the upper Liard River (McPhail and Lindsey 1970, Scott and Crossman 1973; O'Neil et al. 1982; McLeod and O'Neil 1983). Isolated yet reliable reports of chum salmon taken throughout the Mackenzie River drainage date back to 1914 (Stephenson 2006). Chum salmon have been occasionally reported as far east of the Mackenzie River as the Hornaday River (Corkum and McCart 1981, Stephenson 2006). Runs within the Mackenzie River are likely quite small. Of the 30 major fishery surveys that have been conducted over the past 35 years in the Mackenzie River drainage, river drainages along the Canadian coast, and the coastal waters east, west, and within the Mackenzie River delta, almost all report taking no chum salmon (Fechhelm and Griffiths 2001). A 1979 escapement estimate in the Liard River was about 400 fish (Craig and Haldorson 1986).

In the Alaskan Beaufort Sea, small runs of chum salmon have been documented in the Colville River drainage Bendock (1979). In recent years, smolts have been caught in the lower delta (Moulton 2001). Although chum salmon are occasionally taken in the summer subsistence fishery that operates out of the village of Nuiqsut on the Colville River, they constitute only a minor portion of total catch (Moulton et al. 1986). Chum salmon are almost never taken in the fall subsistence fishery that operates from October to December (Moulton and Seavey 2005). There is no direct evidence that chum salmon spawn in the Sagavanirktok River or any other Alaskan River east of the Colville River (Craig and Haldorson 1986). Adult chum salmon are only occasionally taken in Alaskan coastal waters (Fechhelm and Griffiths 2001).

Small runs of chum salmon may also occur in rivers closer to Barrow. Although variable from year to year, substantial numbers of chum are taken in the Chipp River and in Elson Lagoon including adults in spawning condition (C. George, pers. comm., North Slope Borough, Department of Wildlife Management). However, multiple year surveys conducted in the Dease Inlet/Admiralty Bay area reported taking no chum salmon (Philo et al. 1993). Craig and Haldorson (1986) suggest that several rivers along the Chukchi Sea coast between Barrow and Point Hope may support small runs.

Pink Salmon (*Oncorhynchus gorbuscha*)

The pink salmon ranges from La Jolla, California, north to the Arctic and east to the Mackenzie River, west along the Arctic coast of Siberia to the Lena River (Laptev Sea), and south along the coast of Asia to Korea and Japan (Scott and Crossman 1983, Morrow 1989, Heard 2003). In Arctic Canada, rare takes of individual pink salmon have reported since 1936, but in almost all cases only single specimens have been captured (Craig and Haldorson 1986, Babaluk et al. 2000, Stephenson 2006). Most pink salmon have been caught in or near the Mackenzie River Delta. The farthest inland capture was made in the Peel River approximately 120 km from the coast (Hunter 1974 cited in Stephenson 2006). The extraordinarily low numbers of fish reported for Canadian waters suggest they are strays and that there are probably no spawning stocks in the Mackenzie Watershed (Craig and Haldorson 1986, Babaluk et al. 2000, Stephenson 2006). Small runs of pink salmon occur in several drainages along the Chukchi Sea coast (Craig and Haldorson 1986).

In the Alaskan Beaufort Sea, small runs of pink salmon occur in the Colville River. Bendock (1979) caught 64 pink salmon between the mouths of the Itkillik and Etivluk rivers during 1978 and noted fish spawning near the Itkillik River and at Umiat. In 1978, McElderry and Craig (1981) caught two males spawners near Ocean Point just above Nuiqsut. Small numbers of pink salmon are taken in the summer subsistence fishery that operates out of the village of Nuiqsut on the Colville River, but they constitute only a minor portion of total catch (Moulton et al. 1986). Pink salmon are almost never taken in the fall subsistence fishery that operates from October to December in the lower Colville Delta (Moulton and Seavey 2005), however, in recent years, "substantial numbers" of pink salmon have been taken farther inland near the Itkillik River as part of the fall fishery (C. George, pers. comm., North Slope Borough, Department of Wildlife Management). Pink salmon are also taken in the subsistence fisheries operating in the Chipp River and Elson Lagoon just to the east of Point Barrow (C. George, pers. comm., North Slope Borough, Department of Wildlife Management).

In the Sagavanirktok Delta/Prudhoe Bay region, pink salmon are regularly taken in summer fish surveys but numbers are quite low (Fechhelm et al. 2006). In 24 summers of sampling, only 375 pink salmon have been caught. All are adults in spawning condition. In 1982, Griffiths et al. (1983) reported taking eight pink salmon upriver in the west channel near the Sagavanirktok Bridge where several dead spawned-out adults were also observed. However no actual spawning sites or activities have ever been reported for the Sagavanirktok Watershed or any drainage east of the Colville River.

Arctic Expansion

In recent years, concern has been expressed that global warming could allow southern stocks of Pacific salmon from the Bering Sea to expand northward into Arctic waters where they might establish spawning populations (Babaluk et al. 2000, Stephenson 2006). Overall, evidence of climatic change in the Arctic continues to mount (Carmack and MacDonald 2002). Climate models predict a warming trend that could be quite intense at higher latitudes (Walsh and Crane 1992). Carmack and MacDonald (2002) note that the disproportionate influence of warming on Arctic physical systems will have profound effects on Arctic biota. Physical changes will include increased periods of open water, decreased ice cover, rising sea levels, increased storms, shifting water mass fronts, and more. Babaluk et al. (2000) note that changes in the distribution and abundance of salmon in Arctic waters may be useful proxies for monitoring the effects of climate change on the Beaufort Sea.

For 24 of the past 26 years, summer fish monitoring studies have been conducted in Beaufort Sea coastal waters in and around Prudhoe Bay (Fechhelm et al. 2006). Although the catch of pink salmon is relatively low, it is rather persistent through time. From 1981 through 2006, the summer catch rate for pink salmon exhibited no evidence of a protracted shift in abundance (Figure 1). Catch rates for 2003, 2004, and 2005 were significantly higher than all but one of the previous 20 years but CPUE dropped substantially in 2006 when only four pink salmon were taken.

The extension of chum and pink salmon into arctic waters is probably linked to a number of factors. Craig and Haldorson (1986) suggest that intolerance of cold temperatures, particularly in freshwater environments, may limit the establishment of coho and sockeye salmon in the Arctic. Pink and chum salmon are far more tolerant of cold temperatures (Craig and Haldorson 1986).

The predominantly marine life cycle of pink and chum salmon would also give them an advantage in establishing populations along the North Slope. Both species migrate to sea soon after emergence and do not rely on freshwater rearing and overwinting habitat (Heard 2003, Salo 2003). In contrast, sockeye and coho salmon spend one to several years in their natal watersheds before migrating to sea (Burgner 2003, Sandercock 2003). Some stocks of chinook salmon migrate to sea after only three months in freshwater, but most stay within their natal streams for their first year (Morrow 1980). Freshwater overwintering space is at a premium along the Arctic North Slope and the obligatory dependence of sockeye, coho, and possibly chinook salmon could severely limit their success. The ability of fish to exploit available overwintering habitat is considered by some to be the single most important factor limiting the success of amphidromous and freshwater species in the Arctic (Craig 1989).

The obligatory freshwater phase of sockeye and coho salmon would also leave them exposed for longer periods to the cold Arctic temperatures. Craig and Haldorson (1986) speculate that once they emerge into Beaufort Sea coastal waters, chum and pink salmon probably migrate southward toward the Bering Sea thereby avoiding cold Arctic waters during winter. The 1,200+ km summer journey would be well within the migratory capabilities of juvenile pink and chum salmon (Heard 2003, Salo 2003). Mature adults later migrate back to the Beaufort Sea to spawn. Excluding their egg phase, such a migratory cycle would mean that both species would only have to endure Arctic waters during the warmest part of the year.

The expansion of pink salmon into the Arctic may also be hampered by their fixed, two-year life span (Craig and Haldorson 1986). All pink salmon reproduce at age 2 and there is virtually no genetic overlap between alternate year spawning cohorts (Heard 2003). The reproductive output of either year class is confined to a single spawning event and if that spawning fails the bulk of the cohort gene pool could be forfeit. The other species of Pacific salmon are characterized by varying ages at which adults reach sexually maturity. The spawning success of a single cohort is spread out over several years and failure in any single year would not necessarily be catastrophic. Craig and Haldorson (1986) theorized that pink salmon populations in the Arctic probably undergo regular cycles of colonization and extinction due to their precise two-year spawning cycle coupled with the harsh climatic vagaries of the region.

The characteristics of egg deposition could also prevent pink and chum salmon from establishing major spawning stocks in North Slope rivers. Pink salmon from both Asian and North American populations typically spawn at depths of 30-100 cm (Heard 2003). Well-populated spawning grounds are mainly at depths of 20-25 cm , less often reaching depths of 100-150 cm. Redds themselves can be as deep as 46 cm (Scott and Crossman 1973). Chum salmon have adapted to spawning in waters of lesser depths than pink salmon (Salo 2003). In the State of Washington, maximum spawning depths have been reported to be 50 cm, and in Japan 110 cm (Salo 2003). Redd depths are typically less than 50 cm (Salo 2003). On the North Slope, all waterbodies freeze during winter and ice thickness can reach 200+ cm. Much of the substrate where salmon typically spawn would freeze thereby destroying the eggs. Greater survival would likely occur during milder winters when ice cover is less thick. Even during normal winters, much of the reproductive output of the spawning stock could be lost, a factor that could contribute to the relatively small runs that seem to occur in the few Arctic rivers that are populated.

In general, Pacific salmon do not possess the life-history characteristics that define anadromous species of the Arctic. Arctic anadromous fish possess unambiguous K-selective traits: longevity, delayed maturity, and repeat spawning in individuals (Craig 1989). Many species of Arctic anadromous fish have maximum life spans that range from 18-25 years (Craig

1989). In contrast, anadromous salmonids from temperature latitudes have maximum ages that range from 2 to 12 years (Scott and Crossman 1973, Groot and Margolis 2003). Arctic fishes reach sexually maturity in 7 to 11 years depending on species. Pacific salmon generally reach sexual maturity in 2-5 years. Arctic anadromous species are repeat spawners whereas all five species of Pacific salmon die after their first spawning. K-selective traits of Arctic anadromous fish undoubtedly reflective adaptation to the unique environment that they inhabit. K-selective populations are long-lived, have low population turnover rates, and have a relatively stable number of adults. Populations with many year classes of older repeat spawners are better able to withstand intermittent reproductive loss without jeopardizing the survival of the population (Craig 1989). These characteristics enable Arctic fish populations to remain generally stable in what otherwise might be considered a harsh and unstable environment (Johnson 1981, 1983). If these K-selective traits are prerequisites for a successful Arctic existence then they could determine the extent to which more R-selective Pacific salmon are able to expand their range into the Beaufort Sea.

Adverse Effects

The MSA requires federal agencies to consult with the NMFS on all actions or proposed actions permitted, funded, or undertaken by the agency that may adversely affect EFH. An adverse effect is any impact that reduces the quality and/or quality of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species, and their habitats, as well as other ecosystem components. Adverse effects may be site-specific of habitat-wide, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.910[a]).

Pacific salmon fisheries in the Alaska are managed under a combination of domestic and international regulations and treaties (NOAA, NMFS 2004). Salmon fisheries are managed by the Alaska Department of Fish and Game (ADF&G) within state waters, where most of Alaska's commercial fishing occurs. Commercial fishing within the EEZ is limited to southeast Alaska and Federal management is deferred to ADF&G. Harvests of chinook, coho, and sockeye salmon in southeast Alaska are managed by agreement with Canada under the Pacific Salmon Treaty. Management of salmon fisheries in international waters of the North Pacific is under the auspices of the North Pacific Anadromous Fish Commission, which consists of four countries (Canada, Japan, Russia, and the U.S.). Federal management of salmon stocks is largely directed by FMPs designed to limit the bycatch of salmon in non-salmon directed fisheries within the EEZ

By definition, the coastal waters in and around the Liberty Development site should not be classified as EFH for chum and pink salmon despite their marginal presence in the Alaskan Beaufort Sea. EFH pertains to habitat "required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR Part 600). There are no federally-managed commercial salmon fisheries in the Beaufort or Chukchi seas and it is highly doubtful that the low numbers of pink and chum salmon that regularly migrate to the Bering Sea constitute a meaningful component of the commercial fisheries there. There are also no federally-managed fisheries for other species within the Beaufort and Chukchi Seas thereby rendering the bycatch FMP issue moot. Again, it is highly unlikely that Beaufort Sea pink and chum salmon comprise a meaningful portion of bycatch within the North Pacific EEZ.

The MSA defines EFH as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA ' 3(10)). Current theory holds that, upon emergence into coastal waters, the small numbers of salmon that are spawned in the Colville River and rivers west migrate southeast to the warmer waters of the Bering Sea and do not return to the Beaufort Sea until time of spawning (Craig and Haldorson 1986). No juvenile salmon have ever been observed within the Prudhoe Bay area in over 26 years of study (Fechhelm et al. 2006). The few adults that have been caught in the Liberty Development area occur in late summer and are likely stray adult spawners returning to the Colville River. They have already grown to sexual maturity and are no longer feeding. Thus, there is no evidence that the waters in the vicinity of the proposed Liberty Development are used by salmon for any of the ecological requirements defined in the MSA.

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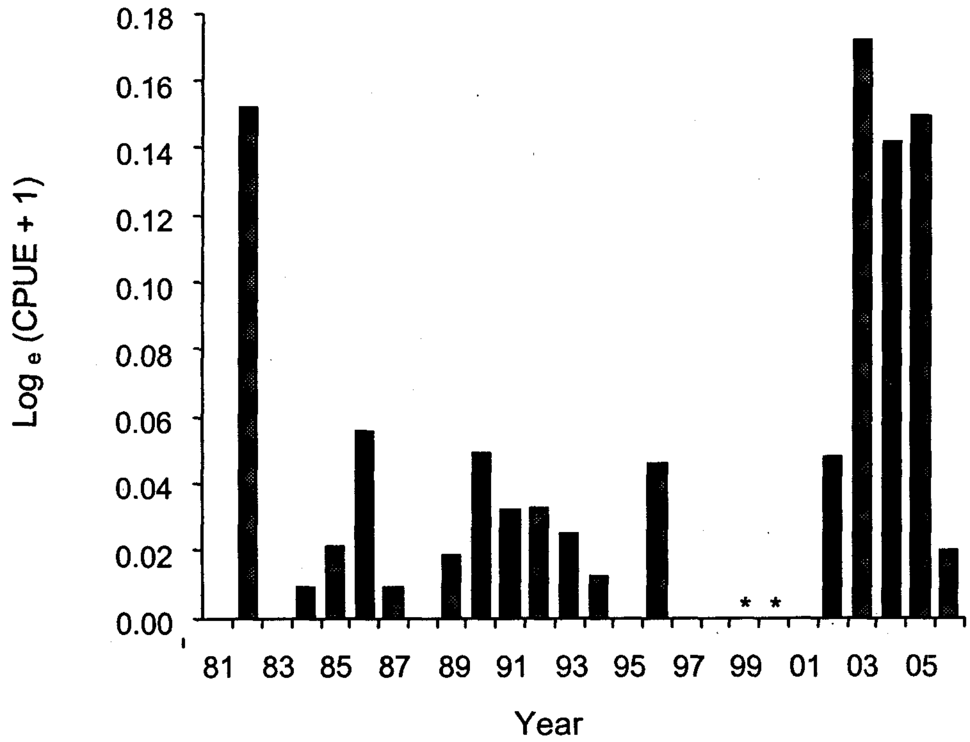

Figure 1. Loge (CPUE [fish/net/24 h]+1) for the 375 pink salmon collected in the Prudhoe Bay area by year. Asterisks indicate years in which no sampling took place. Catch rates for 1982, 2003, 2004, and 2005 were significantly (P = 0.008, t-test, Ostle and Mensing 1972) higher than the remaining 20 summers. Source: Fechhelm et al. (2006).

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

2007_08_31_14_24_06_NOAA_Liberty

August 27, 2007

John Goll, Regional Director
Alaska OCS Region
Minerals Management Service
3801 Centerpoint Dr., Suite 500
Anchorage, Alaska 99503-5823

RE: Liberty Expansion Project
POA-1998-1109-2

Dear Mr. Goll:

The National Marine Fisheries Service (NMFS) has reviewed the Minerals Management Service's (MMS) proposal to expand the Liberty Drill Site. Based on the information provided and our associated review of the U.S. Army Corps of Engineers (Corps) Public Notice (Department of the Army Permit Application Foggy Island Bay, POA-1998-1109-2, Foggy Island Bay) we offer the following comments specific to the Magnuson-Stevens Fishery Conservation and Management Act.

Section 305(b) of the Magnuson-Stevens Act requires federal agencies to consult with NMFS on all actions that may adversely affect Essential Fish Habitat (EFH). NMFS is required to make conservation recommendations, which may include measures to avoid, minimize, mitigate or otherwise offset adverse effects.

In our response to the Corps Public Notice (copy enclosed), NMFS offered two EFH Conservation Recommendations. Based on the information provided by MMS, we have no additional recommendations and no further EFH consultation is necessary.

Should you have any additional questions please contact either Jonathan Taylor or Jeanne Hanson of my staff at 907-271-5006.

Sincerely,

Robert D. Mecum

Robert D. Mecum
Acting Administrator, Alaska Region

Enclosure

UNITED STATES DEPARTMENT OF COMMERC
National Oceanic and Atmospheric Administratio
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

July 18, 2007

Colonel Kevin J. Wilson
U.S. Army Corps of Engineers
P.O. Box 898
Anchorage, Alaska 99506-0898

Re: Foggy Island Bay
POA-1998-1109-2

Attention: Mike Holley

Dear Colonel Wilson:

The National Marine Fisheries Service (NMFS) has reviewed the above referenced Public Notice, applicant BP Exploration (Alaska) Incorporated. The purpose of the proposed project is to recover oil from the offshore Liberty prospect. The project site is located in the North Slope of Alaska, Umiat Meridian. To take advantage of existing infrastructure at Endicott, BP proposes to drill the ultra-extended-reach-drill (uERD) wells from the Endicott Satellite Drilling Island (SDI). The project would include expansion of the existing SDI by 20 acres of fill into marine waters, 18 acres of fill would be associated with a gravel mine site adjacent to the existing Duck Island Mine site, and 0.3 acres of impacts for a boat launch. The project also includes plans for a new bridge across the West Channel of the Sagavanirktok River that will be reviewed as a modification of DA permit number POA-1992-90 or Nationwide Permit 15.

Conservation Recommendations

Fish and Essential Fish Habitat

Under Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation Management Act (Magnuson-Stevens Act), federal agencies are required to consult with the Secretary of Commerce on any action that may adversely affect EFH. The Corps has made a determination that the project may adversely affect EFH. The Magnuson-Stevens Act requires NMFS to make conservation recommendations regarding any federal action that would adversely affect EFH. The construction and operation of the proposed project would not adversely affect EFH and anadromous fish if necessary conservation measures are followed.

1. The applicant should use vegetated swales and/or an oil/water separator (or equivalent system) that remove total suspended solids (TSS) and oil and grease from the parking lot drainage, associated buildings, and roads. The applicant should also implement maintenance and monitoring plans for this system. Non-point source pollution can have deleterious effects on salmonids, particularly growth in juveniles. Petroleum hydrocarbons damage developing salmon eggs, larvae, and fry at extremely low concentrations. Sculpin eggs and larvae, and juvenile Pacific cod, which may occur in near shore areas, would likely experience similar effects.

2. Work on the new Sag River bridge should follow timing window restrictions to the best extent practicable. Timing window for the Sag River is August 15 to September 15.

Please note that under section 305(b)(4) of the Magnuson-Stevens Act, the Corps of Engineers (Corps) is required to respond in writing within 30 days to NMFS EFH Conservation Recommendations. If the Corps does not make a decision within 30 days, the Corps should provide NMFS with a letter to that effect, and indicate when a full response will be provided. Jonathan Taylor is the NMFS EFH contact for this project, and can be reached by telephone at (907) 271-2373 or e-mail at jonathan.e.taylor@noaa.gov.

Sincerely,

Robert D. Mecum
Acting Administrator, Alaska Region

cc:
Corps – Michiel.e.holley@poa02.usace.army.mil
ADNR/OHMP - cindy_anderson@dnr.state.ak.us
EPA - dean.heather@epa.gov
USFWS - phil_brna@fws.gov
HDR Alaska, Inc. - Robin.Reich@hdrinc.com
MOA - WigglesworthDT@ci.anchorage.ak.us

Appendix F

Consultation with Alaska Historic Preservation Officer (SHPO)

7 3130-1RLMMS

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

RECEIVED
JUL 16 2007

JUL 12 2007

Due 8/16

Ms. Judith Bittner
State Historic Preservation Officer
Office of History and Archaeology
550 West 7th Avenue, Suite 1310
Anchorage, Alaska 99501-3565

Dear Ms. Bittner:

The Minerals Management Service (MMS) is in receipt of the BP Exploration (Alaska), Inc.'s (BPXA) Liberty Development and Production Plan (DPP) and Environmental Impact Analysis, dated April 2007. The MMS entered into a Memorandum of Understanding with the US Army Corps of Engineers (USACE), State of Alaska Department of Natural Resources, and BPXA in November 2006. The MMS and USACE are jointly preparing an Environmental Assessment (EA), which is scheduled for completion in August 2007.

The MMS and USACE have mutually agreed to conduct separate consultations per the National Historic Preservation Act. The MMS will address the offshore effects of the proposed construction activities (beyond 3 miles of the shoreline), and the USACE will address the onshore and coastal effects (including the proposed expansion of the Satellite Drilling Island, out to 3 miles of the shoreline).

The BPXA informed our agencies on July 2, 2007, that a cultural resource survey in the area of the proposed project has been contracted to Reanier & Associates, Inc., and the final survey report is scheduled for completion in late 2007. We trust the survey will meet the requirements you have outlined in your recent correspondence.

The MMS has reviewed the offshore area of potential effect for historic resources by consulting its shipwreck database and the Alaska Historic Resources Survey database for other potential archaeological resources. No offshore prehistoric or historic resources were identified. Since no offshore resources were identified, and the well bore would be thousands of feet below the seafloor in offshore waters, the MMS has determined that there will be no effect upon offshore prehistoric or historic resources.

The MMS requests your concurrence with our "no effect" determination for offshore historic and prehistoric resources for the Liberty Development Project.

If you have any questions, please contact Michael Burwell at (907) 334-5249 or Casey Buechler at (907) 334-5265.

Sincerely,

John Goll
Regional Director

cc: USACE
Cash Fay, BPXA
Don Perrin, State of Alaska, DNR / OPMP

No Historic Properties Affected
Alaska State Historic Preservation Officer
Date. 8/9/07
File No.: 3130-1R MMS
MW

Appendix G

Consultation with Native Alaskans (Government to Government)

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

APR 17 2006

Fenton Rexford, Executive Director
Native Village of Kaktovik
PO Box 130
Kaktovik, Alaska 99747

Dear Mr. Rexford:

This letter confirms our meeting with the Native Village of Kaktovik Tribal Council and staff on April 18, 2006 to discuss the Liberty development project. The Minerals Management Service (MMS) and the US Army Corps of Engineers (COE) appreciate this opportunity to initiate joint Government-to-Government consultation with the Native Village of Kaktovik in accordance with Executive Order 13175.

As arranged by Albert Barros, MMS Community Liaison, British Petroleum Exploration, (Alaska), Inc. (BPXA) will provide a summary of the Liberty project via telecom. This will be followed by the MMS and COE overview of the process and schedule for the regulatory and National Environmental Policy Act review of the project. After our presentation, we welcome the opportunity for an open discussion, questions and concerns of the Native Village of Kaktovik.

The Liberty reservoir is located about 5 miles offshore in the central Beaufort Sea. BPXA is proposing to develop the Liberty reservoir from an onshore pad using extended reach drilling (ERD) technologies to reach the reservoir. BPXA is currently evaluating alternatives to onshore development options including pad location and host production facilities (Endicott or Badami).

We will provide the Tribal council and staff ten copies of a brochure dated November 2005 which will provide an overview of the Liberty ERD project and 10 copies of the document titled Liberty Update that summarizes the base or best case alternatives being evaluated by BPXA. Mr. Peter Hanley, BPXA Liberty Regulatory Affairs Manager, will provide an overview of this document.

Attendees will be Jeff Walker and Albert Barros from the MMS, Mike Holley from the COE. Also, participating via telecom will be Mr. Peter Hanley, and Cindy Bailey, BPXA Director, Regional Government and Community Affairs, Alaska.

Thank you for facilitating this meeting in observance of the recently signed MOU between the Native Village of Kaktovik and MMS regarding Government-to-Government Relations. We look forward to participating in the Native Village of Kaktovik Tribal Council's April meeting.

Sincerely,

Jeff Walker
Regional Supervisor
Field Operations

cc: Mike Holley, COE

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

MAY 11 2007

To: (see distribution)

The Minerals Management Service (MMS) is requesting comments on BP Exploration (Alaska) Inc, (BPXA) proposed Development and Production Plan (DPP) for the Liberty Development Project. The Liberty reservoir underlies federal Outer Continental Shelf leases in the central Beaufort Sea, and is located about 5.5 miles offshore. BPXA is proposing to drill 5-6 development wells from the Endicott Satellite Drilling Island (SDI) using ultra-extended reach drilling technologies (uERD). Production from the Liberty reservoir will be processed through the existing Endicott facilities.

Copies of the DPP were distributed directly to your office by BPXA under separate letter. If you did not receive a copy of the DPP, please contact this office. The DPP was deemed submitted in accordance with 30 CFR 250.266 on May 10 2007. We request you review the DPP within your area of expertise. Comments must be submitted to the MMS's office in Anchorage, ATTN: Regional Supervisor, Field Operations, at 3801 Centerpoint Drive, Suite 500, Anchorage, Alaska 99503-5823 by July 09, 2007.

In accordance with Executive Order 13175, Consultation and Coordination with Indian Tribes; receipt of this letter also provides an invitation to Federally Recognized Tribes to hold formal Government to Government consultations if requested.

A copy of the DPP is also available for checkout from the MMS office or online at the MMS website at http://www.mms.gov/alaska. To check out a copy of the DPP, please contact Ms. Tina Huffaker at (907) 334-5207.

The DPP has also been submitted to the State of Alaska, Department of Natural Resources, Office of Project Management and Permitting (OPMP) for consistency review with the Alaska Coastal Management Program. The OPMP Alaska Coastal Management Program will notify review participants under separate cover of the timing for conducting the consistency review.

If you have any questions please feel free to contact me at (907) 334-5303; or Mr. Daniel Hartung at (907) 334-5304, or by email at daniel.hartung@mms.gov.

Sincerely,

Jeff Walker
Regional Supervisor
Field Operations

cc: Peter Hanley, BP Liberty Permit Manager
Mike Holly, AK COE
Don Perrin, AK OPMP

MMS FO LIBERTY DPP DISTRIBUTION

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Mr. Ted Swem
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Rosa Meehan, Ph.D
Chief, Marine Mammals Management
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Ted Rockwell
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Mr. James Helfinstine,
AK Bridge Program Administrator
Commander, 17th Coast Guard District OAN
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Honorable Edward Itta
Mayor of North Slope Borough
PO Box 570
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Johnny Aiken
Director Planning
North Slope Borough
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Taqulik Hepa
North Slope Borough
Dept of Wildlife Management
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Honorable Nate Olemaun, Jr.,
Mayor of Barrow
P.O. Box 629
Barrow, Alaska 99723

Mr. Thomas Olemaun, President
Native Village of Barrow Inupiat Traditional Government
P.O. Box 1130
Barrow, Alaska 99723

Tom Lohman
North Slope Borough
Department of Wildlife Management
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Mr. Isaac Akootchook, President
Native Village of Kaktovik
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Kaktovik, Alaska 99747

Honorable Carl Brower
Mayor of Nuiqsut
PO Box 89148
Nuiqsut, Alaska 99789

Mr. Leonard Lampe, Sr., President
Native Village of Nuiqsut
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Nuiqsut, Alaska 99789

Mr. Harry Brower, Chairman
Alaska Eskimo Whaling Commission
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Barrow, Alaska 99723

Mr. Arnold Brower, Jr., President
Inupiat Community of the Arctic Slope
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Judy Brady
Alaska Oil and Gas Association
121 W. Fireweed Lane, Suite 207
Anchorage, Alaska 99503-2035

Appendix H

Land Cover and Vegetation Survey

VEGETATION/LAND COVER MAP FOR THE LIBERTY GRAVEL MINE SITE, PRUDHOE BAY UNIT, ALASKA

Prepared by
BP Exploration (Alaska) Inc.
and LGL Alaska Research Associates, Inc.

29 August 2007

INTRODUCTION

Development of a gravel mine site is required to provide an estimated 1,000,000 cubic yards of gravel to expand the Endicott Satellite Drilling Island in support of the Liberty field development. The proposed mining area is approximately 7.5 miles northeast of the Deadhorse Airport, adjacent to the existing Duck Island Mine Site at South ½ Section 6, North ½ Section 7, Township 10 North, Range 16 East, Umiat Meridian. The permitted area would cover approximately 63 acres. In accordance with the permit application this document describes the vegetative community types within the proposed mining area.

MATERIALS AND METHODS

Visual interpretation of false color near infrared (NIR) photography was used to make an initial assessment of vegetation type polygons within the proposed permitted area. Aerial photos at a scale of 1:6000 (1 inch = 500 feet) were digitally scanned and georeferenced for use in ArcGIS.

Vegetation polygons were classified using a hierarchical scheme designed specifically for the North Slope of Alaska (Walker 1983). Vegetation types were mapped at Level C of the hierarchy. This scheme was selected because it is commonly used by the U.S. Fish and Wildlife Service to delimit habitats important to waterbirds on the North Slope. In addition, because of its hierarchical nature, this scheme allows vegetation to be classified at various map scales and facilitates direct comparisons with vegetation maps of other parts of the North Slope.

Walker's (1983) vegetation and land cover classification scheme involves categorizing sites with respect to site moisture regime and dominant plant growth forms (and landform type when plant cover is very sparse or non-existent). Many areas on the North Slope consist of complexes of landforms which result in complexes of site moisture and vegetation types. In areas such as these, the classification scheme calls for combining site moisture an plant growth form terms to more accurately describe the character of the area.

A site inspection was completed in August 2007. Information collected during the field inspection was used to clarify vegetation polygon boundaries and community types.

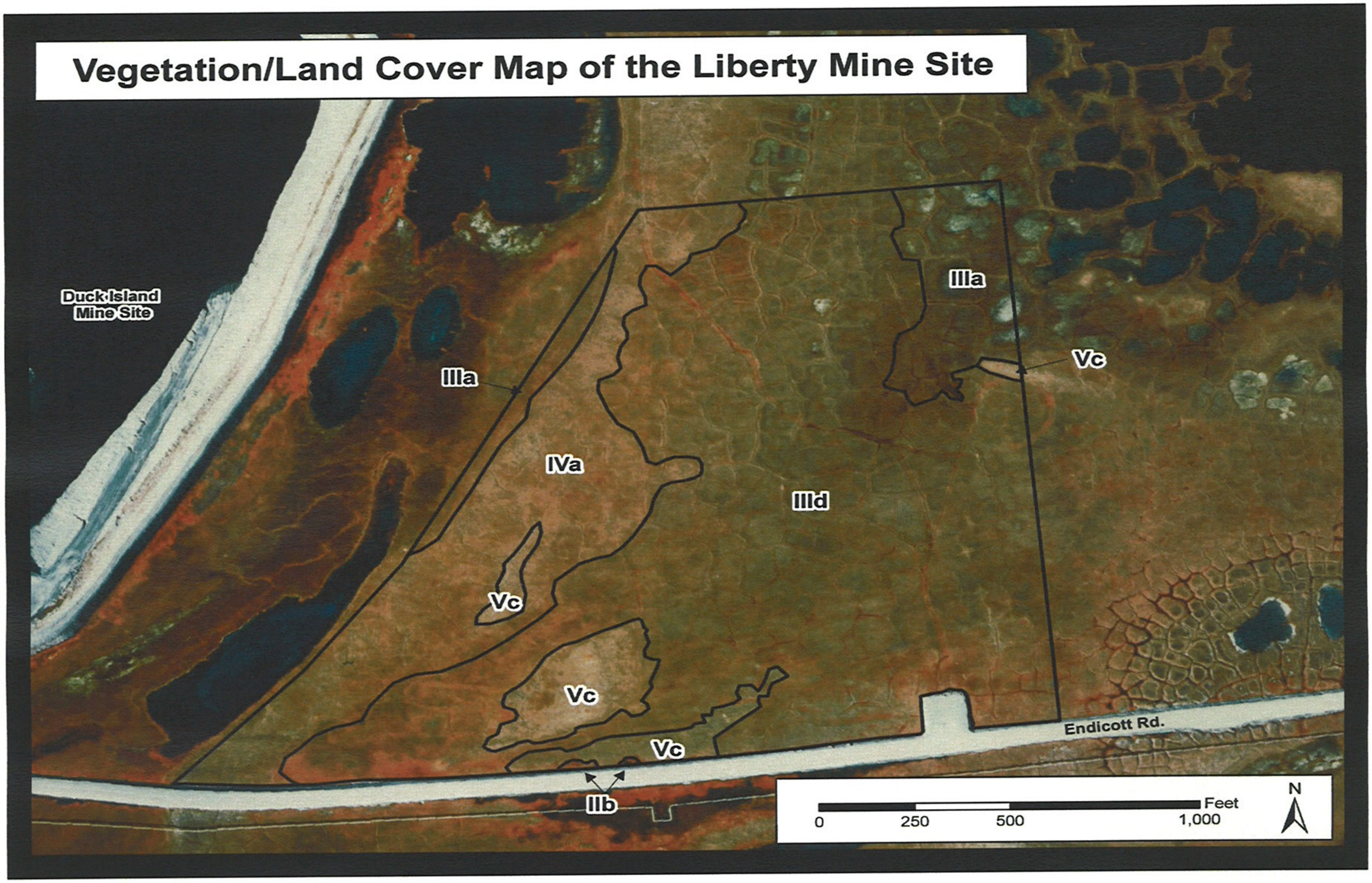
RESULTS

Table 1 provides a brief title description, area, and percent of mapped area for each of vegetation/land cover unit within the mine site boundary. Figure 1 depicts the mapped area and distribution of land cover units.

Table 1. Vegetation/Land cover description and associated map area composition.

Map Unit	Map Unit Description	Area (acres)	% of Mapped Area
IIb	Aquatic Graminoid Tundra (emergent vegetation)	0.08	0.12%
IIIa	Wet Sedge Tundra	5.21	8.29%
IIId	Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned-ground complex)	40.53	64.46%
IVa	Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex (Moist patterned ground complex)	12.92	20.54%
Vc	Dry, Dwarf Shrub, Crustose Lichen Tundra (*Dryas* tundra, pingos, river bars)	4.14	6.59%
	Total:	*62.87*	*100%*

Figure 1. Distribution of land cover types within the Liberty Mine Site boundary.



DISCUSSION

The predominant landform within the mapped area was that of poorly developed low-centered polygons and irregular strangmoor ridges. The vegetation was fairly uniform throughout the mapped area. Vegetation units were delineated based on predominant soil moisture conditions and abundance of secondary community types. While definite lines are provided for mapping purposes, broad transitional zones between community types were common.

The Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (IIId) was the predominant land cover type within the mapped area. This vegetation type is defined by poorly developed low-center polygons. Wet sedge communities are found within the polygon centers and moist sedge communities are common on the slightly elevated polygon rims and strangmoor ridges.

The large, rather central IIId complex within the mine site boundary grades into a slightly wetter area towards the northeast corner of the site. This area was classified as IIIa due to the presence of several small relatively recently drained ponds that were scattered across the area. Pond basins were well vegetated with emergent sedges, primarily *Carex aquatilis*. Staining of the soil surface and vegetation indicated that standing water was likely present for a significant period during the growing season.

The western edge of central IIId map unit was bordered by relatively drier Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex (IVa). This land cover type is typically used to classify a mixture of well developed high- and low-centered polygons. The IVa unit is also, however, used to classify areas of weakly developed strangmoor where moist ridges are dominant. The IVa classification was used for this area to indicate the slightly drier soil conditions, relative to the IIId area, where moist dwarf shrub/graminoid communities were more common.

Additionally, relatively wetter and drier habitats are found within the mine site boundary. Dry community types (V*x*) dominated by shrubs, grasses, and other forbs are common throughout the area but are typically too small to accurately classify at this map scale. Similarly, wet sedge habitats are found adjacent to the Endicott Road and to the west edge of the mine site boundary where the area begins grading towards the ephemeral Duck Island Creek. Emergent vegetation present in the flooded areas and small ponds within the mine area were dominated almost exclusively by *Carex aquatilis*. The emergent grass, *Arctophila fulva*, a highly valued provider of waterfowl habitat, was not present in any of the water bodies within the mine site boundary.

Map units classified as II, or III are probably the most important for waterfowl and shorebirds (Troy 1992). These include lake margins, shallow ponds with or without emergent vegetation, pond/tundra complexes, areas of aquatic graminoid tundra, and areas of wet sedge tundra. These are important areas for feeding birds and in some cases also serve as nesting habitat, especially for waterfowl (Troy 1992). However, most tundra-nesting bird species – especially shorebirds – tend to select nest sites in areas drier than those where they prefer to feed (Troy 1992). Thus, the drier habitats (map unit V [all types]), although less important for feeding, probably provide nesting habitat for some species. The vegetation complexes IIId and IVa are likely to be important bird habitats because these areas provide both moist sites suitable for nesting and nearby wet sites favored for feeding. This is especially so when these vegetation types encompass clusters of lakes and ponds.

References:

Troy, D.M. 1992. Tundra Birds. Chapter IV *in* Prudhoe Bay Waterflood Project: Tundra bird monitoring program 1987. U.S. Army Corps of Engineers, Alaska District, Anchorage, AK.

Walker, D.A. 1983. A hierarchical tundra vegetation classification especially designed for mapping in northern Alaska. Pp. 1332-1337 *in:* Permafrost: fourth international conference proceedings, July 17-23, 1983, Fairbanks, AK. National Academy Press, Washington D.C.

Appendix I

Gravel Site Mining and Rehabilitation Plan

MINING AND REHABILITATION PLAN
LIBERTY GRAVEL MINE SITE
NORTH SLOPE, ALASKA

BP Exploration (Alaska) Inc.
September 2007

INTRODUCTION

A gravel mine site is required to supply an estimated 1,000,000 cubic yards of gravel for the Liberty Development Project consisting primarily of an expansion to the existing Endicott satellite drilling island (SDI).

The goal for the mine site preparation, operation, subsequent closure and rehabilitation is to minimize tundra disturbance.

The following figures provide additional information regarding the mine site development and rehabilitation:

- Figure 1 shows the vicinity of the proposed mine site.
- Figure 2 shows the location of the proposed mine site and overburden storage areas.
- Figure 3 shows the proposed mine site cross sections.
- Figure 4 shows the mine site grading after excavation and features of the rehabilitation plan.
- Figure 5 shows typical cross sections through the rehabilitated mine site.
- Figure 6 shows typical cross sections through the rehabilitated mine site.

The proposed Liberty mine site will disturb approximately 50 acres (including ice pads for staging). This includes a staging area for mining activities, overburden storage areas and the anticipated excavation surface area of approximately 21 acres.

EXISTING CONDITIONS

The proposed Liberty mine site will be located in the eastern operating area of the Prudhoe Bay Unit (EOA/PBU), approximately 7.5 miles northeast of the Deadhorse Airport. The proposed mine site is adjacent to the existing Duck Island Mine Site at

South ½ Section 6, North ½ Section 7, Township 10 North, Range 16 East, Umiat Meridian.

This site was chosen after field geotechnical investigations of several alternative mine sites near the Endicott Road to confirm gravel quality and quantity.

The mine site is still in the planning stages as part of the Liberty Development Project SDI island expansion, therefore, at this stage of the development some flexibility is required regarding mining and rehabilitation plans.

A geotechnical characterization of the material source has been conducted but no development has yet occurred at the site. The outer perimeter boundary shown in the figures describe the maximum aerial extent of the mine site for permitting requirements. The revegetation performance standards are listed in Table 2.

Permits authorizing the proposed mining plan are as follows:

- U.S. Army Corps of Engineers (Section 404)
- Alaska Department of Natural Resources (Material Sale Contract)
- North Slope Borough (Development Permit)

MINING PLAN

General

The mine site will provide gravel for the expansion of the existing SDI to accommodate new facilities and the drilling operations. It is anticipated that gravel will be mined from the site over two winter seasons so that any extra gravel required due to settlement at the SDI can be made up prior to the arrival of the drilling equipment.

The excavated gravel area is shown in Figure 2. The tundra and overburden overlaying the excavated area will be moved adjacent to the north and south sides of the excavated area. The mined area is expected to provide approximately 1,000,000 cubic yards of gravel. Approximately 325,000 cubic yards of overburden is expected to overlay the suitable gravel fill material. The site will be accessed directly by a gravel road from the Endicott Road and a seasonal ice road between the SDI and the mine site. The ice road route will be determined after bathymetric surveys and field reconnaissance of the area between the mine site and the SDI are conducted during the summer 2007. The goal will be to utilize the existing river channel to the extent practicable while avoiding over-wintering fish habitat.

Summer Mining Plan

No summer mining activities are planned.

Winter Mining Plan

Mining operations will occur during the winter months and will include the preparation of a gravel access road for equipment access at the east side of the mine, as well as ice pad staging areas on the north and south sides of the pit for temporary spoil storage. The south side of the mine will be offset approximately 300 ft. from the Endicott Road for safety considerations. A water diversion berm, as depicted in Figure 3, will be constructed around the mine site to protect against flooding. The berm will abut the existing Endicott Road just east of the 48-inch diameter culvert that conducts water under the Endicott Road into the ephemeral Duck Island Creek. The berm will wrap around the site to prevent flood water from flowing into the pit during excavation (see Figure 2). It is not anticipated that the seasonal flow from Duck Island Creek would be diverted from the swale.

Examination of the land form surrounding the mine site suggests that the permafrost is uniform with little thermokarst or ice polygon features. There are shallow ponds to the northeast of the mine site. Based on the experience at the nearby Duck Island Mine Site, BPXA does not expect to encounter significant solid ice features that could thaw and erode into the excavated area.

The site will be monitored during overburden stripping to identify any such ice features. If massive ice is encountered, it will be excavated and replaced with spoil prior to spring break-up.

Mining operations will commence with survey and staking followed by overburden stripping. It is anticipated that an average 10 ft. overburden layer will be removed from the excavated area and stock piled. The organic layer (i.e. the top root mass) within the overburden layer will be removed and stockpiled separately from the inorganic material. The depth of the organic layer will be confirmed by visual inspection during overburden stripping. Mining operations will include blasting and mechanical excavation to an overall depth of approximately 50 ft. with respect to the original land elevation. The 300 ft. offset from the Endicott Road and pipeline will ensure they are not adversely affected by blasting. Blasting safety precautions will be in effect during blasting and all traffic will be halted immediately prior to and until after the blast and "all clear."

Road access to the mine will be via the existing gravel pad turn out from the Endicott Road at the east side of the site as depicted in Figure 2. The access road will connect to the protective flood berm on the west side. Road access ramps will be constructed as mining progresses deeper into the excavated area. The road gradient into the excavated area will not exceed a 10% gradient. Mined gravel will be transported from the mine site to the SDI along an ice road routed north of the Endicott Road. The existing river channel will be used for the ice road where practicable.

The pit side walls will be stepped as shown in Figure 3 and as close to vertical as allowed by safe mining practices. Overburden removed from the excavation area will be stockpiled on ice pads adjacent to the north and south sides of the excavated area. This is intended to reduce the impact to underlying vegetation. The spoil and organic material stockpiles will be used to contour the excavated area and used for mine site rehabilitation after mining is complete.

REHABILITATION PLAN

Introduction

The Liberty Rehabilitation Plan (Rehabilitation Plan) describes methods and procedures proposed for rehabilitating the Liberty mine site and are subject to confirmation based on a biological assessment of the site prior to mining operations. The Rehabilitation Plan may be amended when more site-specific information is available and as the rehabilitation progresses over time. The target revegetation performance standards are listed in Table 1. A proposed treatment, monitoring, and reporting schedule to evaluate progress towards the performance standards is listed in Table 2.

Surrounding Vegetation

The vegetated area surrounding the Liberty mine site lies within the Sagavanirktok River delta, a relatively flat, rolling landscape with minimal topographic relief. The vegetation is wet and moist tundra dominated by *Eriophorum angustifolium* and *Carex aquatilis*. *Arctophila fulva* is present in wetter areas and shallow flooded habitats. *Dupontia fischeri* may be locally prevalent and in drier areas tussock tundra dominated by *Eriophorum vaginatum* may also occur.

Site Preparation

The excavated area will be rehabilitated once mining has been completed. Inorganic spoil will be placed at a nominal 5:1 H:V side slope within the stepped benches on the west side of the pit. The remaining stockpiled inorganic spoil will be placed in the deeper pit excavation to moderate the side slopes. Inorganic overburden will be placed into the pit after mining in the first year. The fill will be placed along the north, west and south faces so as not to encumber vehicle access if required in future. An irregular shoreline will be created along the south side of the pit during backfilling of the overburden material. Scallops to a depth of 1 - 2 ft. and 20 - 40 ft. back will be incorporated along the edge of the future shore line. Excavated material will be used to create small peninsulas and islands near shore. The creation of artificial island or peninsulas will depend on site specific conditions encountered. The exposed land formations will be covered with organic material. The near shore water depth will be at 1 - 2 ft depth.

The stockpiled organic material will be used to cover the disturbed area to encourage natural species revegetation. Excess organic material will be removed from the mine site and relocated to an offsite location (e.g., Duck Island Mine Site disturbed areas) for potential use elsewhere.

The water diversion berm on the west side will be breached as shown in Figures 4 and 5. The breach will be armored with select material to prevent erosion during spring flooding. Although the mine site is slightly elevated with respect to the surrounding area based on observations from the most recent spring break up (2007), water should periodically flood into the abandoned mine site. The fill rate will depend on the annual snow cover and precipitation. The pit will flood gradually over time from locally occurring run-off waters. Once the pit completely fills it will connect with the ephemeral Duck Island Creek through the weir breach on the west side of the mine site. Detailed plans for creating a channel connecting the creek with the mine site will be developed following complete filling of the mine site.

The portions of the water diversion berm remaining after breaching will be covered with stockpiled organic material.

Goals and Objectives

The water diversion berm around the site is intended to allow the short-term establishment of seeded grasses that will assist in stabilizing the soil surface within the mine site while allowing natural colonizers to establish over time. The objective in utilizing stockpiled organic spoil is to ensure adequate soil nutrients to encourage rejuvenation of existing native plants. The shallow gradient created inside the berm is intended to establish diverse and productive wetland and upland plant communities similar to those in the surrounding area, thereby improving the appearance of the site and improving its suitability for some wildlife species. The shallow gradient will also encourage animals to more readily escape from the area after it is flooded. By creating an ice pad under the stockpile areas it is intended that the underlying vegetation is preserved after the stockpiles are removed. The goal is to restore conditions to those that existed prior to creating the stockpiles (Table 1).

Wetland Functions

In recent years, the evaluation of wetland rehabilitation has attempted to assess functionality as a criterion for successful rehabilitation. However, wetland function and thereby the possibility of restoring wetland functions in arctic ecosystems are poorly understood (Funk and Streever 2003, unpub. manuscript). Hydrogeomorphic models or HGM's are one approach being used to make functional wetland assessments. HGM's evaluate different biological and environmental variables and contrast this information to ecologically comparable, 'normal' functioning wetlands. In order to effectively deliver a functional HGM assessment, a significant amount of baseline or reference site data must be available. HGM's are developed locally or regionally for different environmental gradients. There is no HGM for Alaska's North Slope and it is doubtful that such an approach will work.

In consultation with the U.S. Army Corps of Engineers, BPXA has established a practice of defining clear goals, objectives, and performance standards as part of their current approach to rehabilitation. The quantitative measures associated with BPXA's rehabilitation goals, objectives, and performance standards typically focus on percent vascular cover, species composition, and available soil nutrients. Additional qualitative measures often include monitoring the site for wildlife activity, and significant areas of subsidence or thermokarst.

It is reasonable to assume that, until adequate HGM data are made available, inference to wetland functionality may be derived from BPXA's current approach to rehabilitation; reasoning that a positive trend in vegetative establishment and species diversity promotes soil stability, develops soil structure, and indicates adequate plant available nutrients; evaluating surface stability indicates maintenance of thermal equilibrium; and observations of wildlife activity support habitat development and food web structuring.

Rehabilitation Treatments

Disturbed areas outside the excavated area will be seeded with *Puccinellia borealis*, a native grass that is short-lived and non-competitive to invasion by indigenous tundra plant species. An application of approximately 3-5 lb/acre of *P. borealis* should provide adequate cover (BP Exploration (Alaska), Inc. et al. 2004). *P. borealis* seed is available in limited quantities, and this seeding plan (either the species or the year of planting) may be revised if enough seed is not available.

Based on past experience, applying phosphorus fertilizer will greatly enhance establishment of seeded grasses and encourage the invasion of the site by indigenous species. An application of 400 lbs/acre 10:20:20 NPK fertilizer is recommended as a balanced application suitable for most soils in this region. Soil samples will be collected and nutrient analysis conducted to finalize the most appropriate fertilizer application.

The first summer following mine site closure, the area will be allowed to settle, soil samples will be collected, and the area will be inspected to determine the extent of rehabilitation treatments required. Rehabilitation treatments will begin during the following growing season; after breakup and before freeze up in autumn when the soil surface has thawed and drained of excess moisture. The seeded grass is expected to reach maturity by the third growing season following seeding and to begin declining after four to five growing seasons, allowing natural colonizers to occupy the site.

Performance Standards

By the tenth year following cultivation treatments, seeded areas will support 10% total live vascular plant cover excluding seeded grass cultivars. At least five species of naturally colonizing plants should be present, with at least 0.2% cover by each. These performance standards are intended to lead to a soil stabilizing plant cover on the site while also promoting eventual replacement of seeded grasses with naturally colonizing species. These standards do not apply to areas that are ponded for more than four weeks during the growing season. Other disturbed areas, primarily the former overburden stockpile area will, by year 10, support a live vascular cover ≥15% of that found in the surrounding undisturbed area (Table 1).

Monitoring for Performance Standards

Monitoring will be used to evaluate the progress of vegetation relative to performance standards. The final monitoring will establish whether the revegetation performance standards have been met.

Canopy cover and species composition will be assessed using BPXA's standard method, as described in "BP Revegetation and Compliance Monitoring; Standardized Methods for Documenting Plant Community Development" and according to the schedule in Table 2. If intermediate sampling indicates that vegetation has not established enough to meet the proposed standards, additional remedial actions may be required to increase plant cover.

Reporting

Progress reports following BPXA's standard format will be submitted by 1 February of the year following site visits scheduled in Table 2. Reports will be provided to State of Alaska Department of Natural Resources, U. S. Army Corp of Engineers, and the U. S. Fish and Wildlife Service.

Remedial Action

If monitoring suggests that performance standards may not be met by Year 10, additional seeding, fertilizing, and/or other planting approaches will be considered in consultation with agency representatives.

REFERENCES

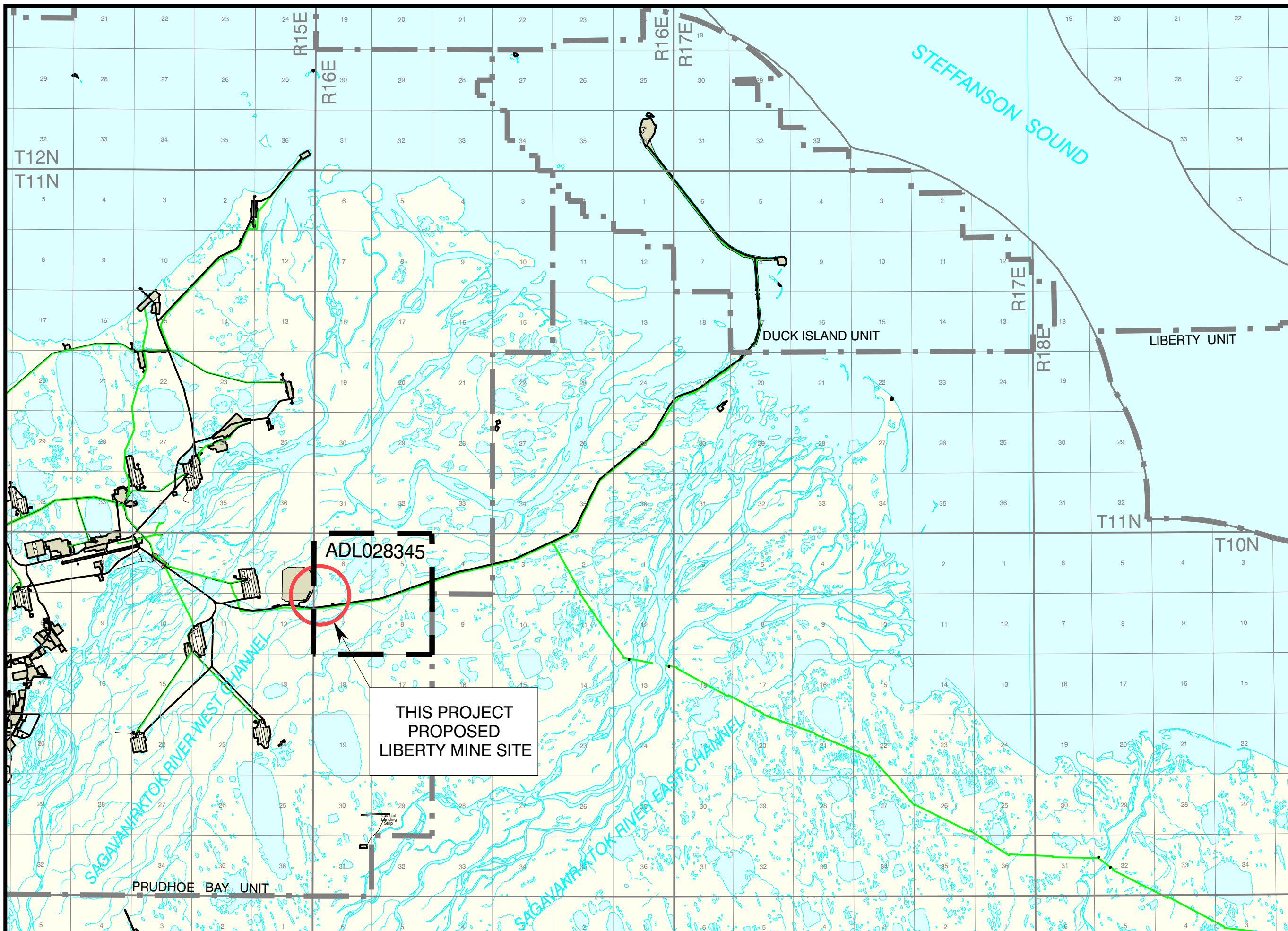
BP Exploration (Alaska), Inc, Conoco Phillips Alaska, Inc., ABR, Inc., and Lazy Mountain Research. 2004. North Slope Plant Establishment Guidelines Table May 11, 2004. Prepared by Oasis Environmental, Inc. 10 pp.

Funk, D.F., and B. Streever. 2003. Wetland function on the Arctic Coastal Plain of Alaska. Unpublished manuscript prepared by LGL Alaska Research Associates, Inc., and BP Exploration (Alaska), Inc. Environmental Studies Program. Anchorage, Alaska.

Table 1. Goals, Objectives, Performance Standards, and Monitoring Methods	
Goals	Flood protection berm: Establish diverse and productive wetland and upland plant communities on the site similar to those of the surrounding area, thereby improving the appearance of the site and improving its suitability for some wildlife species. Former stockpile area: Restore natural conditions comparable to those that existed prior to material stockpiling.
Objectives	Flood protection berm: Short-term establishment of seeded grass that will not persist, allowing natural tundra plant species to colonize the site over time. Former stockpile area: Ensure adequate soil nutrients to encourage rejuvenation of native plants.
Performance Standard	Flood protection berm: By year 10, 10% cover by live vascular plants, including seeded grasses, with at least 1% cover of naturally colonizing species. Species composition consisting of at least 5 naturally colonizing species with 0.2% canopy cover each, on the excavated area and the gravel pad removal area. Former stockpile area: Live vascular cover ≥15% of that found in the surrounding, undisturbed area.
Monitoring Methods	Use BPXA's standard method for measuring plant vegetation cover. Establish photopoints to qualitatively assess changes in site conditions.

Table 2. Proposed schedule for application of rehabilitation treatments, site monitoring, and reporting.

Year	Treatment & Monitoring	Reporting
First summer following site close out	Sample and test soil for fertility and other features. Inspect site to determine extent of rehabilitation activities required. Establish photopoint markers.	None.
Year 0	Apply fertilizer and seed; quantitatively measure cover in former stockpile area; collect photo records.	Progress report.
Year 2	Measure vegetation cover and species composition, and compile a species list, using BPXA's standard method in seeded areas and former stockpile area. Sample soil where revegetation success appears lacking. Observe surface stability qualitatively and collect photo records.	Progress report.
Year 6	Measure vegetation cover and species composition, and compile a species list, using BPXA's standard method in seeded areas and former stockpile area. Sample soil where revegetation success appears lacking. Observe surface stability qualitatively and collect photo records.	Progress report.
Year 10	Measure vegetation cover and species composition, and compile a species list, using BPXA's standard method in seeded areas and former stockpile area. Sample soil where revegetation success appears lacking. Observe surface stability qualitatively and collect photo records.	Final report.



This map is based on U.S.G.S. quad Beechey Point (A-2, A-3, B-2, B-3) and on the Unit Operator's Facility Maps.

NORTH

PROJECT LOCATION:

PRUDHOE BAY UNIT - LIBERTY MINE SITE

NAD83
LAT. = 70° 14' 30.03"
LONG. = -148° 11' 06.48"
ALASKA STATE PLANE ZONE 4, NAD 83
X = 1,864,732.90 FEET
Y = 5,941,043.61 FEET

ADL 028345 SECS. 6, 7 T10N, R16E

DATUM: MEAN SEA LEVEL

PURPOSE: MINE DEVELOPMENT

ADJACENT PROPERTY OWNER: STATE OF ALASKA

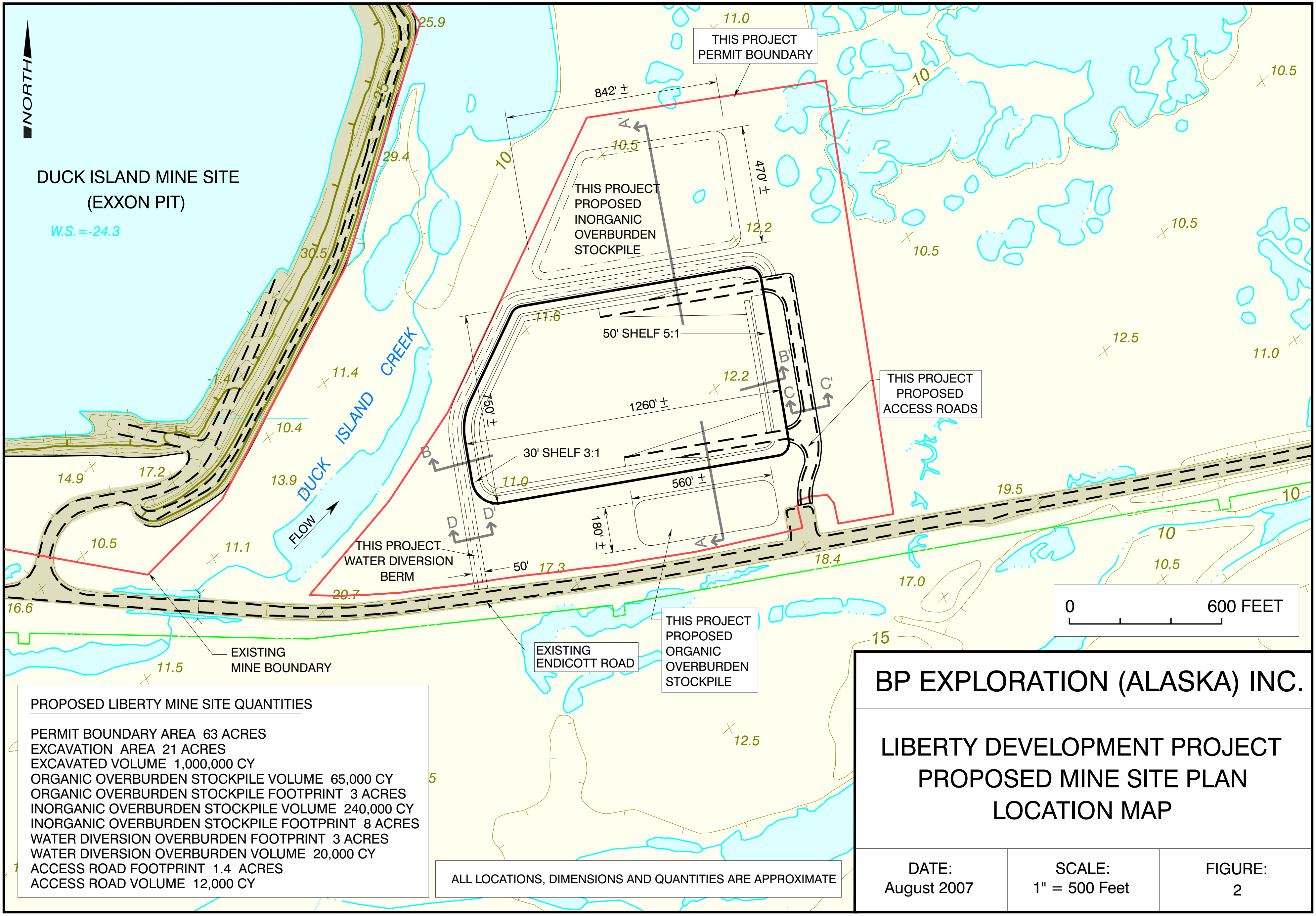
COUNTY: NORTH SLOPE BOROUGH

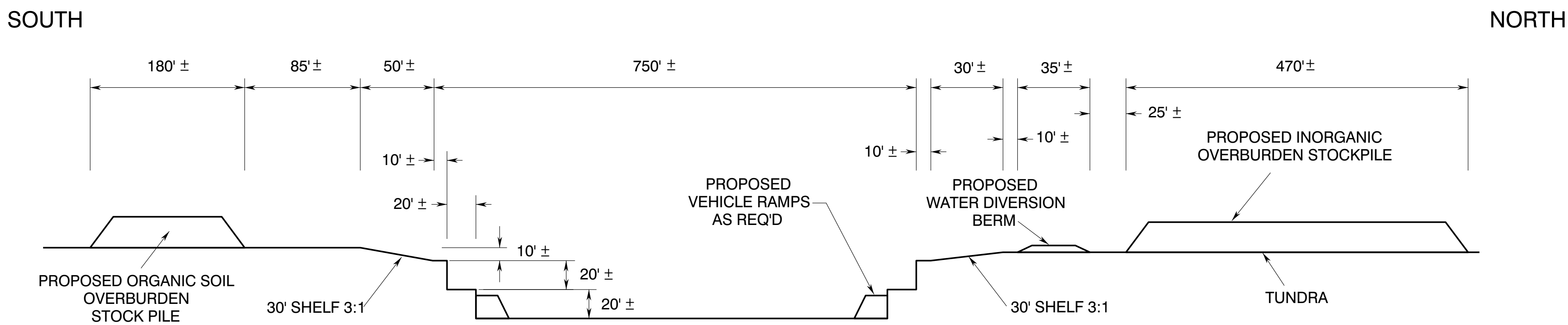
APPLICANT: BP EXPLORATION ALASKA, INC.

BP EXPLORATION (ALASKA) INC.

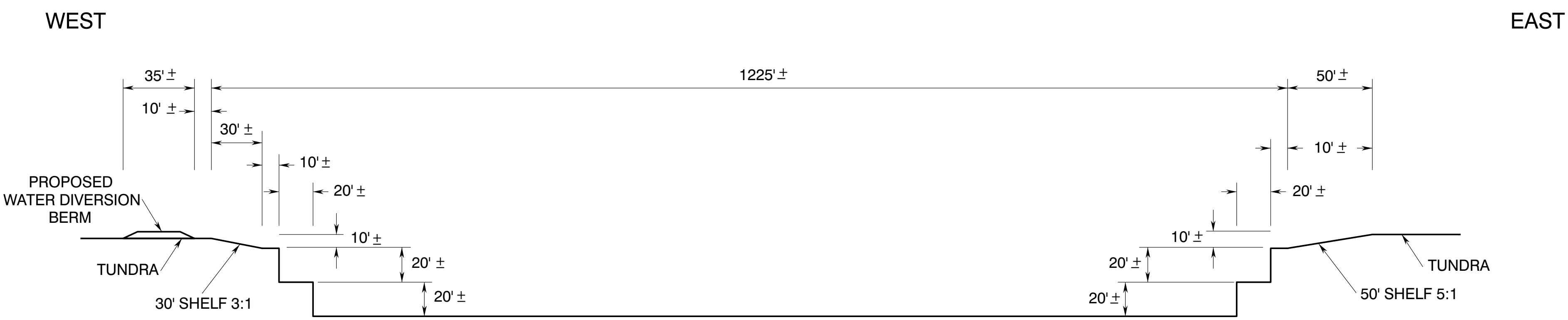
LIBERTY DEVELOPMENT PROJECT
MINE SITE
VICINITY MAP

DATE:	SCALE:	FIGURE:
August 2007	1" = 3 Miles	1

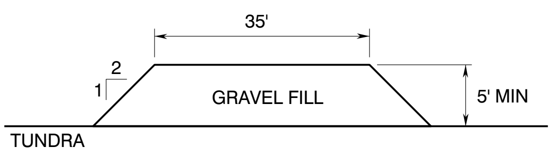

NORTH
DUCK ISLAND MINE SITE
(EXXON PIT)
W.S.=-24.3
DUCK ISLAND CREEK
FLOW
THIS PROJECT PERMIT BOUNDARY
842' ±
470' ±
THIS PROJECT PROPOSED INORGANIC OVERBURDEN STOCKPILE
50' SHELF 5:1
1260' ±
750' ±
30' SHELF 3:1
560' ±
180' ±
50'
THIS PROJECT PROPOSED ACCESS ROADS
THIS PROJECT WATER DIVERSION BERM
EXISTING MINE BOUNDARY
EXISTING ENDICOTT ROAD
THIS PROJECT PROPOSED ORGANIC OVERBURDEN STOCKPILE
0 600 FEET
PROPOSED LIBERTY MINE SITE QUANTITIES
PERMIT BOUNDARY AREA 63 ACRES
EXCAVATION AREA 21 ACRES
EXCAVATED VOLUME 1,000,000 CY
ORGANIC OVERBURDEN STOCKPILE VOLUME 65,000 CY
ORGANIC OVERBURDEN STOCKPILE FOOTPRINT 3 ACRES
INORGANIC OVERBURDEN STOCKPILE VOLUME 240,000 CY
INORGANIC OVERBURDEN STOCKPILE FOOTPRINT 8 ACRES
WATER DIVERSION OVERBURDEN FOOTPRINT 3 ACRES
WATER DIVERSION OVERBURDEN VOLUME 20,000 CY
ACCESS ROAD FOOTPRINT 1.4 ACRES
ACCESS ROAD VOLUME 12,000 CY
ALL LOCATIONS, DIMENSIONS AND QUANTITIES ARE APPROXIMATE
BP EXPLORATION (ALASKA) INC.
LIBERTY DEVELOPMENT PROJECT
PROPOSED MINE SITE PLAN
LOCATION MAP
DATE: August 2007
SCALE: 1" = 500 Feet
FIGURE: 2



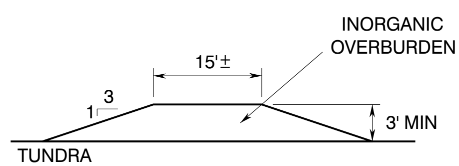
EXCAVATION CROSS SECTION A-A'



EXCAVATION CROSS SECTION B-B'



ACCESS ROAD CROSS SECTION C-C'



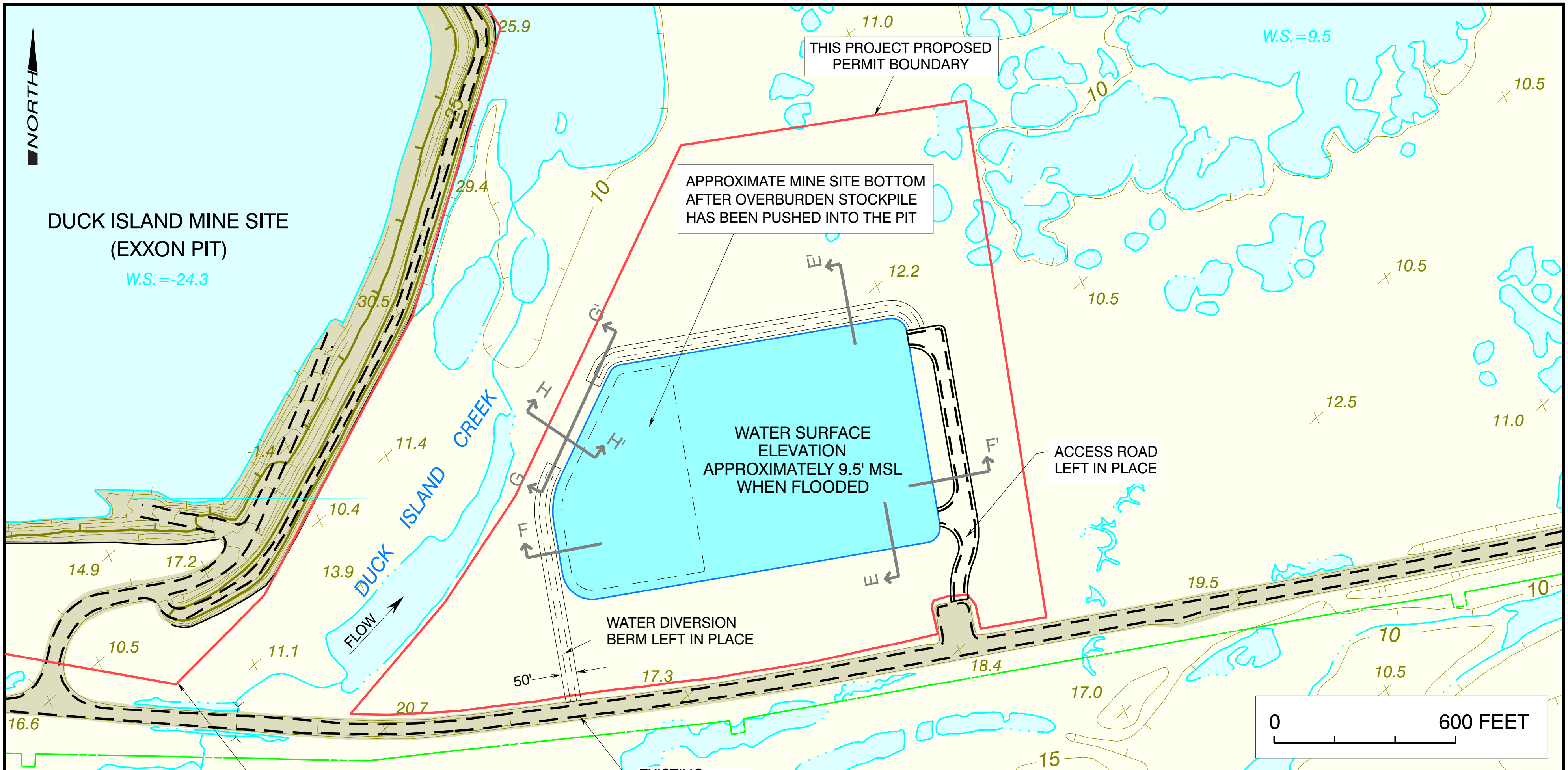
WATER DIVERSION BERM CROSS SECTION D-D'

ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
PROPOSED MINE SITE PLAN
CROSS SECTIONS

DATE:	SCALE:	FIGURE:
August 2007	NOT TO SCALE	3

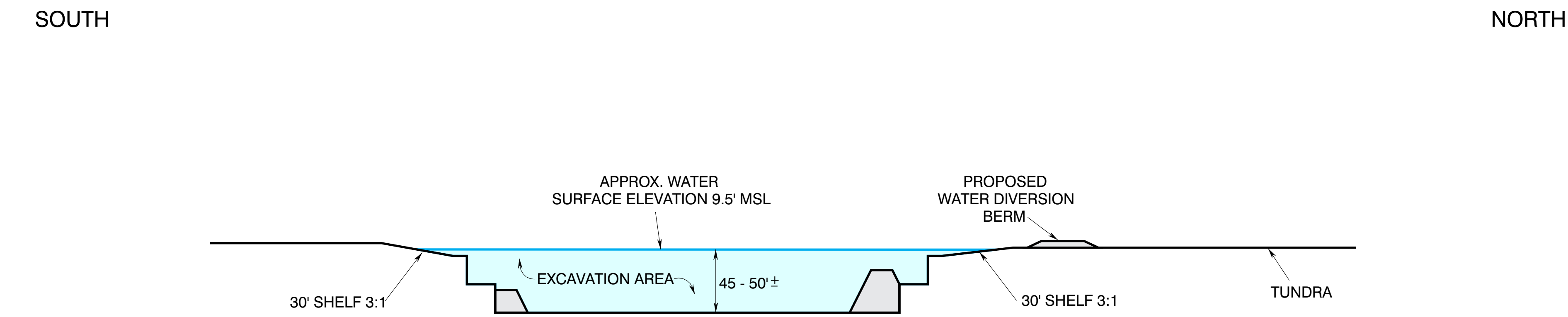


NOTE: INORGANIC OVERBURDEN WILL BE PLACED WITHIN THE EXCAVATED AREA

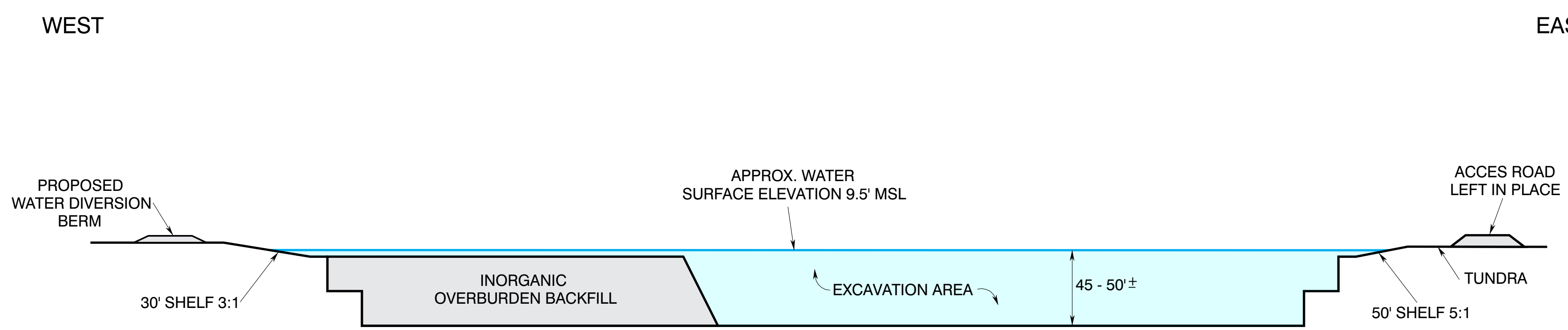
BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
PROPOSED MINE SITE
REHABILITATION PLAN
LOCATION MAP

DATE:	SCALE:	FIGURE:
August 2007	1" = 500 Feet	4



REHAB CROSS SECTION E-E'



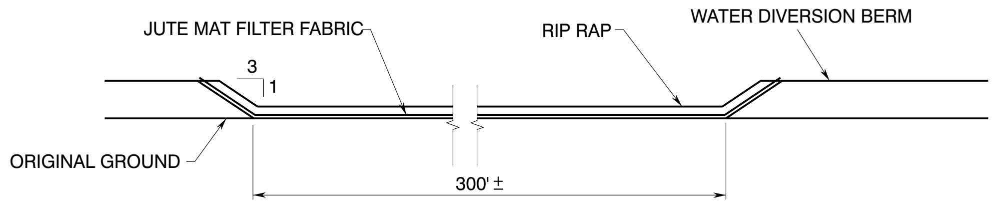
REHAB CROSS SECTION F-F'

ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE

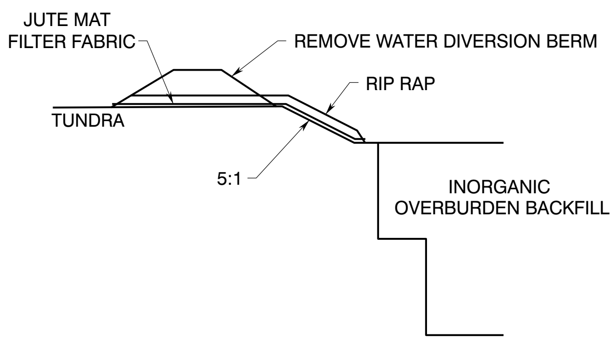
BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
PROPOSED MINE SITE
REHABILITATION PLAN
CROSS SECTIONS

DATE:	SCALE:	FIGURE:
August 2007	NOT TO SCALE	5



SECTION G-G'



SECTION H-H'

ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
PROPOSED MINE SITE
REHABILITATION PLAN
CROSS SECTIONS

DATE:	SCALE:	FIGURE:
August 2007	NOT TO SCALE	6

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U. S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilites, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS Royalty Management Program meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U. S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of : (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protecion.