Ocean Discharge Criteria Evaluation for Oil and Gas Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas, Alaska

(NPDES Permit No.: AKG-28-4300)

United States
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Agency

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Executive Summary

The U.S. Environmental Protection Agency (EPA), Region 10, is issuing a National Pollutant Discharge Elimination System (NPDES) general permit for effluent discharges associated with oil and gas geotechnical surveys and related activities in federal waters of the Beaufort and Chukchi Seas (see Figure 1-1). The Geotechnical General Permit (Geotechnical GP) will authorize twelve types of discharges from facilities engaged in oil and gas geotechnical surveys to evaluate the subsurface characteristics of the seafloor and related activities in federal waters of the Chukchi and Beaufort Seas for a permit term of five years (2015-2020).

Geotechnical surveys include drilling into the subsurface to collect sediment borings to assess geologic stability for potential placement of oil and gas installations. These installations include production and drilling platforms, ice islands, anchor structures for floating exploration drilling vessels, and potential buried pipeline corridors. Geotechnical surveys result in a disturbance of the seafloor and may produce discharges consisting of sediment, rock and cuttings materials, in addition to facility-specific waste streams authorized under this general permit.

Geotechnical "related activities" also result in a disturbance of the seafloor and produce similar discharges. Such related activities may include feasibility testing of mudline cellar construction equipment or other equipment that disturbs the seafloor, and testing and evaluation of trenching technologies.

Section 403(c) of the Clean Water Act (CWA) requires that NPDES permits for discharges into marine waters of the territorial seas, the contiguous zone and the oceans comply with EPA's Ocean Discharge Criteria. Because the area of coverage of the Geotechnical GP is within federal waters of the Beaufort and Chukchi Seas, the scope of this Ocean Discharge Criteria Evaluation extends seaward from the outer boundary of the territorial seas (Figure 1-1). The purpose of this Ocean Discharge Criteria Evaluation (ODCE) is to evaluate the discharges under the Geotechnical GP (Permit No. AKG-28-4300) and assess their potential to cause unreasonable degradation of the marine environment.

The Geotechnical GP does not authorize discharges associated with any activities requiring either of the following: (1) an Exploration Plan submitted to the Bureau of Ocean Energy Management (BOEM) for approval pursuant to Title 30 of the *Code of Federal Regulations* (CFR) 550 Subpart B; or (2) an Application for Permit to Drill submitted to the Bureau of Safety and Environmental Enforcement (BSEE) pursuant to 30 CFR 250 Subpart D. Furthermore, the Geotechnical GP does not authorize discharges associated with geotechnical surveys or related activities conducted at depths greater than 500 feet below the seafloor.

Geotechnical surveys and related activities, as defined, are considered ancillary activities subject to BOEM's regulations at 30 CFR § 550.207-550.210. A permit is not required from BOEM for ancillary activities (30 CFR § 550.105 and § 550.207); however, an Ancillary Activities Notice must be submitted in compliance with 30 CFR § 550.208. The regulations at 30 CFR Part 551 allow ancillary activities to be conducted on unleased lands.

The State of Alaska Department of Environmental Conservation (DEC) has developed a permit for similar discharges to state waters of the Beaufort and Chukchi Seas under its Alaska Pollutant Discharge Elimination System (APDES) program authority. DEC's permit also includes an ODCE for discharges authorized by that permit.

The discharges from oil and gas geotechnical surveys and related activities authorized under the Geotechnical GP are similar in nature to those discharges associated with exploration drilling activities, but at much lower volumes. Whereas an exploration well is drilled into geologic formations (to depths approximately 10,000 feet or greater below the seafloor) to evaluate the presence of hydrocarbon accumulation, geotechnical surveys include collection of sediment borings at depths ranging from approximately 50 feet to no more than 500 feet below the seafloor to assess the seafloor and subsurface characteristics. Operators intend to conduct geotechnical surveying at certain locations within their lease prospects and the area between these prospects and shore, to:

a) delineate potential corridors for buried in-field flow lines and pipelines connecting different prospects,
b) evaluate subsurface suitability for potential placement of ice-islands, jack-up rigs, production and drilling platforms, and anchor structures for floating exploration drilling vessels, and
c) delineate corridors for a potential buried export pipeline between the lease prospects and shore.

The scope of the "related activities" (i.e., estimated discharge volumes, frequency, and duration analyzed in the Fact Sheet and ODCE), is based in part on discharges associated with mudline cellar construction as reported by Shell in 2012 at its Burger A and Sivulliq N/G leases in the Chukchi and Beaufort Sea, respectively. For purposes of the ODCE, EPA assumes four equipment feasibility testing activities would occur each year (two per sea), for a period of 7–10 days per event, totaling 20 events during the 5-year permit term. Each activity would result in a seafloor disturbance of approximately half of a typical mudline cellar dimension. The typical mudline cellar dimension is 20 feet wide and 40 feet deep; therefore, EPA's assumption is that equipment testing would disturb an area that is approximately 10 feet by 20 feet, generating a total of approximately 235,000 gallons of cuttings materials to be discharged during the 5-year permit term. EPA also assumes drilling fluids would not be used for geotechnical related activities.

Table ES-1 below summarizes the types of geotechnical surveys that could occur in any given year by different operators. Geotechnical surveying activities are short in duration and, depending on targeted depth, range between 1 to 3 days to complete one borehole. Borehole diameters can be as small as 4 inches to a maximum of 12 inches.

The depths of boreholes, borehole diameter, and numbers of boreholes differ depending on the specific survey or activity goals. The shallow pipeline borings will generally be drilled to depths less than or equal to 50 feet below the seafloor surface. The deeper pipeline borings would be collected at depths typically between 200 to 300 feet below the seafloor surface. EPA defines the shallow boreholes as those drilled to depths of less than or equal to 50 feet (≤ 50 feet), and deep boreholes as those drilled to depths of greater than 50 feet and less than or equal to 500 feet (> 50 feet and ≤ 500 feet).

For purposes of this evaluation and based on information provided by the Alaska Oil and Gas Association of projected geotechnical surveying activities in the Beaufort and Chukchi Seas, EPA estimates that geotechnical surveys in any given year and performed by multiple operators would include approximately 100 boreholes drilled in federal waters (AOGA 2013). This number is derived by adding the upper range numbers and assuming half of the state/federal boreholes would be drilled in federal waters. Using this approach, the projected 2015 activities total 103 boreholes, while the 2016–2020 activities consist of a total of 86 boreholes per year. For simplicity, EPA estimates 100 boreholes per year.

Table ES-1. Geotechnical survey activity summaries.

2015 ACTIVITY									
Program Type	**Technology**	**Depth of Borehole (feet below seafloor surface)[b]**	**Water Depth (meters) [b]**	**Borehole Diameter (inches) [b]**	**No. of Holes**	**Season/Timing of Activity**	**Location (Sea)**	**State or Federal Waters**	**Duration per Borehole**
Pipeline	Rotary DP	<50	20-45	9	20-24	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Platform	Rotary DP	>50 and ≤500	40-45	9	3-8	Open Water	Chukchi/ Beaufort	Federal	≥3 days
Other	Rotary on Ice	>50 and ≤500	<5 to <10	6.5	50[a]	Winter	Chukchi/ Beaufort	State/ Federal	≥1 day
Pipeline	Rotary/CPT	<50	>20	4-12	40	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Jack Up Drill Unit	Rotary/CPT	>50 and ≤500	<20	4-12	12 [a]	Open Water	Chukchi/ Beaufort	State/ Federal	≥1 day

[a] Half of these boreholes are assumed to occur in federal waters.
[b] 12 inches = 1 foot = meters*3.2808

2016 ACTIVITY									
Program Type	**Technology**	**Depth of Borehole (feet below seafloor surface) [b]**	**Water Depth (meters) [b]**	**Borehole Diameter (inches) [b]**	**No. of Holes**	**Season/Timing of Activity**	**Location**	**State or Federal Waters**	**Duration per Borehole**
Pipeline	Rotary DP	<50	20-45	9	20-24	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Platform	Rotary DP	>50 and ≤500	40-45	9	3-6	Open Water	Chukchi/ Beaufort	Federal	≥3 days
Pipeline	Rotary DP	<200	40-45	9	≥10	Open Water	Chukchi/ Beaufort	Federal	1-2 days
Pipeline	Rotary/CPT	>50	>20	4-12	40	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Jackup Drill Unit	Rotary/CPT	>50 and ≤500	<20	4-12	12 [a]	Open Water	Chukchi/ Beaufort	State/ Federal	≥1 day

[a] Half of these boreholes are assumed to occur in federal waters.
[b] 12 inches = 1 foot = meters*3.2808

2017 ACTIVITY									
Program Type	**Technology**	**Depth of Borehole (feet below seafloor surface) [b]**	**Water Depth (meters) [b]**	**Borehole Diameter (inches) [b]**	**No. of Holes**	**Season/Timing of Activity**	**Location**	**State or Federal Waters**	**Duration per Borehole**
Pipeline	Rotary DP	<50	20-45	9	20-24	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Platform	Rotary DP	>50 and ≤500	40-45	9	3-6	Open Water	Chukchi/ Beaufort	Federal	≥3 days
Pipeline	Rotary DP	<200	40-45	9	≥10	Open Water	Chukchi/ Beaufort	Federal	1-2 days
Pipeline	Rotary/CPT	>50	>20	4-12	40	Open Water	Chukchi/ Beaufort	Federal	≥1 day

Jackup Drill Unit	Rotary/CPT	>50 and ≤500	<20	4-12	12 [a]	Open Water	Chukchi/ Beaufort	State/ Federal	≥1 day

[a] Half of these boreholes are assumed to occur in federal waters.
[b] 12 inches = 1 foot = meters*3.2808

2018 ACTIVITY									
Program Type	**Technology**	**Depth of Borehole (feet below seafloor surface) [b]**	**Water Depth (meters) [b]**	**Borehole Diameter (inches) [b]**	**No. of Holes**	**Season/Timing of Activity**	**Location**	**State or Fed Waters**	**Duration per Borehole**
Pipeline	Rotary DP	<50	20-45	9	20-24	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Platform	Rotary DP	>50 and ≤500	40-45	9	3-6	Open Water	Chukchi/ Beaufort	Federal	≥3 days
Pipeline	Rotary DP	<200	40-45	9	≥10	Open Water	Chukchi/ Beaufort	Federal	1-2 days
Pipeline	Rotary/CPT	>50	>20	4-12	40	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Jackup Drill Unit	Rotary/CPT	>50 and ≤500	<20	4-12	12 [a]	Open Water	Chukchi/ Beaufort	State/Fe deral	≥1 day

[a] Half of these boreholes are assumed to occur in federal waters.
[b] 12 inches = 1 foot = meters*3.2808

2019 ACTIVITY									
Program Type	**Technology**	**Depth of Borehole (feet below seafloor surface) [b]**	**Water Depth (meters) [b]**	**Borehole Diameter (inches) [b]**	**No. of Holes**	**Season/Timing of Activity**	**Location**	**State or Federal Waters**	**Duration per Borehole**
Pipeline	Rotary DP	<50	20-45	9	20-24	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Platform	Rotary DP	>50 and ≤500	40-45	9	3-6	Open Water	Chukchi/ Beaufort	Federal	≥3 days
Pipeline	Rotary DP	<200	40-45	9	≥10	Open Water	Chukchi/ Beaufort	Federal	1-2 days
Pipeline	Rotary/CPT	>50	>20	4-12	40	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Jackup Drill Unit	Rotary/CPT	>50 and ≤500	<20	4-12	12 [a]	Open Water	Chukchi/ Beaufort	State/ Federal	≥1 day

[a] Half of these boreholes are assumed to occur in federal waters.
[b] 12 inches = 1 foot = meters*3.2808

2020 ACTIVITY									
Program Type	**Technology**	**Depth of Borehole (feet below seafloor surface) [b]**	**Water Depth (meters) [b]**	**Borehole Diameter (inches) [b]**	**No. of Holes**	**Season/Timing of Activity**	**Location**	**State or Fed Waters**	**Duration per Borehole**
Pipeline	Rotary DP	<50	20-45	9	20-24	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Platform	Rotary DP	>50 and ≤500	40-45	9	3-6	Open Water	Chukchi/ Beaufort	Federal	≥3 days

Pipeline	Rotary DP	<200	40-45	9	≥10	Open Water	Chukchi/ Beaufort	Federal	1-2 days
Pipeline	Rotary/CPT	>50	>20	4-12	40	Open Water	Chukchi/ Beaufort	Federal	≥1 day
Jackup Drill Unit	Rotary/CPT	>50 and ≤500	<20	4-12	12 [a]	Open Water	Chukchi/ Beaufort	State/ Federal	≥1 day

[a] Half of these boreholes are assumed to occur in federal waters.
[b] 12 inches = 1 foot = meters*3.2808

While the majority of geotechnical surveys and related activities in federal waters would occur during the open water periods (i.e., July–October), it is possible that the activity could occur during the winter months when landfast ice is present, particularly in the Beaufort Sea. Geotechnical surveys and related activities conducted during the open water periods will be performed using drilling systems and/or equipment located on stationary vessels, such as floating, moored, jack-up and/or lift barges. The geotechnical surveys would utilize rotary drilling type systems, including conventional and newer seabed-based technology, from the deck of a vessel that is secured by either dynamic positioning or an anchoring system. During the winter months, geotechnical drilling units and support equipment would be staged on the ice surface. In these instances, the activities would be conducted on-ice and equipment and personnel transported to the site locations via truck.

In general, the shallow pipeline boreholes will rely on the use of seawater and not water-based drilling fluids; however, the use of drilling fluids may be necessary based on the nature of subsurface conditions. Related activities would only occur during the open water period and do not require water-based drilling fluids.

The Geotechnical GP will authorize the following waste streams to be discharged:

- Discharge 001 – Water-based Drilling Fluids and Drill Cuttings
- Discharge 002 – Deck Drainage
- Discharge 003 – Sanitary Wastes
- Discharge 004 – Domestic Wastes
- Discharge 005 – Desalination Unit Wastes
- Discharge 006 – Bilge Water
- Discharge 007 – Boiler Blowdown
- Discharge 008 – Fire Control System Test Water
- Discharge 009 – Non-Contact Cooling Water
- Discharge 010 – Uncontaminated Ballast Water
- Discharge 011 – Drill Cuttings (not associated with Drilling Fluids)
- Discharge 012 – Cement Slurry

EPA derived discharge volume estimates on a per shallow- and deep-borehole basis using information submitted in Shell's 2013 NPDES permit application for geotechnical surveying activities. The per-borehole discharge volumes were extrapolated and presented using the estimate of 100 boreholes in federal waters per year (Table ES-2).

Table ES-2. Estimated discharge volumes associated with geotechnical surveys per borehole and per year.

Discharge	Estimated Discharge Volume[1] per Shallow[2] Geotechnical Borehole	Estimated Discharge Volumes per Deep[3] Geotechnical Boreholes	Estimated Discharge Volumes per Year[4]
	≤ 50 feet	> 50 and ≤ 500 feet	100 boreholes
	U.S. Liquid Gallons		
Water-based drilling fluids and drill cuttings (001)[5]	7,000[6]	21,000[6]	1,232,000[6]
Deck drainage (002)	2,000	6,000	352,000
Sanitary wastes (003)	2,473	7,418	435,186
Domestic wastes (004)	21,000	63,000	3,696,000
Desalination unit wastes (005)	109,631	328,892	19,294,977
Bilge water (006)	3,170	9,510	557,927
Boiler blowdown (007)	N/A	--	--
Fire control system test water (008)	2,000	6,000	352,000
Non-contact cooling water (009)	2,726,234	8,178,703	479,817,254
Uncontaminated ballast water (010)	504	1,512	88,704
Drill cuttings (not associated with drilling fluids) (011)[7]	N/A[8]	--	--
Cement slurry (012)	1	3	114

1 Source: Shell's NPDES Permit Application Form 2C (April 3, 2013) and L. Davis (personal communication, August 7, 2013).
2 Shallow boreholes: Depth ≤ 50 feet
3 Deep boreholes: Depth >50 feet and ≤ 500 feet
4 Source: AOGA 2013
5 Discharged at the seafloor and may include mud pit cleanup materials. To provide a conservative estimate, EPA assumes all 100 boreholes would utilize water-based drilling fluids. Also, approximately 4,800 gallons of drilling fluids is estimated to be discharged from the mud pit per year. This discharge volume is in addition to the Discharge 001 estimated volume presented in the table above.
6 Conservative estimates that include entrained seawater and do not account for boring sample removal.
7 Discharge 011 includes the cuttings materials generated from geotechnical related activities. For purposes of the ODCE, EPA estimates that approximately 235,000 gallons of cuttings materials would be discharged from equipment feasibility testing activities during the 5-year permit term.
8 Discharge 011 may also include cuttings from shallow boreholes. While the majority of shallow boreholes may not use water-based drilling fluids, to provide a conservative estimate, EPA assumes drilling fluids would be used and the volumes are captured above under Discharge 001.

This ODCE evaluates the waste streams authorized to be discharged by the Geotechnical GP. EPA's Ocean Discharge Criteria (Title 40 of the *Code of Federal Regulations* (CFR) Part 125, Subpart M) set forth specific determinations that must be made before permit issuance to ensure that there is no unreasonable degradation of the marine environment. Unreasonable degradation of the marine environment is defined (40 CFR 125.121[e]) as follows:

- Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or
- Loss of aesthetic, recreational, scientific, or economic values, which are unreasonable in relation to the benefit derived from the discharge.

This ODCE is based on 10 criteria (40 CFR 125.122):

- Quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged;
- Potential transport of such pollutants by biological, physical, or chemical processes;
- Composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain;
- Importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism;
- Existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs;
- Potential impacts on human health through direct and indirect pathways;
- Existing or potential recreational and commercial fishing, including finfishing and shellfishing;
- Any applicable requirements of an approved Coastal Zone Management Plan;
- Other factors relating to the effects of the discharge as may be appropriate; and
- Marine water quality criteria developed pursuant to CWA section 304(a)(1).

If the Regional Administrator determines that the discharge will not cause unreasonable degradation of the marine environment, an NPDES permit may be issued. If the Regional Administrator determines that the discharge will cause unreasonable degradation of the marine environment, an NPDES permit may not be issued.

If the Regional Administrator has insufficient information to determine, prior to permit issuance, that there will be no unreasonable degradation of the marine environment, an NPDES permit may not be issued unless the Regional Administrator, on the basis of best available information, determines that: (1) such discharge will not cause irreparable harm to the marine environment during the period in which monitoring will take place; (2) there are no reasonable alternatives to the on-site disposal of these materials; and (3) the discharge will be in compliance with certain specified permit conditions (40 CFR 125.122). "Irreparable harm" is defined as "significant undesirable effects occurring after the date of permit issuance which will not be reversed after cessation or modification of the discharge" (40 CFR 125.122[a]).

A summary of the evaluation conducted for each of the 10 criteria is presented below.

Criterion 1. The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

The discharges from geotechnical surveys and related activities to federal waters are not expected to cause an unreasonable degradation of the marine environment because the pollutants associated with those discharges are not bioaccumulative or persistent. The Geotechnical GP will authorize only the discharge of water-based drilling fluids, which if used, would most likely occur for deeper boreholes. Recent studies show that metals associated with water-based drilling fluids are not readily adsorbed by living organisms (Neff 2010). Effects on benthic and zooplankton communities are expected to be limited to physical smothering in the vicinity of the discharge (Section 3.4.2 discusses the nature and extent of deposition).

The Geotechnical GP applies limits on the concentrations of mercury and cadmium in stock barite, and places suspended particulate phase toxicity limits on the discharges of water-based drilling fluids. These limits are established by the national Effluent Limitation Guidelines (ELGs) for the oil and gas extraction point source category (40 CFR Part 435) and are applied by EPA for the Geotechnical GP to ensure unreasonable degradation does not occur. EPA also requires baseline site characterization at each geotechnical surveys and related activities, or submission of existing, representative baseline data and post-activity environmental monitoring at locations that use water-based drilling fluids. This data will establish the areas of potential impact and will be evaluated by EPA to ensure unreasonable degradation does not occur during the 5-year permit term. The data will also be used in future agency decision-making.

Criterion 2. The potential transport of such pollutants by biological, physical, or chemical processes.

Pollutant transfer can occur through biological, physical, or chemical processes. While some degree of physical transfer is expected from geotechnical surveys and related activities in the Beaufort and Chukchi Seas, the effects would be limited by the short duration of activity (i.e., 1 to 3 days to drill one geotechnical borehole depending on the diameter and depths of the holes and 7 to 10 days for geotechnical-related activities) and the quantity and composition of discharges. Due to the short duration of geotechnical borehole drilling and related activities the relatively small volumes of drilling fluids (if used) and cuttings generated when compared to exploration well drilling, the expected areas of deposition and thickness, and the distances between geotechnical surveys and related activities, benthic habitat effects are likely to occur in a limited area and the extent and duration of effects are expected to be short term.

Drilling fluid and cuttings deposition will not result in significant accumulations on the seafloor (see Section 3.4.2). Table ES-3 below summarizes the amount of water-based drilling fluids and drill cuttings discharged for each borehole, based on the diameter and depths of each borehole. The estimates include a conservative assumption that water-based drilling fluids would be used to collect all boreholes during the open water season.

Table ES-3. Summary of water-based drilling fluids and drill cuttings produced per borehole, by depth (AOGA, 2013)

Drill Season	Borehole Diameter[2]	Cuttings and Drilling Fluids Discharged[1] per Borehole by Depth								
		Depth: 50 feet			Depth: 200 feet			Depth 500 feet		
		Cuttings	Drilling Fluids[3]	Total	Cuttings	Drilling Fluids	Total	Cuttings	Drilling Fluids	Total
Open Water	7 inches	11 ft^3	22 ft^3	33 ft^3	48 ft^3	89 ft^3	137 ft^3	124 ft^3	223 ft^3	347 ft^3
	8 inches	15 ft^3	22 ft^3	37 ft^3	64 ft^3	89 ft^3	154 ft^3	165 ft^3	223 ft^3	388 ft^3
	9 inches	20 ft^3	23 ft^3	43 ft^3	85 ft^3	89 ft^3	174 ft^3	213 ft^3	223 ft^3	437 ft^3
On-Ice	8 inches	15 ft^3	--[4]	15 ft^3	65 ft^3	--	65 ft^3	166 ft^3	--	166 ft^3

1 Conversion: 1 cubic foot (ft^3) = 7.480 U.S. gallons.

2 Borehole diameters range between 4 and 12 inches. This table reflects estimated volumes for an average size diameter borehole.

[3] Drilling fluids are not expected to be used for boreholes drilled at 50 feet or less below the seafloor surface; however, the volumes are included here to provide estimates sufficient to cover all possible scenarios.

[4] Water-based drilling fluids are not expected to be used for this activity.

Drilling fluids and drill cuttings are not directly discharged at the sea surface, or within the water column. They are pushed out of the borehole to the seafloor surface by the pressure of the boring activity and drilling fluids in the well bore. Additionally, the Geotechnical GP requires that the discharge of any mud pit materials occur at the seafloor.

Chemical transport of drilling fluids is not well described in the literature. Any occurrence would most likely result from oxidative/reductive reactions in sediments that change the speciation and sorption-desorption processes that change the physical distribution of pollutants.

Criterion 3. The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act (ESA), or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.

Within the nearshore shallower areas, there is some potential for authorized discharges to produce either acute or chronic effects on biological communities through exposure in the water column or in the benthic environment due to relatively low dilution and the potential presence of sensitive biological communities. For purposes of the ODCE, nearshore shallow areas are defined as the portion of the shelf between the coast and the approximately 20-meter isobath. This definition is consistent with that used in the Department of Interior-sponsored studies in the Beaufort Sea.

Marine organisms in shallow areas could also be exposed to sources of contaminants, including trace metals; however, the extent of exposure is short term (a matter of days) due to the relatively short duration of activity, the anticipated discharge volumes, the expected rapid dilution and deposition of discharged materials, and the required treatment and effluent limitations placed by the permit. The limits, restrictions, and requirements in the Geotechnical GP will minimize contaminant exposure to the biological communities and species that exist in the area. Additionally, the Geotechnical GP's Area of Coverage is within federal waters, generally located 3nm miles from shore, which are in deeper waters.

Eight threatened and endangered species occur within the Area of Coverage: two avian species (spectacled eider, and Steller's eider), three cetacean species (bowhead, fin, and humpback whales), two pinnipeds (bearded seal and ringed seal), and one carnivore (polar bear). The Pacific walrus is a candidate species, subject to annual review by the U.S. Fish and Wildlife Service (USFWS). These species live or spend a portion of their lives in the Area of Coverage. The potential effects on those species include temporary behavioral changes resulting from geotechnical surveys and related activities, and potential exposure to contaminants in the discharges. On the basis of the transient use of the area by those species, the short duration of activities at any one location (1 to 3 days for geotechnical boreholes; 7 to 10 days for related activities), and the limited areal extent of potential impacts, the risks to the biological communities through exposure are expected to be minimal.

EPA has completed a Biological Evaluation (BE) on the effects of authorized discharges on endangered, threatened, proposed and candidate species. The BE concluded that the discharges "may affect, but are not likely to adversely affect" ESA listed, candidate, and proposed species, or their designated critical habitat areas. The USFWS and the National Marine Fisheries Service (NMFS) have concurred with EPA's determinations of effect.

Criterion 4. The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

The Area of Coverage provides foraging habitat for a number of species, including marine mammals and birds. Bowhead whale migrations occur through the southern portions of the area with whales following open water leads generally in the shear zone as they move from the Chukchi Sea to the Beaufort Sea. Polar bear dens are found near shorefast ice and pack ice. Ringed seals are polar bear's primary food source, and areas near ice edges, leads, or polynyas where ocean depth is minimal are the most productive hunting grounds (USFWS 2009). Polar bears are more likely to be encountered during activities conducted in shallow, nearshore locations in the Beaufort Sea. Fish and other whale species use the Area of Coverage for feeding, spawning, and migration. The limited duration of the discharges authorized under the Geotechnical GP would not degrade the receiving waters or sensitive habitat.

The Geotechnical GP contains seasonal and area restrictions on the discharges, including prohibitions on discharges onto stable ice, to the Spring Lead System within the 3-25 nautical mile deferral area in the Chukchi Sea before July 1, and water-based drilling fluids and drill cuttings (Discharge 001) during spring and fall bowhead whale hunting activities in the Chukchi and Beaufort Sea. The permit also requires environmental monitoring for two phases to ensure protection of the receiving water environment and regional biological communities. Phase I baseline site characterization is required for all locations of geotechnical surveys and related activities, or submission of existing, representative baseline data; and Phase II post-activity monitoring is required if water-based drilling fluids are used.

Criterion 5. The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.

No marine sanctuaries or other special aquatic sites, as defined by 40 CFR 125.122, are in or adjacent to the Geotechnical GP Area of Coverage. The nearest special aquatic site—the Alaska Maritime National Wildlife Refuge (Chukchi Unit)—is approximately 60 miles to the southeast of the Chukchi Sea. The refuge provides habitat to a number of arctic seabird species and encompasses shoreline areas from south of Cape Thompson (located approximately 26 miles to the southeast of Point Hope) to Cape Lisburne.

The National Historic Preservation Act (NHPA) requires federal agencies to ensure that any agency-funded and permitted actions do not adversely affect historic properties that are included in the National Register of Historic Places or that meet the criteria for the National Register. The Geotechnical GP requires a baseline site characterization at each location, or submission of existing, representative baseline data. Information gathered from the baseline site characterization or otherwise submitted will assist EPA with meeting the NHPA Section 106 requirements and ensure potential historic properties are not affected by the permit.

Criterion 6. The potential impacts on human health through direct and indirect pathways.

Human health within the communities on the North Slope, Northwest Arctic, and St. Lawrence Island communities is directly related to the subsistence activities in and along the Chukchi and Beaufort Seas. In addition to providing a food source, subsistence activities serve important cultural and social functions for Alaska Natives. Individuals in the communities have expressed concerns related to contaminant exposure through consumption of subsistence foods and other environmental pathways. Concerns have also been expressed over animals swimming through discharge plumes that may contain chemicals.

Current levels of contamination in subsistence food sources are low (NMFS 2013). EPA recognizes that even the perception of contamination could produce an adverse effect by causing hunters to avoid harvesting particular species or from particular areas. Reduction of subsistence harvest or consumption of subsistence resources because of a lack of confidence in the foods could produce an effect on human health. Because discharges could influence subsistence harvest activities, the Geotechnical GP prohibits the discharge water-based drilling fluids and drill cuttings during spring and fall bowhead hunting activities in the Chukchi and Beaufort Sea, respectively. As discussed further below, the permit also: (1) prohibits discharges into the Spring Lead System within the 3-25 nautical mile deferral area in the Chukchi Sea prior to July 1; (2) limits the concentrations of pollutants to be discharged; (3) requires collection of environmental data or submission of existing, representative data the discharge area before conducting geotechnical surveys and/or related activities; and (4) requires additional monitoring after completion of geotechnical surveys and related activities when drilling fluids are used. These requirements ensure direct and indirect human health impacts would not occur.

Criterion 7. Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

In 2009, the North Pacific Fishery Management Council developed a Fishery Management Plan (FMP) for fish resources in the Arctic Management Area. The geographic extent of the Arctic Management Area is all marine waters in the U.S. Exclusive Economic Zone of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait and westward to the U.S./Russia maritime boundary line and eastward to the U.S./Canada maritime boundary. The plan establishes a framework for sustainably managing Arctic marine resources. It prohibits commercial fishing in the Arctic waters of the region until sufficient information is available to support sustainable fisheries management (74 FR 56734, November 3, 2009). The FMPs applicable to salmon and Pacific halibut fisheries likewise prohibit the harvest of those species in the Arctic Management Area. The Council's Arctic FMP is created under authority of the U.S. Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and includes the following:

- All Federal waters of the U.S. Arctic will be closed to commercial fishing for any species of finfish, mollusks, crustaceans, and all other forms of marine animal and plant life; however, harvest of marine mammals and birds is not regulated by the Arctic FMP.
- The Arctic FMP will not regulate subsistence or recreational fishing or State of Alaska-managed fisheries in the Arctic.

Subsistence fishing occurs throughout the coastal region of the Arctic Management Area by residents of villages during open water seasons. Some activities occur to a limited extent in the area during winter, generally using gill nets threaded through hole in the ice or by jigging. In summer, rod and reel, gill net, and jigging are techniques used to capture fish. Species harvested for subsistence purposes include Pacific herring, Dolly Varden char, whitefishes, Arctic and saffron cod, and sculpins (NPFMC 2009).

There are few recreational fisheries in the Arctic Management Area. Most recreational catch in the Arctic likely would occur in state waters located almost exclusively in inland lakes and streams, or along the coast or in river delta waters. These activities would fall under the classification of sport, subsistence, or personal use fisheries, and are regulated by state law (NPFMC 2009).

Based on the limited duration of the discharges authorized and the limits and requirements established in the Geotechnical GP, it is not expected that the discharges would affect fishing success or the quality of the fish harvested.

Criterion 8. Any applicable requirements of an approved Coastal Zone Management Plan.

As of July 1, 2011, there is no longer an approved Coastal Zone Management Act (CZMA) program in the State of Alaska, per AS 44.66.030, because the Alaska State Legislature did not pass legislation required to extend the program. Consequently, federal agencies are no longer required to provide the State of Alaska with CZMA consistency determinations.

Criterion 9. Such other factors relating to the effects of the discharge as may be appropriate.

EPA has determined that the discharges authorized by the Geotechnical GP will not have disproportionately high and adverse human health or environmental effects with respect to the discharge of pollutants on minority or low-income populations living on the North Slope, Northwest Arctic and St. Lawrence Island, particularly the coastal communities. In making this determination, EPA considered the potential effects of the discharges on the communities, including subsistence areas, and the marine environment. EPA's evaluation and determinations are discussed in more detail in Section 6.9.

Criterion 10. Marine water quality criteria developed pursuant to CWA section 304(a)(1).

EPA's national recommended water quality criteria for the protection of aquatic life and human health in surface water for the applicable pollutants of concern are presented below in Table ES-4. These criteria are published pursuant to Section 304(a) of the CWA and provide guidance for states and tribes to use in adopting water quality standards.

Compliance with federal water quality criteria is evaluated under this criterion. Parameters of concern for impacts on water quality in discharges from geotechnical surveys and related activities include oil and grease, metals, chlorine, pH, temperature and total suspended solids (TSS).

Table ES-4. National recommended water quality criteria for applicable pollutants of concern.

Pollutant[1]	Saltwater Aquatic Life		Human Health Consumption (Organisms Only) µg/L
	CMC[2] (Acute) µg/L	CCC[3] (Chronic) µg/L	
Cadmium[5]	40	8.8	--[4]
Chlorine	13	7.5	--
Mercury[5]	1.8	0.94	--
Methylmercury[5]	1.8	0.94	0.3
Oil and Grease	Narrative[6]		--
pH	--	6.5–8.5	--
TSS	Narrative[7]		--
Temperature	Species Dependent[8]		--

1 Source: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
2 Criterion maximum concentration
3 Criterion continuous concentration
4 EPA has not calculated criteria for contaminants with blanks
5 A priority pollutant, defined by EPA as a set of regulated pollutants for which the agency has developed analytical test methods. The current list of 126 priority pollutants can be found in Appendix A to 40 CFR Part 423.
6 For aquatic life: (a) 0.01 of the lowest continuous flow 96-hour LC50 to several important freshwater and marine species, each having demonstrated high susceptibility to oils and petrochemicals; (b) levels of oils or petrochemicals in the sediment which

cause deleterious effects to the biota; (3) surface waters shall be virtually free from floating nonpetroleum oils of vegetable or animal origin, as well as petroleum-derived oils (USEPA 1986).

7 The depth of light penetration not be reduced by more than 10 percent (USEPA 1986).

8 (a) The maximum acceptable increase in the weekly average temperature resulting from artificial sources is 1°C (1.8°F) during all seasons of the year, providing the summer maxima are not exceeded; and (b) daily temperature cycles characteristic of the water body segment should not be altered in either amplitude or frequency (USEPA 1986).

The Geotechnical GP contains a prohibition on discharge if the waste streams contain free oil, as determined by visual observation and/or the static sheen test. To control the levels of metal constituents in the discharge, the permit limits the concentrations of indicator metals, such as mercury and cadmium in stock barite, established by the national Effluent Limitation Guidelines. The permit requires deck drainage (Discharge 002), bilge water (Discharge 006), and ballast water, if contaminated, (Discharge 010) to be treated through an oil-water separator prior to discharge to control oil and grease. The permit also requires pH monitoring for Discharges 001, 002, 004, 005, 006, 007, 008, and 010 as well as limiting pH for the discharges of sanitary wastes (Discharge 003) and non-contact cooling water (Discharge 009) if chemicals are added to the system.

Finally, the Geotechnical GP contains a daily maximum limitation of 1 milligram per liter of chlorine for sanitary waste water (Discharge 003) and effluent limitations for TSS that are based on secondary treatment standards based on best professional judgment.

Because the effluent limitations and requirements contained in the permit comply with federal water quality criteria, EPA concludes that the discharges will not cause an unreasonable degradation of the marine environment.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

ACC	Alaska Coastal Current
AKMAP	Alaska Monitoring and Assessment Program
As	Arsenic
BMP	Best Management Practices
BOEM	Bureau of Ocean Energy Management
BOD	Biochemical Oxygen Demand
BSEE	Bureau of Safety and Environmental Enforcement
Cd	Cadmium
CFR	Code of Federal Regulations
CPT	Cone Penetrometer Tests
CZMA	Coastal Zone Management Act
CWA	Clean Water Act
DP	Dynamic Positioning
EFH	Essential Fish Habitat
EJ	Environmental Justice
ELG	effluent limitation guidelines
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESI	Environmental Sensitivity Index
FMP	fisheries management plan
FR	Federal Register
GP	General Permit
Hg	Mercury
JPC	Jumbo Piston Corer
LC_{50}	lethal concentration to 50% test organisms
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MSD	Marine Sanitation Device
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
ODCE	Ocean Discharge Criteria Evaluation

Pb	Lead
RSD	Relative Standard Deviation
SLS	Spring Lead System
SPP	suspended particulate phase
TSS	total suspended solids

UNITS

µg/g	micrograms per gram
µg/L	micrograms per liter
°C	degrees Celsius
°F	degrees Fahrenheit
bbl	barrels
bbl/day	barrels per day
cm	centimeters
cm/s	centimeters per second
ft	feet
ft/sec	feet per second
g	grams
gal	gallons
gal/day	gallons per day
h	hour
in	inches
kg	kilograms
km	kilometers
L	liters
m	meters
mg/kg	milligram per kilogram
mg/L	milligrams per liter
mi	miles
mm	millimeter
m/s	meters per second
nmi	nautical miles
ppm	part per million
ppt	part per thousand
Sv	Sverdrups

1. INTRODUCTION

1.1. Purpose

The U.S. Environmental Protection Agency (EPA) is issuing a National Pollutant Discharge Elimination System (NPDES) general permit for wastewater discharges associated with oil and gas geotechnical surveys and related activities in federal waters of the Beaufort and Chukchi Seas (Geotechnical GP, AKG-28-4300) off northern Alaska (Figure 1-1). Section 403(c) of the Clean Water Act (CWA) requires that NPDES permits for discharges into the territorial seas, the contiguous zone, and the oceans, comply with EPA's Ocean Discharge Criteria. As the Geotechnical GP applies to discharges to federal waters, the geographic scope of the Ocean Discharge Criteria Evaluation (ODCE) extends seaward from the outer boundary of the territorial seas. The purpose of ODCE is to assess the discharges authorized under the Geotechnical GP and evaluate the potential for unreasonable degradation of the marine environment.

EPA's Ocean Discharge Criteria (Title 40 of the *Code of Federal Regulations* [CFR] Part 125, Subpart M) set forth factors the Regional Administrator must consider when determining whether discharges to the Outer Continental Shelf (OCS) will cause unreasonable degradation of the marine environment. Unreasonable degradation is defined as follows (40 CFR 125.121(e)):

- Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or
- Loss of aesthetic, recreational, scientific, or economic values that are unreasonable in relation to the benefit derived from the discharge.

EPA regulations set out 10 criteria to consider when conducting an ODCE (40 CFR 125.122):

1. Quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.
2. Potential transport of such pollutants by biological, physical, or chemical processes.
3. Composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.
4. Importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.
5. Existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.
6. Potential impacts on human health through direct and indirect pathways.

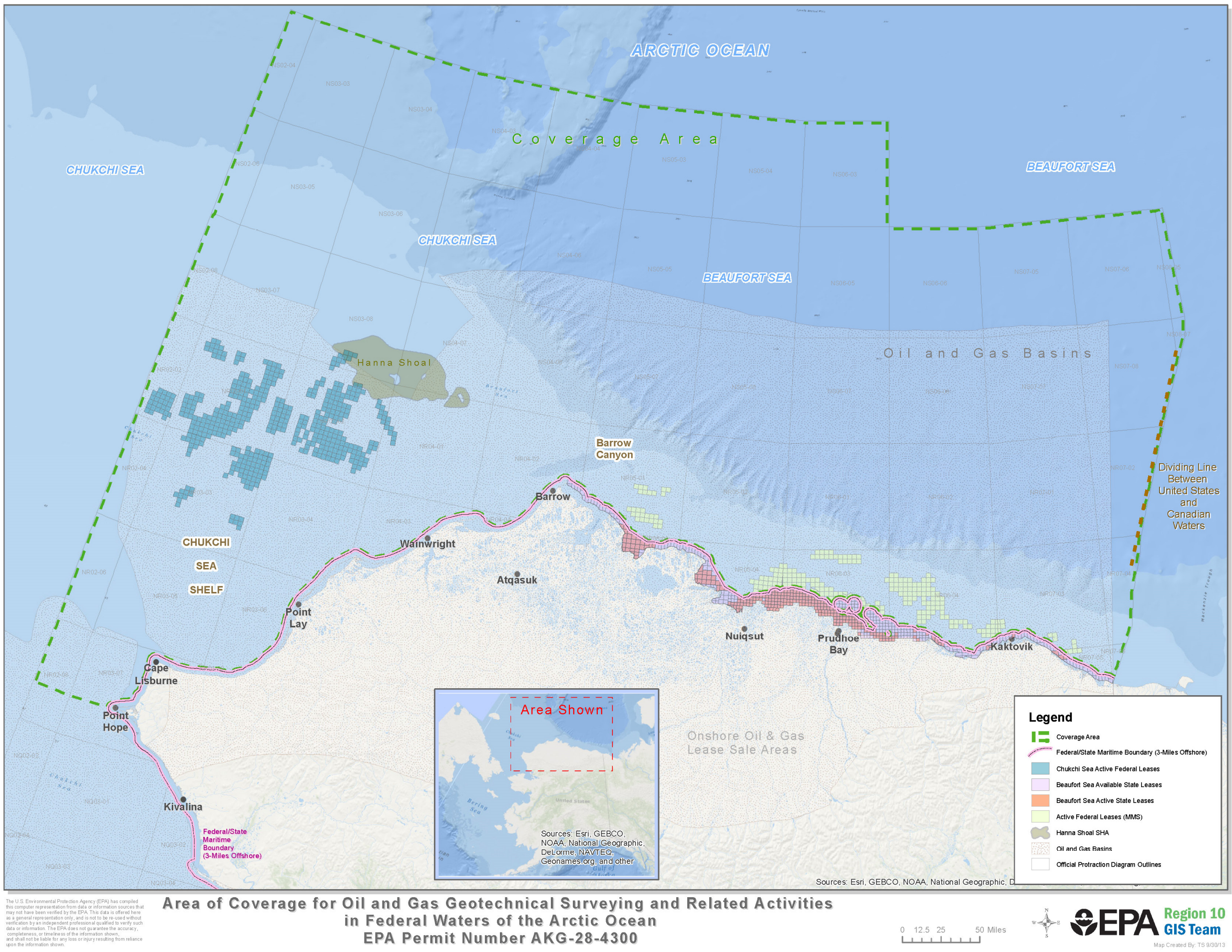

Figure 1-1. Area of coverage for oil and gas geotechnical surveys and related activities in federal waters of the Beaufort and Chukchi Seas.

7. Existing or potential recreational and commercial fishing, including finfishing and shellfishing.
8. Any applicable requirements of an approved Coastal Zone Management Plan.
9. Other factors relating to the effects of the discharge as may be appropriate.
10. Marine water quality criteria developed pursuant to CWA section 304(a)(1).

On the basis of the analysis in this ODCE, the Regional Administrator will determine whether the general permit may be issued. The Regional Administrator can make one of three findings:

1. The discharges will not cause unreasonable degradation of the marine environment and issue the permit.
2. The discharges will cause unreasonable degradation of the marine environment, and deny the permit.
3. There is insufficient information to determine, before permit issuance, that there will be no unreasonable degradation of the marine environment, and issue the permit if, on the basis of available information, that:

- Such discharge will not cause irreparable harm[1] to the marine environment during the period in which monitoring will take place.
- There are no reasonable alternatives to the on-site disposal of these materials.
- The discharge will be in compliance with additional permit conditions set out under (40 CFR 125.123(d)).

1.2. Scope of Analysis

This document evaluates the impacts of waste water discharges associated with the Geotechnical GP for geotechnical surveys and related activities in federal waters of the Beaufort and Chukchi Seas. Oil and gas exploration, development and production activities, and their associated discharges, are not authorized by the Geotechnical GP and are not evaluated in this document. Sections 2.2 and 6.9.2 discuss the differences between exploration and geotechnical surveys and related activities and compare the estimated volumes discharged associated with both types of activities.

This document relies extensively on information provided in the Final, Supplemental, and Draft Environmental Impact Statements for BOEM Multiple Lease Sales 193, 209, 212, 217 and 221 (MMS 2007, 2008; BOEMRE 2010) and the Environmental Assessment for Sale 202 (MMS 2006); the Effects of Oil and Gas Activities in the Arctic Ocean Draft and Supplemental Draft Environmental Impact Statement (NMFS 2011a, 2013), and the ODCEs for EPA's Beaufort and Chukchi Exploration NPDES General Permits (USEPA 2012b). The information presented here is a synthesis of those documents.

1.2.1. Geotechnical GP Area of Coverage

The Area of Coverage authorized by the Geotechnical GP includes federal waters of the Beaufort and Chukchi Seas located seaward from the outer boundary of the territorial seas to the U.S./Russian border to the west and extending eastward to the U.S./Canadian border. The Area of Coverage includes the lease sale planning areas managed by the Bureau of Ocean Energy Management (BOEM) located in the OCS, as well as those from the planning area boundary to the outer boundary of the territorial seas, where geotechnical surveys and related activities could occur within federal waters.

1.2.2. Nature and Type of Activity

Geotechnical surveying is conducted to evaluate the seafloor and subsurface characteristics to:

- Delineate potential corridors for buried in-field flow lines and pipelines connecting different prospects.
- Evaluate subsurface suitability for potential placement of ice-islands, jack-up rigs, production and drilling platforms, and anchor structures for floating exploration drilling vessels.
- Delineate corridors for a potential buried export pipeline between the lease prospects and shore.

Drilling boreholes to varying depths and removing sediment boring samples are the primary activities conducted during geotechnical surveying. Geotechnical related activities include feasibility testing of mudline cellar construction equipment, testing and evaluation of trenching technologies, or other equipment that disturbs the seafloor.

[1] *Irreparable harm* is defined as significant undesirable effects occurring after the date of permit issuance, which will not be reversed after cessation or modification of the discharge [40 CFR 125.121(a)].

The Geotechnical GP does not authorize discharges associated with any activities requiring either of the following: (1) an Exploration Plan submitted to the Bureau of Ocean Energy Management (BOEM) for approval pursuant to 30 CFR 550 Subpart B; or (2) an Application for Permit to Drill submitted to the Bureau of Safety and Environmental Enforcement (BSEE) pursuant to 30 CFR 250 Subpart D. The Geotechnical GP does not authorize discharges associated with geotechnical activities conducted at depths greater than 500 feet below the seafloor. The Geotechnical GP also does not authorize discharges to State of Alaska waters landward from the outer boundary of the traditional 3-mile territorial seas. For purposes of the ODCE and Geotechnical GP, EPA relied on the following definition of territorial seas provided at 33 U.S.C. §1362(8), "The term 'territorial seas' means the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three miles."

Ice is present much of the year in both the Chukchi and Beaufort Seas. While the majority of geotechnical surveying activities would occur during the open water periods (i.e., July to October), it is possible that within nearshore locations, the geotechnical surveys could occur during the winter months when landfast ice is present. Related activities are expected to occur only during the open water season.

During the open water season, geotechnical surveys and related activities will be conducted using vessels, such as floating, moored, jack-up and/or lift barges. The vessels may remain stationary relative to the seafloor by means of a dynamic-positioning (DP) system, such as single-beam sonar and ultra-short baseline acoustic positioning, which automatically controls and coordinates vessel movements using bow and/or stern thrusters as well as the primary propeller(s). Vessels may also be anchored to the seafloor. Winter geotechnical surveys during landfast ice periods will not require a vessel for the drilling activities; the geotechnical equipment would be staged on the ice surface. Geotechnical surveys and related activities generally do not require any chase/support vessels. The actual timing of geotechnical surveys and related activities is strongly influenced by ice and weather conditions.

Geotechnical surveys are generally short in duration and, depending on targeted depth, range between 1 to 3 days to complete one borehole. The typical diameter of the boreholes ranges from 4 to 12 inches. For purposes of this evaluation, and based on available information, EPA estimates that geotechnical surveying in federal waters of the Beaufort and Chukchi Seas in any given year and performed by multiple operators could consist of drilling approximately 100 boreholes. The depths of the boreholes, borehole diameter, and numbers of boreholes differ depending on specific geotechnical program goals (e.g., shallow pipeline, deep assessment, or deep platform assessment). The shallow pipeline borings will generally be drilled no deeper than 50 feet below the seafloor. The deep pipeline borings would be conducted at depths no greater than 500 feet and would be more typically range between 200 to 300 feet below the seafloor.

Of the estimated 100 boreholes that may be drilled per year in federal waters of both the Beaufort and Chukchi Seas, approximately 1/3 of the boreholes would be shallow holes (≤ 50 feet below seafloor surface), and the remaining boreholes would be collected at deeper depths (> 50 feet and ≤ 500 feet below the seafloor surface).

It is anticipated that geotechnical surveys would be conducted on a 24 hour per day schedule. Shallow boreholes can be completed during one day. Deeper boreholes would require 2–3 days per hole to complete. While it is not likely that a completed borehole will be plugged after samples have been collected, if the substrate conditions warrant the borehole to be plugged to maintain sub-seafloor stability, a heavy cement-bentonite slurry would be used.

Geotechnical related activities are estimated by EPA to occur at a frequency of two events per sea per year, for a combined total of 20 events during the 5-year term of the permit (2015–2020). Each activity would take approximately 7–10 days to complete.

The Geotechnical GP will authorize discharges from geotechnical surveys and related activities and associated discharges from geotechnical facilities for a permit term of five years, as discussed below.

1.2.3. Authorized Discharges

The Geotechnical GP covers facilities that discharge effluent associated with oil and gas geotechnical surveys and related activities in federal waters of the Beaufort and Chukchi Seas. Authorized discharges consist of the following:

- Discharge 001 – Water-Based Drilling Fluids and Drill Cuttings
- Discharge 002 – Deck Drainage
- Discharge 003 – Sanitary Wastes
- Discharge 004 – Domestic Wastes
- Discharge 005 – Desalination Unit Wastes
- Discharge 006 – Bilge Water
- Discharge 007 – Boiler Blowdown
- Discharge 008 – Fire Control System Test Water
- Discharge 009 – Non-Contact Cooling Water
- Discharge 010 – Uncontaminated Ballast Water
- Discharge 011 – Drill Cuttings (not associated with Drilling Fluids)
- Discharge 012 – Cement Slurry

EPA has applied the Effluent Limitation Guidelines (ELGs) for the Offshore Category of the Oil and Gas Extraction Point Source Category, found at 40 CFR 435, Subpart A, to the water-based drilling fluids and drill cuttings discharge (Discharge 001), and to other discharges as appropriate, based on Best Professional Judgment (40 CFR 122.44). ELGs are technology-based national standards for controlling conventional and toxic pollutants, based on the performance of treatment and control technologies.

1.3. Overview of Document

This ODCE provides an evaluation of the types of geotechnical surveys and related activities discharges, estimated discharge volumes, and potential effects from discharges authorized under the Geotechnical GP on receiving water quality, biological communities, and human receptors. Section 2 provides a general description of the anticipated geotechnical surveys and related activities. Section 3 discusses the types and estimated quantities of discharges, and describes the potential dispersion of the discharged materials. Section 4 summarizes the physical environments in the Chukchi and Beaufort Seas. Section 5 summarizes the aquatic communities and important species, including threatened and endangered species, and the potential biological and ecological effects from discharges associated with geotechnical surveys and related activities on those species. Section 6 addresses the ten ocean discharge criteria and evaluates whether the Geotechnical GP will cause unreasonable degradation of the marine environment.

2. OIL AND GAS GEOTECHNICAL SURVEYING AND RELATED ACTIVITIES

2.1. Description of the Activities

Geotechnical surveys and related activities will include collection of sediment borings to assess the seafloor and subsurface conditions for potential installations of development and production platforms, ice islands, anchor structures for floating exploration drilling vessels, and for buried oil delivery pipeline systems. Examples of related activities include feasibility testing of mudline cellar construction equipment and other equipment that disturbs the seafloor.

Geotechnical surveying operations are generally short in duration and, depending on depths ranging from 50 feet to no greater than 500 feet below the seafloor surface, can be completed within 1 to 3 days per borehole. Uncertainties associated with subsurface and/or weather conditions can reduce or extend this time. It is anticipated that geotechnical drilling will be conducted on a 24 hour per day schedule. For purposes of this evaluation, EPA estimates that approximately 100 geotechnical boreholes would be completed each year in federal waters during the 5-year permit term. EPA assumes that approximately 1/3 of the boreholes would be shallow holes (≤ 50 feet), and 2/3 of the boreholes would be collected at deeper depths (> 50 feet and ≤ 500 feet).

Spacing between borehole locations will vary. Initial pipeline spacing could range from boreholes 5 to 10 kilometers (16,500 to 32,800 feet) apart; however, as the pipeline route is refined over time, the spacing would need to be closer and could range from 0.5 to 1 kilometers (1,640 to 3,281 feet) apart. Other geotechnical surveys may require spacing of approximately 500 feet between boreholes and up to ¼ to ½ mile (1,320 to 2,640 feet) between holes. In the case of evaluating jack up rig spud cans (cylindrically shaped steel shoes with pointed ends, similar to a cleat, that are driven into the ocean floor to add stability to the rig during operations), boreholes are typically spaced 3–5 meters (10 to 16.4 feet) apart. Depending upon the stratigraphy, boreholes might be drilled in all 3 jack up rig spud can locations. The actual spacing of these boreholes would then be dependent upon the jack up rig selected. However, spud cans are usually on the order of 30–40 meters (98.4 to 131.2 feet) apart.

Geotechnical related activities could occur twice per year per sea, consisting of a total of 10 events per sea, or 20 times over the 5-year term of the permit. A reasonable assumption of the scope of the equipment feasibility testing activities may include seafloor disturbance of half the size and scale of the mudline cellars completed by Shell in 2012 at the Burger and Sivulliq prospects, as feasibility testing of equipment are not expected to result in construction of the entire mudline cellar. The feasibility testing activities are expected to be completed approximately 7–10 days per event. Shell's mudline cellars are 20 feet wide and 40 feet deep.

Geotechnical surveys and related activities in the OCS must be conducted in accordance with BOEM and BSEE regulations. Per BOEM regulations at 30 CFR 550.07 these types of geotechnical surveying activities are considered ancillary activities. While a permit is not required from BOEM for ancillary activities (30 CFR 550.105), prior to authorizing the activities, BOEM requires notification by the operator at least 30 days in advance of planned surveys (30 CFR 550.208).

Water-based drilling fluids may be used to drill geotechnical boreholes, especially the deeper holes below 50 feet. The primary purpose of drilling fluids include: (1) providing a lubricant during the drilling process; (2) helping to promote borehole stability; (3) helping to remove cuttings and debris from the hole so sediment borings can more easily be retrieved to the vessel; and (4) preventing the loss or damage of equipment in the borehole.

It is anticipated that seawater will be used as the primary lubricant, particularly for the shallow holes. However, hole sweeps, i.e., removal of cuttings from the borehole, may require the use of additives, such as a salt water gel (i.e., Attapulgite Clay, Sepiolite, guargum or polymers) as a viscosifying agent. Deeper holes may require the use of barite to increase the weight of the drilling fluid to increase ~~for~~ hole stability. The general make-up of water-based drilling fluids includes 6.4% salt water gel, 1.3% barite, and 92.3% seawater.

Drilling fluids are mixed onboard the vessel in a “mud pit,” either a round or square open-top container, which has an approximate holding capacity of 800 to 1,600 gallons. A mud pit is fitted with a mud agitator to keep the solids (drilling additives) from settling to the bottom of the container. Operators intend to pre-mix large batches of drilling fluids in the mud pit, and depending on the sizes of the pit, multiple batches may be mixed during a season and a single batch of fluids could be used to drill multiple geotechnical boreholes. If solids become a problem in the mud pit during the season, then the system will be “cleaned” by flushing the container with seawater, agitating, and discharging the mixture at the seafloor. Any excess drilling fluids that remain in the mud pit after completion of the last geotechnical borehole of the season will be discharged at the seafloor.

There are three primary technologies used to conduct geotechnical surveys:

- Seabed-Based Drilling System
- Jumbo Piston Corer Sampling System
- Conventional Wet-Rotary Drilling Technology

Seabed-based drilling systems are operated remotely from an A-frame onboard the facility. The seabed-based drilling system is placed on the seafloor, and conducts cased-hole drilling to recover boring samples (each boring sample is approximately 3m in length). The system has enough casings to drill to 100 feet below the seafloor at one time, obtaining undisturbed boring samples up to that depth. The system can also drill upwards of 300 feet below the seafloor; however, there are no additional casings available for use beyond 100 feet. Seabed-based drilling systems do not require the use of drilling fluids as the borehole is cased from the seafloor mudline to the bottom of the hole. The casing is removed upon completion of the borehole. Due to the continuous core sampling ability, the amount of cuttings deposited at the seafloor is much less compared to the conventional rotary drilling technology (discussed below). This technology can conduct cone penetrometer tests (CPT). Tests performed using a CPT provide *in situ* data on site stratigraphy (i.e., subsurface sediment and rock layers), homogeneity of subsurface stratigraphy and pore-water pressure; this data helps corroborate information obtained from laboratory analysis of the collected boring samples.

The jumbo piston corer (JPC) has been used in Arctic conditions for borehole assessments upwards of 60 to 100 feet below the seafloor. The JPC is not a drilling technology, but rather a core sampling system, which consists of a continuous coring tool that is lowered to the seafloor on a heavy lift winch operated from an A-frame. The coring tool has a trigger device that is activated once the JPC nears the seafloor, allowing the JPC to freefall from a set distance, driving the corer into the seafloor in one continuous motion. Some JPC sampling systems utilize a weighted corehead (4,000–5,000 pounds), to retrieve sediment samples from greater depths. With either method, the JPC retrieves an undisturbed continuous core sample between 60–100 feet in length (L. Davis, Shell, personal communication (9/25/2013) and

Woods Hole Oceanographic Institution Seafloor Laboratory Sampling Website (accessed 9/25/2013)). Since the JPC coring system does not conduct any drilling operations, it does not require the use of drilling fluids and will not result in the discharge of cuttings at the seafloor. CPT soundings are generally conducted at a site adjacent to the borehole location.

The conventional wet-rotary drilling technology is the primary system proposed for use in the Beaufort and Chukchi Seas. The conventional techniques are generally performed from a variety of vessel types with standard drill pipe and a top-drive drilling rig. These activities are generally performed from the deck of a vessel positioned on location by either dynamic positioning utilizing satellite technology, or with older vessels, a 4-point anchor spread (Shell 2014). The conventional wet-rotary drilling technology has the ability to drill up to 500 feet below the seafloor. It generally requires the use of seawater (without additives) or drilling fluids as a lubricant. The use of drilling fluids is dependent on the desired depth of the borehole and the subsurface sediment characteristics. All drilling fluids and drill cuttings are discharged at the seafloor.

Stationary vessels are used to conduct geotechnical surveying activities during the open water periods. During the winter months, the drilling equipment and other supporting equipment would be staged on the ice surface.

2.2. Comparison of Geotechnical Surveys to Exploration Activities

There are numerous differences between geotechnical surveys and related activities and exploration drilling, including associated discharges associated with each activity. Some key differences include:

- Goals of the activities
- Sizes of the holes, drilling depths below the seafloor surface, and duration of the activities
- Types of equipment used
- Discharge location of drilling fluids and drill cuttings (Discharge 001)
- Discharge volumes

The primary goal under an exploration drilling program is to drill exploration wells to determine the nature of potential hydrocarbon reservoirs. These wells include multiple casings and are drilled into geologic formations that are typically 10,000 feet or more below the seafloor surface and can take approximately 30 to 45 days to complete, depending on targeted depths and type of drill rig used. Whereas, the focus of geotechnical surveying and related activity is to evaluate the characteristics of the subsurface conditions and the feasibility of equipment for use in Arctic conditions, respectively. A detailed description of these activities is provided above in Section 2.1.

The initial exploration well drilling process typically requires a large-diameter pipe, typically 36 inches, called the conductor casing, that is hammered, jetted, or placed on the seafloor, depending on the composition of the substrate (USEPA 1993). As the drill hole deepens, drilling is stopped periodically to add sections of cylindrical steel casing through which the drill string operates. The casing keeps the walls from collapsing and binding the drill string. To keep each string of casing in place, cement is pumped down through the new string of casing, forced out of the open hole and back up the annular space outside the casing, between it and the open hole, filling the voids. Once the cement is set outside the casing, the drilling process can continue. The addition of casing can be continued until final well depth is reached. Geotechnical surveys, on the other hand, do not involve multiple casings; rather, a coring tool is used to collect and remove the boring sample.

During exploration drilling, drilling fluids are pumped down through the drill pipe and ejected from the drill bit into the well. The drilling fluids lift cuttings off the bottom of the well away from the drill bit, and circulate the cuttings back to the surface through the annular space between the outside of the pipe and the borehole. The cuttings and fluid are sent through a series of shaker tables and separators to remove the fluid from the cuttings. The cuttings are then disposed through an outfall or disposal caisson, depending on the type of exploratory drilling rig or unit.

The drilling fluid is returned to the mud pit for recycling. As drilling proceeds, these components accumulate and eventually the fluid becomes too viscous for further use. When this happens, a portion of the drilling fluid is discharged (to the water column), and water and additives, such as barite (barium sulfate), are added to the remaining drilling fluid to bring concentrations back to proper levels, to counteract reservoir pressures and prevent water from seeping into the well from the surrounding rock formation (Neff 2008; USEPA 2000).

Unlike exploration drilling, seawater will be used as the primary lubricant to drill the shallow geotechnical boreholes. In certain instances and for deeper boreholes, a salt water gel may be used to assist with the displacement of cuttings from the borehole. Deeper holes may also require the use of barite to increase the weight of the drilling fluid for hole stability. The drilling fluids and drill cuttings associated with geotechnical surveys are pushed out of the borehole to the seafloor surface and discharged at the seafloor.

As discussed in Sections 3.1 and 3.2, the discharges from oil and gas geotechnical surveys and related activities authorized under the Geotechnical GP are similar in nature to those discharges associated with exploration drilling activities. However, the expected discharge volumes from geotechnical surveys and related activities are significantly less.

3. AUTHORIZED DISCHARGES, ESTIMATED QUANTITIES, AND MODELED BEHAVIOR

3.1. Authorized Discharges

Geotechnical surveys and related activities generate a number of waste streams that are discharged into federal waters of the Chukchi and Beaufort Seas. Geotechnical surveys result in a disturbance of the seafloor and may produce discharges consisting of sediment, rock and cuttings materials, in addition to facility-specific waste streams associated with stationary vessels. Related activities also result in a disturbance of the seafloor and produce similar discharges.

The Geotechnical GP authorizes discharges of 12 waste streams listed in Section 1.2.3, subject to specific requirements, and includes the general provisions:

- No discharge within the 3-25 nautical mile lease deferral area in the Chukchi Sea prior to July 1.
- No discharge of water-based drilling fluids and drill cuttings (Discharge 001) during bowhead hunting activities in the Chukchi and Beaufort Seas in the spring and fall, respectively.
- All mud pit discharges must occur at the seafloor.
- No discharge of any waste stream onto stable ice.
- No discharge of any waste stream if an oil sheen is detected either through visual observation or a static sheen test.
- Chemicals added to any discharge must not exceed the maximum concentrations specified in the EPA product registration labeling or the manufacturer's recommended concentration. An inventory of all chemicals used must be kept and reported, including product names, registration number, constituents, total quantities used, rates of use, where in the process they are used, and calculated maximum concentrations in any discharged waste stream.
- Toxicity characterization must be conducted for the following waste streams if chemicals are added: deck drainage (002); desalination unit wastes (005); bilge water (006); boiler blowdown (007); fire control system test water (008); and non-contact cooling water (009). Effluent toxicity characterization must be conducted weekly, or once per discharge event, as applicable.
- Report the volumes of each waste streams discharged.

3.2. Summary of Permit Changes

EPA made several changes to the requirements of the Geotechnical GP from the draft version, as discussed in this ODCE and the Fact Sheet that accompanied the Geotechnical GP re-proposal. The changes included the following:

Adding a seasonal restriction to prohibit all discharges within the 3-25 nautical mile deferral area in the Chukchi Sea (

-) before July 1;
- Clarifying Environmental Monitoring Program (EMP) requirements;
- Clarifying drilling fluid testing requirements for Drilling Fluids and Drill Cuttings (Discharge 001);
- Revising sampling frequencies for total residual chlorine and fecal coliform associated with Sanitary Wastewater (Discharge 003); and

- Clarifying Notice of Intent (NOI) submission requirements.

The seasonal restriction prohibiting all discharges within the 3-25 nautical mile deferral area in the Chukchi Sea corresponds with other federal regulatory requirements, such as BOEM's decision to defer the 3-25 nautical mile area in the Chukchi Sea from leasing. The July 1 date is based on many factors, including the fact that offshore activities are traditionally conducted during the open water (ice-free) season, which typically begins on or after July 1, and corresponds with NMFS' estimate of completion of the spring bowhead whale migration (NMFS 2011) and its standard restriction under the Marine Mammal Protection Act (MMPA) prohibiting vessel entry into the Chukchi Sea through the Bering Strait prior to July 1 (NMFS 2012).

3.3. Description of the Discharges

3.3.1. Water-Based Drilling Fluids and Drill Cuttings (Discharge 001)

The Geotechnical GP authorizes the discharge of water-based drilling fluids and drill cuttings, including the discharge of residual drilling fluids from the mud pit cleanup operations, which typically occurs once per season, to the seafloor. Drilling fluids are not returned to the sea surface; they exit the borehole at the seafloor at the top of the borehole with the cuttings.

Drilling fluids and drill cuttings discharges are subject to the following effluent limitations:

- Suspended particulate phase acute toxicity testing of drilling fluids (once per season OR if a new drilling fluids formulation or lot/supply of stock barite is used during the season, then a new test must be conducted).
- No discharge upon failure of the static sheen test (daily).
- No discharge of drilling fluids or drill cuttings generated using drilling fluids that contain diesel oil.
- Mercury and cadmium concentrations in stock barite are limited at 1 milligrams per kilogram (mg/kg) and 3 mg/kg, respectively.
- The drilling fluid systems must be analyzed for metals of concern if barite is used.

As discussed in the Fact Sheet for the permit re-proposal, EPA removed the "once per batch" testing requirements for suspended particulate phase toxicity and mercury and cadmium. The testing frequency has been replaced with once per season, and sampling may be performed pre-season. If a new drilling fluids formulation or lot/supply of stock barite is used during the season, however, then additional testing is required.

Additionally, the Geotechnical GP requires environmental monitoring for two phases: Phase I site characterization for all locations of geotechnical surveys and related activities, or submission of existing, representative baseline data; and Phase II post-activity monitoring if water-based drilling fluids are used.

As discussed above, seawater will be used as the primary lubricant to collect the shallow geotechnical boreholes. In certain instances, a salt water gel may be used to assist with the displacement of cuttings from the borehole, called "borehole sweeps." Deeper holes may require the addition of barite to increase the weight of the drilling fluid for hole stability. The general make-up of water-based drilling fluids for geotechnical surveying is 92.3% seawater, 6.4% salt water gel, and 1.3% barite.

Examples of salt water gel, or visosifier agents include Attapulgite Clay, Sepiolite, guargum, or other natural polymers. Attapulgite is a naturally occurring hydrated magnesium aluminum silicate clay mineral. Guar gum is extracted from the Guar seed. The most important property of Guar Gum is its ability to hydrate rapidly in cold water to attain uniform and very high viscosity. It is widely used in the oil and gas industry for controlling fluid and water loss and lubricating and cooling of drill bits (http://npguar.com/en/guar_gum.php). Both attapulgite and Guar Gum are listed under the Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic) (OSPAR) List of Substances Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR) (AOGA 2013).

Barite is a chemically inert mineral that is heavy and soft, and is the principal weighting agent in water-based drilling fluids. Barite is composed of over 90 percent barium sulfate, which is virtually insoluble in seawater, and is used in geotechnical activities to increase borehole stability. Quartz, chert, silicates, other minerals, and trace levels of metals can also be present in barite. Barite is a concern because it is known to contain trace contaminants of several toxic heavy metals such as mercury, cadmium, arsenic, chromium, copper, lead, nickel, and zinc (USEPA 2000).

Table 3-1 presents the metals concentrations generally found in barite that were the basis for the cadmium and mercury limitations in the Oil and Gas Offshore Subcategory of the effluent limitation guidelines.

Table 3-1. Typical metals concentrations in barite used in drilling fluids.

Metal	Barite concentrations (mg/kg)
Aluminum	9,069.9
Antimony	5.7
Arsenic	7.1
Barium	359,747.0
Beryllium	0.7
Cadmium	1.1
Chromium	240.0
Copper	18.7
Iron	15,344.3
Lead	35.1
Mercury	0.1
Nickel	13.5
Selenium	1.1
Silver	0.7
Thallium	1.2
Tin	14.6
Titanium	87.5
Zinc	200.5

Source: USEPA (1993) 821-R-93-003 (Offshore ELG Development Document); Table XI-6

Drilling fluids will be mixed as a batch and used to drill multiple geotechnical boreholes. The composition of drilling fluids may be adjusted from one borehole to the next. Given the relatively shallow depths of the geotechnical boreholes as compared to exploration drilling, it is expected that one batch of drilling fluids would be used during the season; however, it is possible that multiple batches may be used for one hole. The Geotechnical GP requires testing for suspended particulate phase toxicity and mercury and cadmium in stock barite no less than once per season, with additional testing required if the drilling fluids formulation or lot/supply of stock barite changes during the course of a drill season.

3.4. Other Discharges

In addition to water-based drilling fluids and drill cuttings (Discharge 001), the Geotechnical GP authorizes 11 other waste streams for discharge. For purposes of the ODCE, the discussion of sanitary and domestic wastewater is combined. Discharges 002, 003, 004, 005, 006, 007, 008, 009, and 010 are also referred collectively as "miscellaneous discharges" in the ODCE. Discharge 011 includes cuttings materials that are not associated with drilling fluids, i.e. where no drilling chemicals or additives are used. The Geotechnical GP includes specific effluent limitations, monitoring and reporting requirements for each of the waste streams.

3.4.1. Deck Drainage (Discharge 002)

Deck drainage refers to any wastewater generated from deck washing, spillage, rainwater, and runoff from curbs, gutters, and drains, including drip pans and wash areas. Such drainage could include pollutants such as detergents used in deck and equipment washing, oil, grease, and drilling fluids spilled during normal operations.

When water from rainfall or from equipment cleaning comes in contact with oil-coated surfaces, the water becomes contaminated and must be treated prior to discharge. The Geotechnical GP requires separate area drains for washdown and rainfall that may be contaminated with oil and grease from those area drains that would not be contaminated so the waste streams are not comingled. The permit also requires all deck drainage contaminated with oil and grease to be treated through an oil-water separator prior to discharge, monitoring for pH, and effluent toxicity characterization if chemicals are used in the system.

3.4.2. Sanitary and Domestic Waste (Discharge 003 and 004)

Sanitary waste (Discharge 003) is human body waste discharged from toilets and urinals and treated with a marine sanitation device (MSD). The discharge is subject to secondary treatment and consists of chlorinated effluent. Domestic waste (Discharge 004) refers to gray water from sinks, showers, laundries, safety showers, eyewash stations, and galleys. Gray water can include kitchen solids, detergents, cleansers, oil and grease. The Geotechnical GP prohibits the discharge of floating solids, garbage, debris, sludge, deposits, foam, scum, or other residues of any kind. In cases where sanitary and domestic wastes are mixed prior to discharge, the most stringent discharge limitations for both discharges must apply to the mixed waste stream.

The volume of sanitary and domestic wastes varies widely with time, occupancy, facility characteristics and operational situation. Pollutants of concern in sanitary waste controlled by the Geotechnical GP include biochemical oxygen demand, pH, total suspended solids (TSS), fecal coliform bacteria, and total residual chlorine.

3.4.3. Desalination Unit Waste (Discharge 005)

Desalination unit waste is residual high-concentration brine, associated with the process of creating freshwater from seawater. The concentrate is similar to seawater in chemical composition; however, anion and cation concentrations are higher. The Geotechnical GP requires pH monitoring and effluent toxicity characterization if chemicals are added.

3.4.4. Bilge Water (Discharge 006)

Bilge water is seawater that collects in the lower internal parts of a vessel hull. It could become contaminated with oil and grease and with solids, such as rust, when it collects at low points in the bilges. The Geotechnical GP requires treatment of all bilge water through an oil-water separator before discharge, monitoring for pH, and effluent toxicity characterization if chemicals are added. Additionally, the permit includes a best management practices (BMP) provision requiring the operator to ensure that intake and exchange activities minimize the risk of introducing non-indigenous/invasive species to both the Chukchi and Beaufort Seas.

3.4.5. Boiler Blowdown (Discharge 007)

Boiler blowdown is the discharge of water and minerals drained from boiler drums to minimize solids buildup in the boiler. The Geotechnical GP requires monitoring for pH and effluent toxicity characterization if chemicals are added.

3.4.6. Fire Control System Test Water (Discharge 008)

Fire control system test water is seawater that is released while training personnel in fire protection, and the testing and maintaining of fire protection equipment. Similar to the other miscellaneous discharges discussed above, the Geotechnical GP requires monitoring for pH and effluent toxicity characterization if chemicals are added.

3.4.7. Non-Contact Cooling Water (Discharge 009)

Non-contact cooling water is seawater that is used for non-contact, once-through cooling of various pieces of equipment on the vessel. Non-contact cooling water consists of one of the highest volumes of the discharges authorized under the Geotechnical GP. The volume of non-contact cooling water depends on the configuration of heat exchange systems. Some systems use smaller volumes of water that are heated to a greater extent, resulting in a higher temperature differential between wastewater and receiving water. Other systems use larger volumes of water to cool equipment, resulting in a smaller difference between the temperatures of wastewater and receiving water. Depending on the heat exchanger materials and the system's design, biocides or oxidizing agents might be needed to control biofouling on condenser tubes and intake and discharge conduits.

The Geotechnical GP requires monitoring for pH, temperature, and effluent toxicity characterization if chemicals are added. In addition, the permit establishes a pH limit of 6.5–8.5 standard units if chemicals are added, and includes a BMP provision requiring the operator to ensure that cooling water intake structures are selected and operated to minimize impingement and entrainment of fish and shellfish.

3.4.8. Uncontaminated Ballast Water (Discharge 010)

Ballast water is seawater added or removed to maintain the proper ballast floater level and vessel draft. The Geotechnical GP requires all ballast water contaminated with oil and grease to be treated through an oil-water separator before discharge. The permit also requires monitoring for pH.

3.4.9. Drill Cuttings (not associated with Drilling Fluids) (Discharge 011)

Drill cuttings are small rock particles, varying in size from fine silt to gravel, deposited onto the seafloor surface as a result of boring activities. This waste stream is comprised of cuttings not associated drilling fluids. Cuttings materials are either pushed out of the borehole or flushed out by the use of seawater. This discharge is generally associated with shallow boreholes and the geotechnical related activities that may include feasibility testing and evaluation of oil and gas technologies, such as mudline cellar construction or trenching that would disturb the seafloor surface.

3.4.10. Excess Cement Slurry (Discharge 012)

Most geotechnical boreholes will not be plugged, however, in rare cases the substrate conditions may warrant the holes to be plugged to ensure sub-seafloor stability. If needed, a heavy bentonite slurry would be used.

3.5. Estimated Discharge Quantities

The estimated scope of geotechnical surveys in the Beaufort and Chukchi Seas in any given year performed by multiple operators within federal waters is approximately 100 boreholes. Discharge estimates for geotechnical surveys and related activities were derived by EPA using available information and best professional judgment. The tables below provide an estimate of potential volumes that could be discharged for each waste stream during the 5-year term of the Geotechnical GP. Table 3-2 provides estimated discharge volumes of waste streams, by depth and per year, associated with geotechnical surveying activities to be conducted in federal waters of the Beaufort and Chukchi Seas. All boreholes are assumed to require the use of water-based drilling fluids and drill cuttings, though in reality, most shallow boreholes may only utilize seawater.

Table 3-2. Estimated discharge volumes of waste streams associated with geotechnical activities per borehole and per year.

Discharge	Estimated Discharge Volume[1] per Shallow[2] Geotechnical Borehole	Estimated Discharge Volumes per Deep[3] Geotechnical Boreholes	Estimated Discharge Volumes per Year[4]
	≤ 50 feet	> 50 and ≤ 500 feet	100 boreholes
	U.S. Liquid Gallons		
Water-based drilling fluids and drill cuttings (001)[5]	7,000[6]	21,000[6]	1,232,000[6]
Deck drainage (002)	2,000	6,000	352,000
Sanitary wastes (003)	2,473	7,418	435,186
Domestic wastes (004)	21,000	63,000	3,696,000
Desalination unit wastes (005)	109,631	328,892	19,294,977
Bilge water (006)	3,170	9,510	557,927
Boiler blowdown (007)	N/A	--	--
Fire control system test water (008)	2,000	6,000	352,000
Non-contact cooling water (009)	2,726,234	8,178,703	479,817,254
Uncontaminated ballast water (010)	504	1,512	88,704
Drill cuttings (not associated with drilling fluids) (011)[7]	N/A[8]	--	--
Cement slurry (012)	1	3	114

1 Source: Shell's NPDES Permit Application Form 2C (April 3, 2013) and L. Davis (personal communication, August 7, 2013).
2 Shallow boreholes: Depth ≤ 50 feet
3 Deep boreholes: Depth >50 feet and ≤ 500 feet
4 Source: AOGA 2013
5 Discharged at the seafloor and may include mud pit cleanup materials. To provide a conservative estimate, EPA assumes all 100 boreholes would utilize water-based drilling fluids. Also, approximately 4,800 gallons of drilling fluids is estimated to be discharged from the mud pit per year. This discharge volume is in addition to the Discharge 001 estimated volume presented in the table above.
6 Conservative estimates that include entrained seawater and do not account for boring sample removal.

[7] Discharge 011 includes the cuttings materials generated from geotechnical related activities. For purposes of the ODCE, EPA estimates that approximately 235,000 gallons of cuttings materials would be discharged from equipment feasibility testing activities during the 5-year permit term.

[8] Discharge 011 may also include cuttings from shallow boreholes. While the majority of shallow boreholes may not use water-based drilling fluids, to provide a conservative estimate, EPA assumes drilling fluids would be used and the volumes are captured above under Discharge 001.

As discussed in Section 3.1.1, above, mud pit cleanup would be discharged at the end of a geotechnical surveying season. Estimated discharge volumes have not been provided by industry; therefore, for purposes of this ODCE evaluation, EPA assumes that the mud pit capacities are either 800 or 1,600 gallons. If four different companies operate each season and all use drilling fluids to collect a total of 100 boreholes, then approximately 4,800 gallons of mud pit materials (seawater and additives) would be discharged per year at the seafloor under Discharge 001 (USEPA 2013).

The discharges of cuttings materials associated with geotechnical related activities would occur under Discharge 011. EPA assumes that those activities would occur two times per year per sea (i.e., four geotechnical related activities would occur each year), consisting of a total of 20 events over the five year term of the permit. The duration of geotechnical related activities would consist of approximately 7–10 days per event. Furthermore, EPA assumes each equipment feasibility test would disturb an area half the dimensions of a typical mudline cellar, resulting in a seafloor disturbance of approximately 10 feet wide by 20 feet deep. Therefore, one feasibility testing activity would result in an approximate discharge volume of 11,750 gallons for a total volume of 235,000 gallons of cuttings discharged during the 5-year term of the permit. These assumptions are based in part on discharges associated with mudline cellar construction reported by Shell for its Burger A and Sivulliq N/G leases in the Chukchi and Beaufort Sea, respectively, and on best professional judgment.

Discharge 011 may also include cuttings from shallow boreholes. While the majority of shallow boreholes may not use water-based drilling fluids, to provide a conservative estimate, EPA assumes drilling fluids would be used and the volumes are captured under Discharge 001.

3.6. Predictive Modeling of Discharges

3.6.1. Dilution of Suspended Drilling Fluid and Drill Cuttings

EPA applied a two-dimensional advection diffusion equation to predict dilution of drilling fluids and drill cuttings. The first analysis isolated the drilling fluids discharge, and included scenarios for the range of expected discharge rates (172 to 556 gallons per day (gal/day)) and current speeds (0.02 to 0.4 meters per second (m/s). Dilution was estimated at three distances from the location of the borehole on the surface of the seafloor (1, 10, and 100 meters). Across all scenarios, the predicted dilution ranges from a low of 6.5 (1 meter distance, 556 gal/day discharge, and 0.02 m/s current) to a high of 4188 (100 meter distance, 172 gal/day discharge, and 0.4 m/s current). Because the analysis is based on simple lateral spreading, the predicted dilution at 100 meters is 10 times the dilution at 1 meter (i.e., proportional to the square root of the radius) for a given current speed and discharge rate. At a fixed distance of 100 meters, across all current speeds and discharge rates, the dilution ranges from 65 to 4188. The results for dilution of drilling fluids discharges are shown in Table 3-3.

Table 3-3. Predicted dilution for drilling fluids discharges from geotechnical surveys.

Case ID	Current Speed (m/s)	Discharge Rate (gal/day)	Discharge Rate (cm/s)	Dilution Factor at 1 meter	Dilution Factor at 10 meters	Dilution Factor at 100 meters
101	0.02	172	7.57 E-6	20.9	66.2	209.4
102	0.02	333	14.65 E-6	10.8	34.2	108.2
103	0.02	556	24.46 E-6	6.5	20.5	64.8
104	0.10	172	7.57 E-6	104.7	331.1	1047.0
105	0.10	333	14.65 E-6	54.1	171.1	541.1
106	0.10	556	24.46 E-6	32.4	102.5	324.1
107	0.30	172	7.57 E-6	314.1	993.4	3141.0
108	0.30	333	14.65 E-6	162.3	513.3	1623.0
109	0.30	556	24.46 E-6	97.2	307.4	972.2
110	0.40	172	7.57 E-6	418.8	1325.0	4188.0
111	0.40	333	14.65 E-6	216.4	684.4	2164.0
112	0.40	556	24.46 E-6	129.6	409.9	1296.0

The same analytical approach was used for the combined discharge of drilling fluids and drill cuttings. The results are linearly proportional to the discharge rate, and the total discharge is assumed to be comprised of nearly equal parts cuttings and drilling fluids. The expected total discharge rate ranges from 322 to 1093 gal/day. The predicted dilution ranges from a low of 3.3 (1 meter distance, 1093 gal/day discharge, and 0.02 m/s current) to a high of 2238 (100 meters distance, 322 gal/day discharge, and 0.4m/s current). At 100 meters, across all scenarios, the dilution ranges from 33 to 2238. The results are presented below in Table 3-4.

Table 3-4. Predicted dilution for combined drilling fluids and cuttings discharges from geotechnical investigations.

Case ID	Current Speed (m/s)	Discharge Rate (gal/day)	Discharge Rate (cm/s)	Dilution Factor at 1 m	Dilution Factor at 10 meters	Dilution Factor at 100 meters
101	0.02	322	14.17 E-6	11.2	35.4	111.9
102	0.02	651	28.64 E-6	5.5	17.5	55.3
103	0.02	1093	48.08 E-6	3.3	10.4	33.0
104	0.10	322	14.17 E-6	55.9	176.9	559.4
105	0.10	651	28.64 E-6	27.7	87.5	276.8
106	0.10	1093	48.08 E-6	16.5	52.1	164.9
107	0.30	322	14.17 E-6	167.8	530.7	1678.0
108	0.30	651	28.64 E-6	83.0	262.6	830.3
109	0.30	1093	48.08 E-6	49.5	156.4	494.6
110	0.40	322	14.17 E-6	223.8	707.6	2238.0
111	0.40	651	28.64 E-6	110.7	350.1	1107.0
112	0.40	1093	48.08 E-6	65.9	208.5	659.5

3.6.2. Thickness and Extent of Drilling Fluids and Drill Cuttings

EPA estimated the thickness of deposition of drilling fluids and drill cuttings based on the advection diffusion equation. The same range of ambient currents and discharge rates were used as in the dilution analysis (see Section 3.4.1, above). Similar to the dilution analysis, the predicted thickness of deposition at 100 meters is 10 times the thickness at 1 meter (i.e., proportional to the square root of the radius) for a given current speed and discharge rate. Across all scenarios, the predicted thickness ranges from a high of 30 millimeters (1 meter distance, 1093 gal/day discharge, and 0.02 m/s current) to a low of 0.04 millimeters (100 meters distance, 322 gal/day discharge, and 0.4 m/s current). At 100 meters, across all current speeds and discharge rates, the thickness of deposition for the combined discharge of drilling fluids and drill cuttings ranges from 0.04 to 3 millimeters (mm).

For detailed information about the model and simulation results, see *Results from Geotechnical Surveying and Related Activities Modeling Scenarios Technical Memorandum*, (Modeling Technical Memorandum) dated November 12, 2013 (Hamrick 2013).

The results of the combined deposition of drilling fluids and drill cuttings are shown below in Table 3-5.

Table 3-5. Deposition thickness for combined drilling fluids and drill cuttings discharges from geotechnical surveys.

Case ID	Current Speed (m/s)	Discharge Rate (gal/day)	Discharge Rate (cm/s)	Thickness at 1 m (mm)	Thickness at 10 m (mm)	Thickness at 100 m (mm)
101	0.02	322	14.17 E-6	8.94	2.83	0.89
102	0.02	651	28.64 E-6	18.07	5.71	1.81
103	0.02	1093	48.08 E-6	30.33	9.59	3.03
104	0.10	322	14.17 E-6	1.79	0.57	0.18
105	0.10	651	28.64 E-6	3.61	1.14	0.36
106	0.10	1093	48.08 E-6	6.06	1.92	0.61
107	0.30	322	14.17 E-6	0.60	0.19	0.06
108	0.30	651	28.64 E-6	1.20	0.38	0.12
109	0.30	1093	48.08 E-6	2.02	0.64	0.20
110	0.40	322	14.17 E-6	0.45	0.14	0.04
111	0.40	651	28.64 E-6	0.90	0.29	0.09
112	0.40	1093	48.08 E-6	1.52	0.48	0.15

3.6.3. Dilution of Miscellaneous Discharges

EPA has also conducted an analysis to estimate the dilution of the aqueous phase of discharges from geotechnical activity under the permit (Tetra Tech 2013). Similar to the model used for dilution of drilling fluids and drill cuttings discharges, the two-dimensional advection diffusion equation was used to predict dilution for miscellaneous discharges, such as deck drainage, desalination unit wastes, and non-contact cooling water.

The analysis of miscellaneous discharges covered a larger number of scenarios than the drilling fluids and drill cuttings discharges. Because drilling fluids and drill cuttings are always to be discharged at the seafloor and are not positively buoyant, the range of scenarios for drilling fluids and drill cuttings discharge is narrower than the range of miscellaneous discharges, which can be discharged at a wider range of depths. In addition, there is a wide range of discharge rates for the miscellaneous discharges.

The analysis included a range of discharge rates (50 to 62,500 bbl/day), discharge depths (2 to 50 meters), and current speeds (0.02 to 0.4 m/s). The range of depths analyzed was wider than the depth of discharge expected under the permit (20 to 50 meters). Dilution was estimated at three distances from the location of the outfall (10, 100, and 1000 meters). Across all scenarios and a minimum depth of 20 meters, the predicted dilution factor ranges from a low of 12 (case 145: 20 meters depth, 10 meters distance, 62,500 bbl/day discharge, and 0.02 m/s current) to a high over 12 million (case 196: 50 meters depth, 1000 meters distance, 50 bbl/day discharge, and 0.4 m/s current). Again, because the analysis is based on simple lateral spreading, the predicted dilution is proportional to the square root of the radius) for a given scenario.

For the worst case scenario (case 145), the dilution factor ranges from 12 at a distance of 10 meters to 123 at a distance of 1000 meters. For this case, if the ambient concentration of a pollutant of concern is zero, then the concentration of that pollutant at a distance of 10 meters will be $1/12^{th}$ or 8 percent of the discharge concentration. If the pollutant is present in the ambient water, the concentration at a given distance from the outfall will be function of the dilution, discharge concentration, and ambient concentration.

This dilution analysis does not include buoyancy-based mixing due to salinity and/or temperature differentials between the discharge and ambient waters. Since buoyancy processes increase dilution, this analysis provides conservative estimates of dilution.

The results for all scenarios miscellaneous discharges are shown in Table 3-6.

Table 3-6. Predicted dilution for miscellaneous discharges.

Case ID	Effective Water Depth (meters)	Current Speed (m/s)	Discharge Rate (bbl/day)	Discharge Rate (cm/s)	Dilution Factor at 10 meters	Dilution Factor at 100 meters	Dilution Factor at 1000 meters
101	2	0.02	50	0.00009	487	1541	4874
102	2	0.02	250	0.00046	97	308	975
103	2	0.02	1250	0.00230	20	62	195
104	2	0.02	2500	0.00460	10	31	97
105	2	0.02	62500	0.11500	0	1	4
106	2	0.10	50	0.00009	2437	7706	24370
107	2	0.10	250	0.00046	487	1541	4874
108	2	0.10	1250	0.00230	97	308	975
109	2	0.10	2500	0.00460	49	154	487
110	2	0.10	62500	0.11500	2	6	20
111	2	0.30	50	0.00009	7311	23120	73110
112	2	0.30	250	0.00046	1462	4624	14620
113	2	0.30	1250	0.00230	292	925	2924
114	2	0.30	2500	0.00460	146	462	1462
115	2	0.30	62500	0.11500	6	19	58
116	2	0.40	50	0.00009	9748	30830	97480
117	2	0.40	250	0.00046	1950	6165	19500
118	2	0.40	1250	0.00230	390	1233	3899
119	2	0.40	2500	0.00460	195	617	1950
120	2	0.40	62500	0.11500	8	25	78
121	5	0.02	50	0.00009	1927	6092	19270
122	5	0.02	250	0.00046	385	1218	3853
123	5	0.02	1250	0.00230	77	244	771
124	5	0.02	2500	0.00460	39	122	385
125	5	0.02	62500	0.11500	2	5	15
126	5	0.10	50	0.00009	9633	30460	96330
127	5	0.10	250	0.00046	1927	6092	19270
128	5	0.10	1250	0.00230	385	1218	3853
129	5	0.10	2500	0.00460	193	609	1927
130	5	0.10	62500	0.11500	8	24	77
131	5	0.30	50	0.00009	28900	91390	289000
132	5	0.30	250	0.00046	5780	18280	57800
133	5	0.30	1250	0.00230	1156	3655	11560
134	5	0.30	2500	0.00460	578	1828	5780
135	5	0.30	62500	0.11500	23	73	231
136	5	0.40	50	0.00009	38530	121800	385300
137	5	0.40	250	0.00046	7706	24370	77060
138	5	0.40	1250	0.00230	1541	4874	15410
139	5	0.40	2500	0.00460	771	2437	7706

Table 3-6. Predicted dilution for miscellaneous discharges (*continued*).

Case ID	Effective Water Depth (meters)	Current Speed (m/s)	Discharge Rate (bbl/day)	Discharge Rate (cm/s)	Dilution at 10 meters	Dilution at 100 meters	Dilution at 1000 meters
140	5	0.40	62500	0.11500	31	97	308
141	20	0.02	50	0.00009	15410	48740	154100
142	20	0.02	250	0.00046	3083	9748	30830
143	20	0.02	1250	0.00230	617	1950	6165
144	20	0.02	2500	0.00460	308	975	3083
145	20	0.02	62500	0.11500	12	39	123
146	20	0.10	50	0.00009	77060	243700	770600
147	20	0.10	250	0.00046	15410	48740	154100
148	20	0.10	1250	0.00230	3083	9748	30830
149	20	0.10	2500	0.00460	1541	4874	15410
150	20	0.10	62500	0.11500	62	195	617
151	20	0.30	50	0.00009	231200	731100	2312000
152	20	0.30	250	0.00046	46240	146200	462400
153	20	0.30	1250	0.00230	9248	29240	92480
154	20	0.30	2500	0.00460	4624	14620	46240
155	20	0.30	62500	0.11500	185	585	1850
156	20	0.40	50	0.00009	308300	974800	3083000
157	20	0.40	250	0.00046	61650	195000	616500
158	20	0.40	1250	0.00230	12330	38990	123300
159	20	0.40	2500	0.00460	6165	19500	61650
160	20	0.40	62500	0.11500	247	780	2466
161	40	0.02	50	0.00009	43590	137900	435900
162	40	0.02	250	0.00046	8719	27570	87190
163	40	0.02	1250	0.00230	1744	5514	17440
164	40	0.02	2500	0.00460	872	2757	8719
165	40	0.02	62500	0.11500	35	110	349
166	40	0.10	50	0.00009	218000	689300	2180000
167	40	0.10	250	0.00046	43590	137900	435900
168	40	0.10	1250	0.00230	8719	27570	87190
169	40	0.10	2500	0.00460	4359	13790	43590
170	40	0.10	62500	0.11500	174	551	1744
171	40	0.30	50	0.00009	653900	2068000	6539000
172	40	0.30	250	0.00046	130800	413600	1308000
173	40	0.30	1250	0.00230	26160	82710	261600
174	40	0.30	2500	0.00460	13080	41360	130800
175	40	0.30	62500	0.11500	523	1654	5231

Table 3-6. Predicted dilution for miscellaneous discharge cases (continued).

Case ID	Effective Water Depth (meters)	Current Speed (m/s)	Discharge Rate (bbl/day)	Discharge Rate (cm/s)	Dilution at 10 meters	Dilution at 100 meters	Dilution at 1000 meters
176	40	0.40	50	0.00009	871900	2757000	8719000
177	40	0.40	250	0.00046	174400	551400	1744000
178	40	0.40	1250	0.00230	34870	110300	348700
179	40	0.40	2500	0.00460	17440	55140	174400
180	40	0.40	62500	0.11500	698	2206	6975
181	50	0.02	50	0.00009	60920	192700	609200
182	50	0.02	250	0.00046	12180	38530	121800
183	50	0.02	1250	0.00230	2437	7706	24370
184	50	0.02	2500	0.00460	1218	3853	12180
185	50	0.02	62500	0.11500	49	154	487
186	50	0.10	50	0.00009	304600	963300	3046000
187	50	0.10	250	0.00046	60920	192700	609200
188	50	0.10	1250	0.00230	12180	38530	121800
189	50	0.10	2500	0.00460	6092	19270	60920
190	50	0.10	62500	0.11500	244	771	2437
191	50	0.30	50	0.00009	913900	2890000	9139000
192	50	0.30	250	0.00046	182800	578000	1828000
193	50	0.30	1250	0.00230	36550	115600	365500
194	50	0.30	2500	0.00460	18280	57800	182800
195	50	0.30	62500	0.11500	731	2312	7311
196	50	0.40	50	0.00009	1218000	3853000	12180000
197	50	0.40	250	0.00046	243700	770600	2437000
198	50	0.40	1250	0.00230	48740	154100	487400
199	50	0.40	2500	0.00460	24370	77060	243700
200	50	0.40	62500	0.11500	975	3083	9748

4. DESCRIPTION OF THE EXISTING PHYSICAL ENVIRONMENT

4.1. Climate and Meteorology

The Area of Coverage is in the Arctic Climate Zone and is characterized by cold temperatures, nearly constant wind, and low precipitation. Important meteorological conditions that could affect the Geotechnical GP discharges include air temperature, rain and snowfall, and wind speed and direction.

Air temperature controls the ice formation and break-up and whether ice would need to be managed as part of Geotechnical GP activities. Precipitation determines the quantity and concentration of pollutants discharged from deck drainage and wind speed and direction influence coastal oceanographic conditions. The following sections describe the physical setting of the Area of Coverage of the Geotechnical GP.

4.1.1. Air Temperature

Subfreezing temperatures prevail for most of the year throughout both the Chukchi and Beaufort Seas. An extreme low temperature of -62 ^{0}F has been recorded at Prudhoe Bay. Prolonged periods of high winds, during winter, lead to extreme ice pressures and dangerous wind-chill conditions. There is brief summer season usually lasting from June to August, with temperatures generally above the freezing point with precipitation usually falling in the form of rain (MMS 2008).

The *Arctic Climate Impact Assessment* (ACIA 2005) summarizes spatial and temporal temperature trends in the Arctic according to observations from the Global Historical Climatology Network database (Peterson and Vose 1997 cited in MMS 2008) and the Climate Research Unit database (Jones and Moberg 2003 cited in MMS 2008). Both time series for stations north of latitude 60°N show a statistically significant warming trend of 0.16 °F per decade for the period of 1900 to 2003 (ACIA 2005 cited in MMS 2008). In general, temperatures increased from 1900 to the mid-1940s, decreased until about the mid-1960s, and then increased again to the present. When temperature trends are broken down by season, the largest changes occurred in winter and spring. The greater amount of warming in the Arctic compared to that for the globe as a whole is consistent with climate model projections (IPCC 2007 cited in MMS 2008). As discussed in Section 6.2, temperature would not have a substantial effect on the behavior of the discharges, and therefore changes in temperature are not expected to affect the discharges.

4.1.2. Precipitation

There is great seasonal variation in precipitation in the Beaufort-Chukchi Sea region. Rainfall is usually light during the short summer months; however, heavier rainstorms occasionally occur. These heavier rainstorms typically occur during July and August (Alaska Annual Temperature Summary (WRCC 2011 cited in NMFS 2013)).

Along the Beaufort Sea coast, total annual precipitation ranges from four to six inches, while the average annual snowfall ranges from approximately 30 to 42 inches. The Chukchi Sea coast receives more annual precipitation and average annual snowfall. Annual precipitation ranges from four to 11 inches while average snowfall ranges from approximately 40 to 53 inches per year (Alaska Annual Temperature Summary (WRCC 2011 cited in NMFS 2013)).

4.1.3. Winds

Surface winds exhibit seasonally complicated flow regimes in the Chukchi and Beaufort Seas and have considerable directional variation along the coast and offshore. Along the Beaufort Sea coast, onshore winds are predominantly from the east, east-northeast, and northeast, while offshore winds most commonly come from the west, west-southwest, and southwest. Winter winds along the Chukchi Sea coast exhibit a strong northerly prevalence; however, wind directions can vary from northwest in the western part of the sea to northeast in the eastern part. During the summer, the Chukchi Sea experiences winds that alternate between the north and south (Alaska Prevailing Wind Direction (WRCC 2011 cited in NMFS 2013)).

4.2. Oceanography

Oceanographic considerations include tides, wind, freshwater overflow and inputs, ice movement, stratification, and current regime. The following is a brief review of the oceanographic and meteorological conditions within the Area of Coverage.

4.2.1. Bathymetric Features and Water Depths

The Chukchi and Beaufort Seas are parts of the Arctic Ocean and both are linked, atmospherically and oceanographically, to the Pacific Ocean. Affecting regional meteorological conditions is the atmospheric connection to the Aleutian Low. The oceanographic connection is the Bering Strait that draws relatively warm nutrient-rich water into the Arctic Ocean from the Bering Sea (Weingartner and Danielson 2010 cited in NMFS 2013).

While the Chukchi Sea is an overall shallow sea with a mean depth of 131 to 164 feet (40–50 meters), the continental shelf of the Beaufort Sea depth gradually increases from approximately 121 feet (36.9 meters) to a maximum depth of around 12,467 feet (3,800 meters) along the shelf break and continental shelf (Weingartner 2008, Greenberg et al. 1981, cited in NMFS 2013).

Several major bathymetric features exist in both seas including three major sea valleys, the Herald and Barrow Canyons near the western and eastern edges of the Chukchi Sea and the Barrow Canyon, just northwest of Barrow. Additionally, two large shoals, the Hanna and Herald define the western and eastern edges of the Chukchi Sea. Those topographic features exert a steering effect on the oceanographic circulation patterns in the area (MMS 2008). Barrow Canyon is just northwest of Barrow and serves to drain water from the Chukchi Sea and bring upwelled water from the basin to the shelf. They are narrow (less than 250 meters), have low elevations (less than 2 meters) and, particular to the Arctic, they are short (Stutz, Trembainis and Pilkey 1999 cited in MMS 2008). The shoals rise 5–10 meters (16–33 feet) above the surrounding seafloor and are found in water depths of 10–20 meters (33–65 feet) (MMS 2008). Barrier islands provide two main benefits: they protect the coastlines from severe storm damage; and they harbor several habitats that are refuges for wildlife. The salt marsh ecosystems of the islands and the coast help to purify runoff from mainland streams and rivers. Continental shelves vary in width from almost zero up to the 930 mi-wide Siberian shelf in the Arctic Ocean and average 78 kilometers (48 miles) in width. The continental slope in the Beaufort Sea has water depths varying from 60 to 1,500 meters (197 to 4,921 feet). The shelf varies in width between Barrow and Canada and generally is a narrow shelf averaging about 80.5 kilometers (50 miles).

4.2.2. Circulation and Currents

Current velocity and turbulence can vary markedly with location/site characteristics and can affect the movement and concentration of suspended matter, and the entrainment, resuspension, and advection of sedimented matter. The direction of the current determines the predominant location of the discharge plume while current velocity influences the extent of area affected. Velocity and boundary conditions also affect mixing because turbulence increases with current speed and proximity to the seafloor.

The Chukchi Sea is fed by Pacific Ocean and Arctic Ocean waters. Pacific waters enter the Chukchi Sea through the Bering Strait in the south. Arctic waters enter the Chukchi Sea through Long Strait and in episodic up-shelf transfers from the Arctic Ocean proper (e.g., via Barrow Canyon). The circulation and modification of waters in the Chukchi Sea influence the input to the Arctic Ocean from the Pacific. Although the volume of water from the Pacific through the Bering Strait is relatively small (~ 0.8 Sverdrups [Sv] northward in the annual mean [Sv is a unit of volume transport equal to 1,000,000 cubic meters per second [264,172,100 gallons per second]), it contributes seawater of high heat and freshwater content, low density, and high nutrients to the Chukchi Sea and the Arctic Ocean (MMS 2008).

Circulation in the Beaufort Sea can be divided into waters shallower than 40 meters and in offshore waters deeper than 40 m. Offshore waters are primarily influenced by the large-scale Arctic circulation known as the Beaufort Gyre, which is driven by large atmospheric pressure fields. In the Beaufort Gyre, water moves to the west in a clockwise motion at a mean rate of 5–10 centimeters per second (cm/s). The southern portion of the Beaufort Gyre is found in the offshore region of the proposed Beaufort Sea sales area. The Beaufort Gyre expands and contracts, depending on the state of the Arctic Oscillation (Steele et al. 2004 as cited in MMS 2008). Below the surface flow of the Beaufort Gyre, the mean flow of the Atlantic layer (centered at 500 meters) is counterclockwise in the Canada Basin. Below the polar mixed layer, currents appear to be driven primarily by ocean circulation rather than the winds (Aagaard et al. 1998 cited in MMS 2008). The figures below collectively illustrate the major water mass flows in the Chukchi and Beaufort Seas.

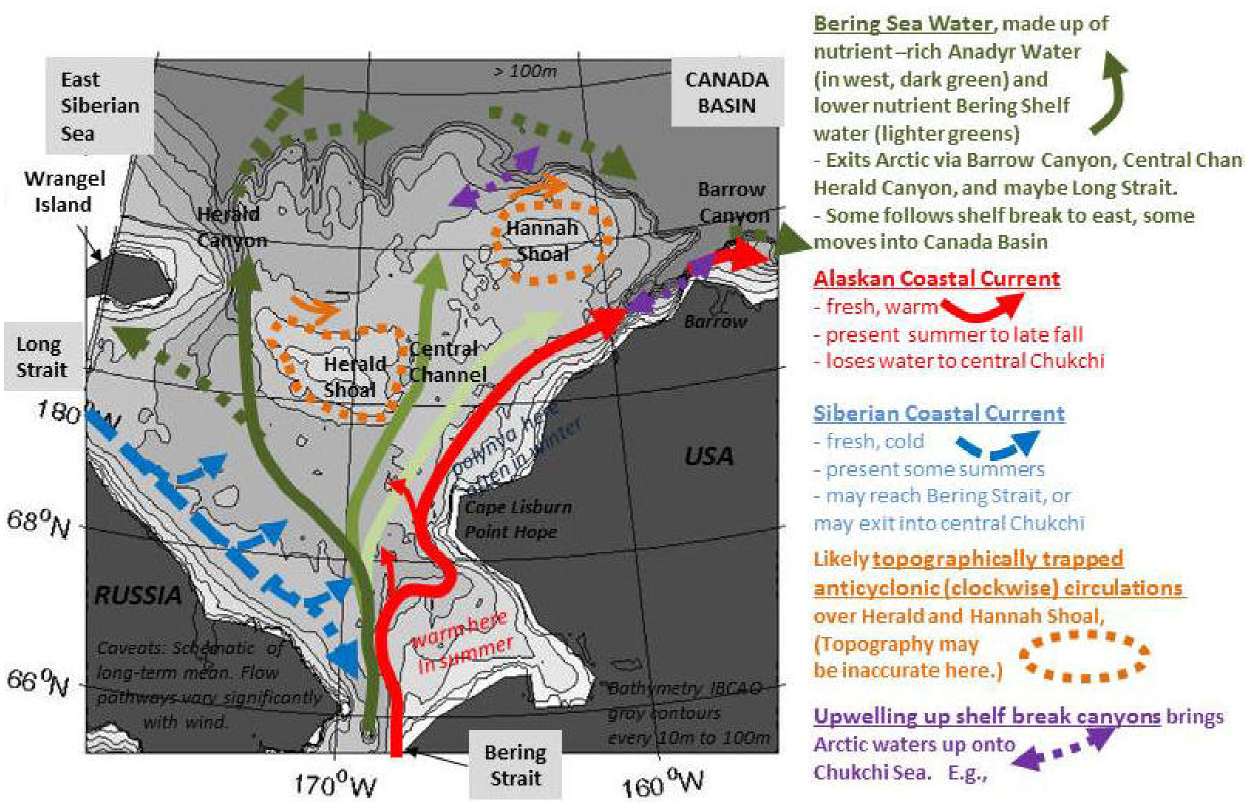

Figure 4-1. Circulation and Outflows of the Chukchi Sea.
(Source http://psc.apl.washington.edu/HLD/Chukchi/Chukchi.html)

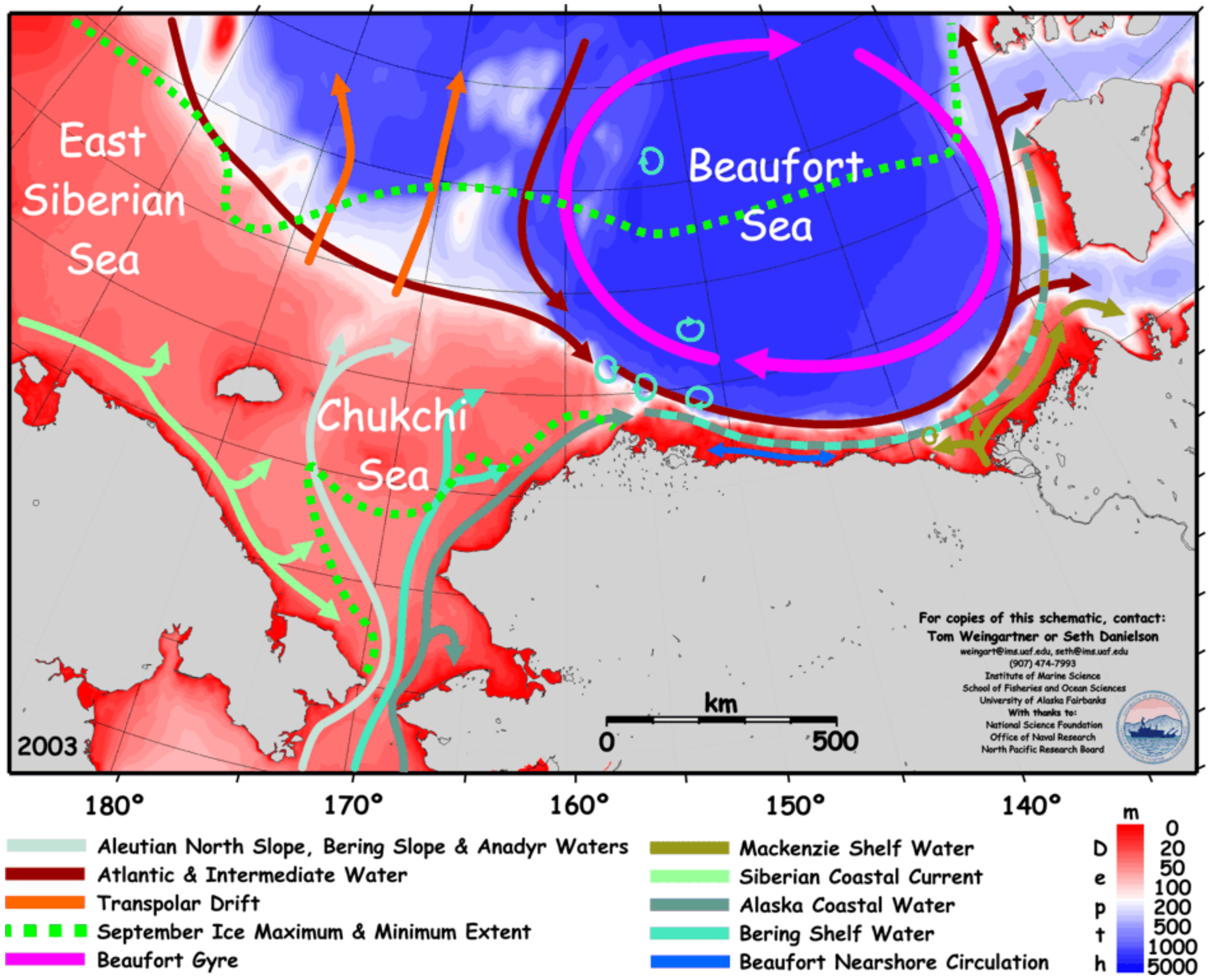

Figure 4-2. Satellite-tracked drifter study of water mass circulation in the Chukchi and Beaufort Seas.
(*Source* http://www.ims.uaf.edu/)

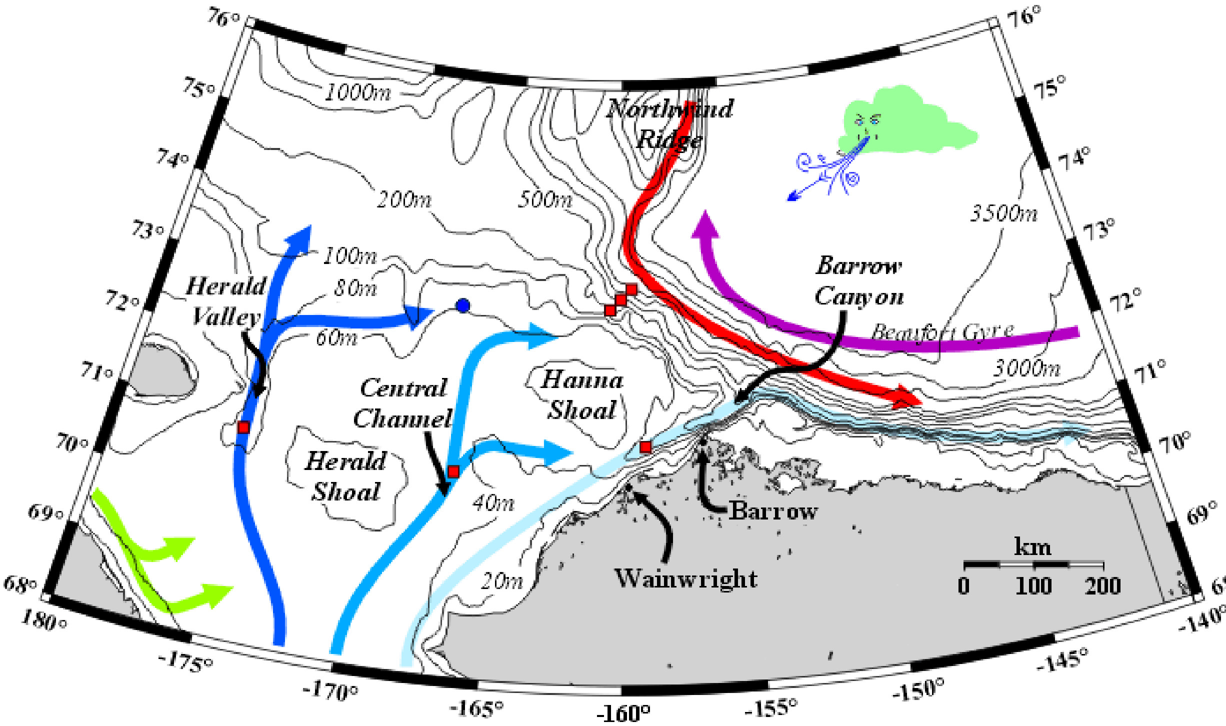

Figure 4-3. Mean circulation data for the Chukchi Sea and Beaufort/Chukchi slope. (*Source: IMS (2010)).*

The Alaska Coastal Current (ACC) is a narrow, fast-moving current flowing northeasterly at approximately 0.16 feet per second (ft/sec) along the Alaska coastline. North of Cape Lisburne, the ACC parallels the 66-foot isobath until it reaches the Barrow Sea Valley at Wainwright. It then follows parallel with the valley from Wainwright to Point Barrow where it turns and flows southeasterly parallel to the coastline. The ACC flow is variable, and directional reversals can persist for several weeks because of changes in wind direction. During northeasterly flow, clockwise eddies can separate the nearshore circulation from the ACC between Cape Lisburne and Icy Cape (MMS 1990).

The currents in the ACC are strongly influenced by the bathymetry and wind. Current speeds of 0.66 to 1.0 ft/sec are characteristic of the eastern Chukchi Sea. Bottom temperature gradients and currents are greatest in the vicinity of Icy Cape and Point Franklin (Weingartner and Okkonen 2001 in MMS 1991). Current velocities of 1.67 to 2.85 ft/sec have been reported south of Icy Cape (MMS 1990).

MMS (1990) reports that during open-water periods, ACC waters are driven by the wind. Northeasterly winds promote upwelling that brings cooler bottom water into the nearshore area. Southwesterly winds establish a warm coastal jet in the nearshore region, which displaces the cooler bottom water. Easterly winds shift the ACC offshore, centering it approximately 12.4 miles from the coast. Westerly winds shift the ACC closer to the coast. Traditional knowledge confirms the movement of tides along with wind direction but also indicates that tides can move opposite the wind direction. One observer offshore Omalik Lagoon reported that the currents 5 to 10 miles out move to the north with a south wind and to the south with a northeast wind (SRB&A 2011). Traditional knowledge participants stated that in the summer, currents move from north to south or south to north but can change direction rapidly, and their direction can depend on the distance from shore (SRB&A 2011). The mean surface current direction year-round is to the west and parallels the bathymetry. The tidal action coupled with the easterly nearshore circulation results in the gradual removal of warm, brackish water from nearshore and replaces it with colder, more saline water. Alternatively, tidal action coupled with westerly nearshore circulation causes accumulation of warm, brackish water along the coast. Other controls on nearshore circulation include river discharge, ice melt, bathymetry, and the configuration of the coastline.

In the landfast ice zone of the nearshore Beaufort, Weingartner et al. (2009) determined that during the open water season, mid-depth currents are at least 20 cm/s, whereas during the landfast ice season, they generally are less than 10 cm/s. Tidal currents are less than 3 cm/s and most likely have a negligible dynamical effect on the currents and circulation (MMS 2008). During ice covered periods, landfast ice in the nearshore areas protects the water from the effects of the winds. Therefore, the circulation pattern is influenced by storms and brine drainage (MMS 2008).

4.2.3. Tides

Tidal ranges for the Beaufort and Chukchi Seas are small, ranging from <0.3 meter (1 feet) to <0.7 meter (2 feet). The Beaufort Sea tides propagate from west to east along the coast. Tidal currents are largest on the western side of the Chukchi Sea and near Wrangel Island, ranging up to 5 cm/s (0.1 knots/s). While tides may not seem to exert an important influence on the oceanography of the seas, they likely play an important role in seas ice dynamics and movement (Woodgate et al. 2005).

4.2.4. Stratification, Salinity, and Temperature

Nearshore waters are strongly influenced by inputs of fresh water from rivers, particularly in the Beaufort Sea. In nearshore areas, a two-layered stratified system is formed with fresher water from riverine input overlying more saline oceanic water. The surface layer generally shows a marked decrease in salinity in the vicinity of major rivers. In the winter, the lack of freshwater input into coastal waters results in weak stratification. Freshwater input also causes a marked temperature division between nearshore and offshore waters.

In the Beaufort area, the MacKenzie River flows all year long, contributing the largest amount of freshwater per year. Coastal water temperature typically ranges from 41 to 50 °F and has salinities that are generally less than 31.5 parts per thousand (ppt) (Lewbel and Gallaway 1984 in MMS 2003). Offshore waters are colder and more saline than the coastal waters. Water temperatures are near 32 °F and have salinities of 32.2 to 33 ppt (Lewbel and Gallaway 1984 cited in MMS 2003).

During the spring (May to July) warm water (above 32 °F) appears in the Chukchi Sea because of the gradual increase of solar radiation and warm water advected through the eastern Bering Strait (NMFS 2013). During the summer (July to August), the deep waters are generally still cold, ranging from 32 to 37 °F, depending on location, however, temperatures can reach above 48 °F. During the fall (September to October), the surface water temperatures stay cool ranging from 36 to 43 °F. The Chukchi Sea surface temperatures fall below 32 °F during the winter (November to April).

4.3. Ice

Sea ice, formed by the freezing of sea water, is a dominant feature of the Arctic environment. It is frozen seawater that floats on the ocean surface; it forms and melts with the polar seasons. Annual formation and decay of sea ice greatly influence the oceanographic dynamics of the Chukchi and Beaufort Seas regulating heat, moisture, and salinity. Sea ice insulates the relatively warm ocean water from the cold polar atmosphere, except where cracks or leads (areas of open water between large pieces of ice) in the ice allow exchange of heat and water vapor from ocean to atmosphere in winter. Sea ice impacts virtually all of the physical, biological, and cultural aspects of life of the region. In general, sea ice reaches its maximum extent in March and minimum extent in September.

In the Chukchi Sea, sea ice generally begins forming in late September or early October, with full ice coverage by mid-November or early December (MMS 2008). However, traditional knowledge information indicates that freeze ups are happening later, starting in October, and while hunters have used the ice starting in October in the past, they now have to wait until December (SRB&A 2011). Ice begins melting in early May in the southern part of Chukchi Sea, and early to mid-June in the northern region. Maximum open water occurs in September (MMS 2008); however, in the Arctic, some sea ice persists year after year.

In the Beaufort Sea, sea ice generally begins forming in late September or early October, with full ice coverage by mid-November or early December. Ice begins melting in early May in the southern part of Beaufort Sea, and early to mid-June in the northern region. Maximum open water occurs in September (MMS 2008).

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 during summer and more recently during winter. Simulations conducted for the trajectory of Arctic sea ice indicate decreasing September ice trends that are typically four times larger than observed trends, and predict near ice-free September conditions by 2040 (Holland et al. 2006). Factors causing reductions in winter sea ice can be different from those in summer.

4.3.1. Landfast Ice Zone

Landfast ice, or fast ice, which is attached to the shore, is relatively immobile and extends to variable distances off shore: generally 8- to 15-meter isobaths, but it can extend beyond the 20-meter (65.6-foot) isobath. It is usually reformed yearly, although it can contain floes of multiyear pack ice. About mid-May, the near-shore ice begins to melt; by July, the pack ice retreats northward. Much of the fast ice melts within the 10-meter isobath during the summer, but it is very dependent upon the wind direction which controls the ice floes. Traditional knowledge workshop participants during development of the Beaufort and Chukchi Exploration NPDES General Permits indicated that breakup varies from year to year, generally occurring in June or July. Freeze up typically occurs in October, although open water might be present in certain areas all winter long (SRB&A 2011) and reaches its maximum extent in March and April (NMFS 2011). Landfast ice is characterized by a gradual advance from the coast in early winter and a rapid retreat in the spring (Mahoney et al. 2007 cited in MMS 2008). The advance is not a continuous advance but involves the forming, breakup, and reforming of the landfast ice.

The two types of landfast ice are bottomfast and floating. Bottomfast ice, also called grounded ice, is frozen to the bottom out to a depth of about 2 m; in areas deeper than 2 m, landfast ice floats. Movement of ice in the landfast zone (called ice shoves, or *ivu* by the Inupiaq) is intermittent and can occur at any time but is more common during freeze up and breakup. Onshore winds are highly correlated with ice shoves (MMS 2008). Landfast ice moves in two general ways: (1) pile-ups and rideups and (2) breakouts. Onshore movement of the ice generates pileups and rideups, which can extend up to 20 meters inland (MMS 2008). Landfast ice can also move because of breakouts, where landfast ice breaks and drifts with pack ice.

The Beaufort Sea has much more extensive landfast ice cover than the Chukchi Sea. Differences in geographic setting and bathymetry between the Chukchi and Beaufort Seas lead to marked differences in the character of sea ice in these two regions. Due to its more southerly location and connection to the Pacific Ocean, the Chukchi Sea experiences a longer open water season than the Beaufort. In addition, due to the combination of a thinner ice pack and a coastline that offers the opportunity for open water creation under almost any drift direction, sea ice in the Chukchi Sea is more mobile and changeable than sea ice in the Beaufort. This is also reflected in the greater extent of landfast sea ice in the Beaufort Sea (Pew 2013).

4.3.2. Stamukhi Ice Zone

Seaward of the landfast-ice zone is the stamukhi, or shear, ice zone. In this zone, large pressure ridges, leads, polynyas (large areas of open water), and rubble fields occur between stationary landfast ice and mobile pack ice when winds drive the pack ice into the landfast ice (MMS 2008). Pressure ridges in the Beaufort reach depths of 18 to 25 meters (59 to 82 ft) and act as sea anchors for landfast ice. In the Chukchi Sea, the most intense ridging occurs in waters from 15 to 40 m (49 to 131 ft) deep, while moderate ridging extends seaward and shoreward of these regions (NMFS 2011).

4.3.3. Pack Ice

Pack ice is seaward of the stamukhi ice zone and includes first-year ice, multiyear un-deformed and deformed ice, and ice islands. First-year ice forms in fractures, leads, and polynyas and varies in thickness from inches to more than 3 feet. Traditional knowledge indicates that in recent years, ice has been less stable, there is less multiyear ice, pack ice is smaller, and large icebergs are rarely seen (SRB&A 2011). The Chukchi open-water system appears to be the result of the general westward motion seen in the Beaufort Gyre and is strongly influenced by the wind direction. Historically, first-year floes off the Chukchi Sea coast had a thickness of about 4 to 5 feet, and multiyear floes were 10 to 16.4 feet thick. Sea ice that is thicker than 16.4 feet is common in Arctic Ocean pack ice and is generally believed to consist of pressure ridges and rubble fields (Eicken et al. 2006 cited in MMS 2008). Increased ridging generally occurs from east to west and in the vicinity of shoals and large necks of land (MMS 2008).

Ice islands are icebergs that have broken off from an ice shelf with a thickness of 100 to 164.0 feet and range from tens of thousands of square feet to nearly 200 square miles. Movement of floating ice is controlled by atmospheric systems and oceanographic circulation. During winter, movement is small and occurs with strong winds that last for several days. The long-term direction of ice movement is from east to west in response to the Beaufort Gyre; however, weather systems can cause short-term variations. A system of seven recurring leads and polynyas develop in the Chukchi Sea. The Chukchi Sea has some of the largest areal fractions of leads along the northern coast of Alaska and Canada, because of the wind-driven polynyas that form along the coast from Point Hope to Barrow (MMS 2008). A general observation made by participants in traditional knowledge workshops was that the pack ice breaks up more quickly and that once the ice goes out, it does not return (SRB&A 2011).

4.3.4. Spring Lead System

Arctic leads are long, narrow channels of open water in the pack ice that can be hundreds of meters wide and kilometers long (Tschudi et al. 2002). Spring leads and polynyas provide important habitat for several seal species, polar bears, and migrating bowhead and beluga whales. Iñupiat hunters rely on the spring leads and areas of open-water for spring hunting of bowheads from April to June (Norton and Graves 2004 as cited in NMFS 2012).

The development of leads is highly dependent on the passage of individual weather systems. Lead patterns appear to be marginally linked to the prevailing atmospheric circulation regime. Eicken et al.

(2006) evaluated the lead distribution patterns and landfast ice extent along the northern Alaska and northwest Canadian coast between 1993 and 2004. Based on their results and on datasets published in previous studies, they found that major lead patterns and landfast ice patterns are repeated and that they appear to conform to consistent seasonal and spatial patterns of variability. These patterns are controlled to a large extent by a combination of topographic (or bathymetric) constraints, atmospheric forcing and large-scale ice dynamics (Eicken et al. 2006). Highest lead fractions and largest sizes are observed in the eastern Chukchi Sea and off the Mackenzie Delta, with fewer and smaller leads present in the central Beaufort Sea. This is a result of the prevailing easterly wind directions, forcing ice offshore and creating recurring flaw leads and polynyas along the landfast ice edge (Eiken et al. 2006).

Figure 4-4 through Figure 4-11 depict the locations of spring leads during March, April, May and June of the years 1994 and 2009 using data from the MMS OCS STUDY 2005-068 (Eicken et al., 2006) and from additional data provided directly by Dr. Hajo Eicken at the University of Alaska, Fairbanks. In addition to the locations of the spring leads, the figures show the Beaufort and Chukchi sea lease areas, the Chukchi Sea deferral area, Steller's eider critical habitat areas, and Environmental Sensitivity Index (ESI) areas for humpback and bowhead whales, i.e., areas that have been identified as at risk if an oil spill occurs nearby. Figures of the spring lead system for additional years are included in the administrative record for the Geotechnical GP. The recent data provided by Dr. Eicken have not yet been published and should be considered preliminary.

While these figures also depict critical habitat areas for polar bears, EPA notes that the designation of critical habitat for the polar bears by the USFWS was vacated and remanded on January 10, 2013 by the U.S. District Court for the District of Alaska. Therefore, at this time, there is no critical habitat designated for the polar bear (http://www.fws.gov/alaska/fisheries/mmm/polarbear/esa.htm).

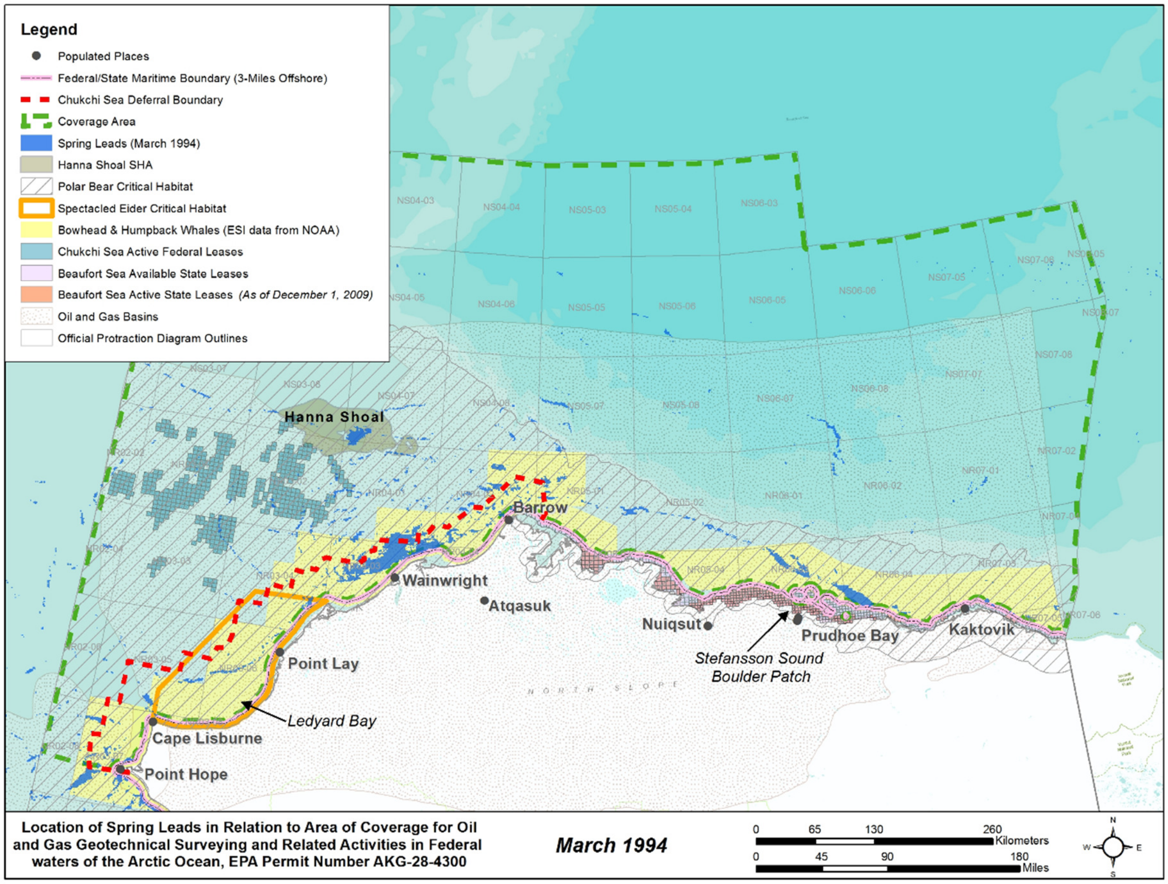

Figure 4-4. Spring Leads for March 1994 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

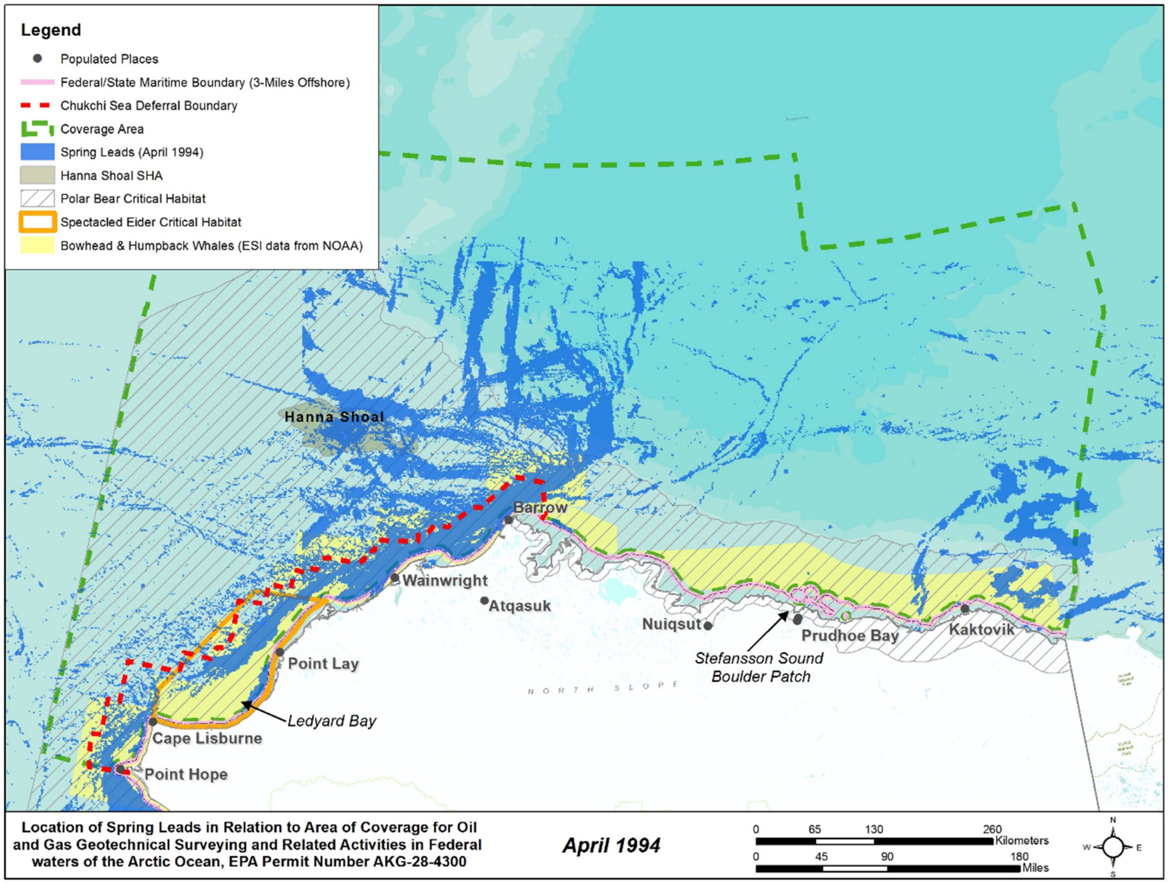

Figure 4-5. Spring Leads for April 1994 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

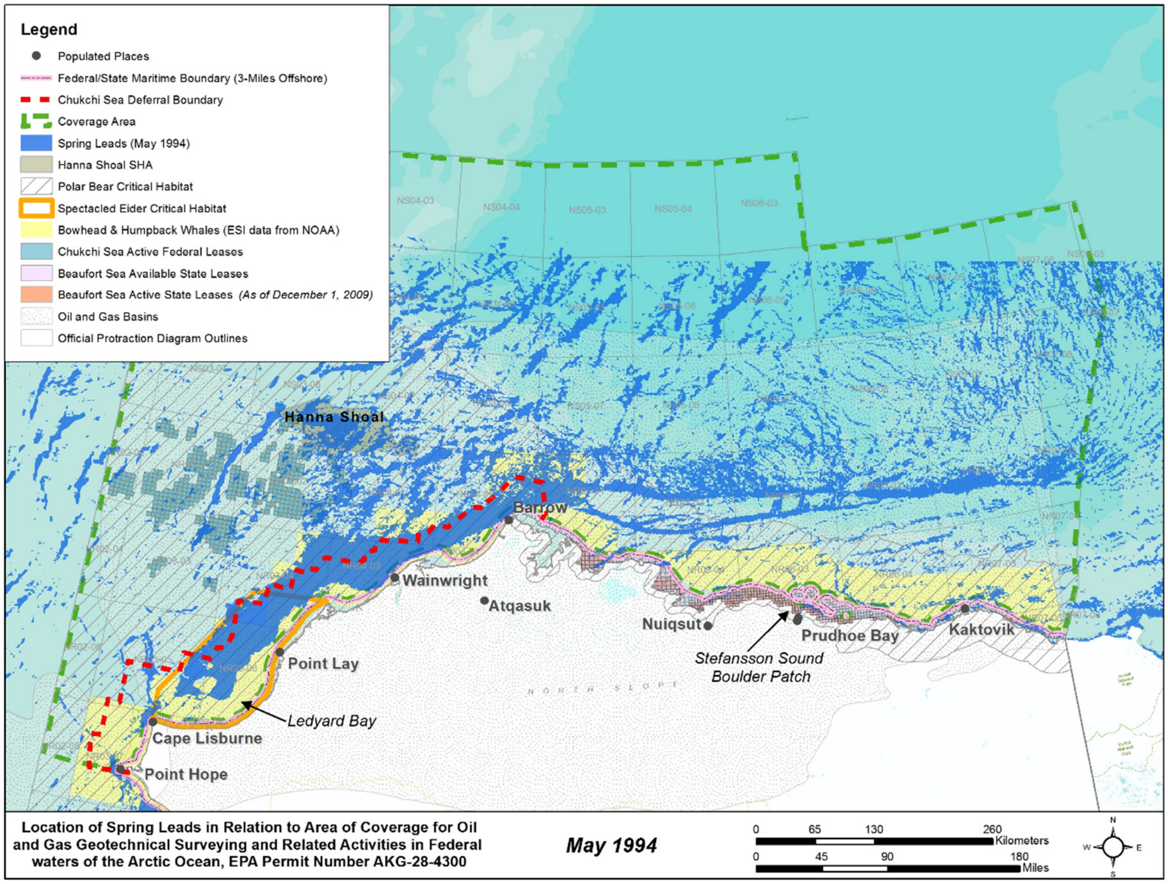

Figure 4-6. Spring Leads for May 1994 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

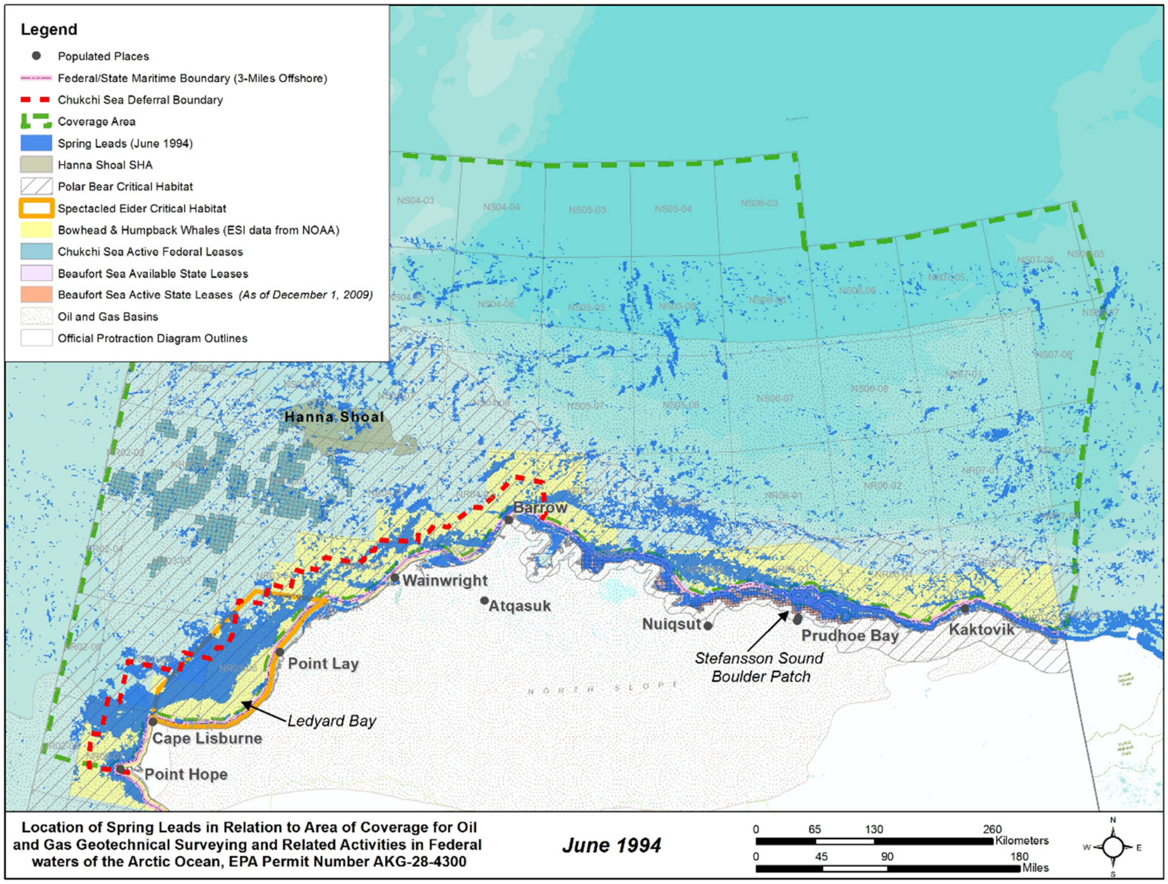

Figure 4-7. Spring Leads for June 1994 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

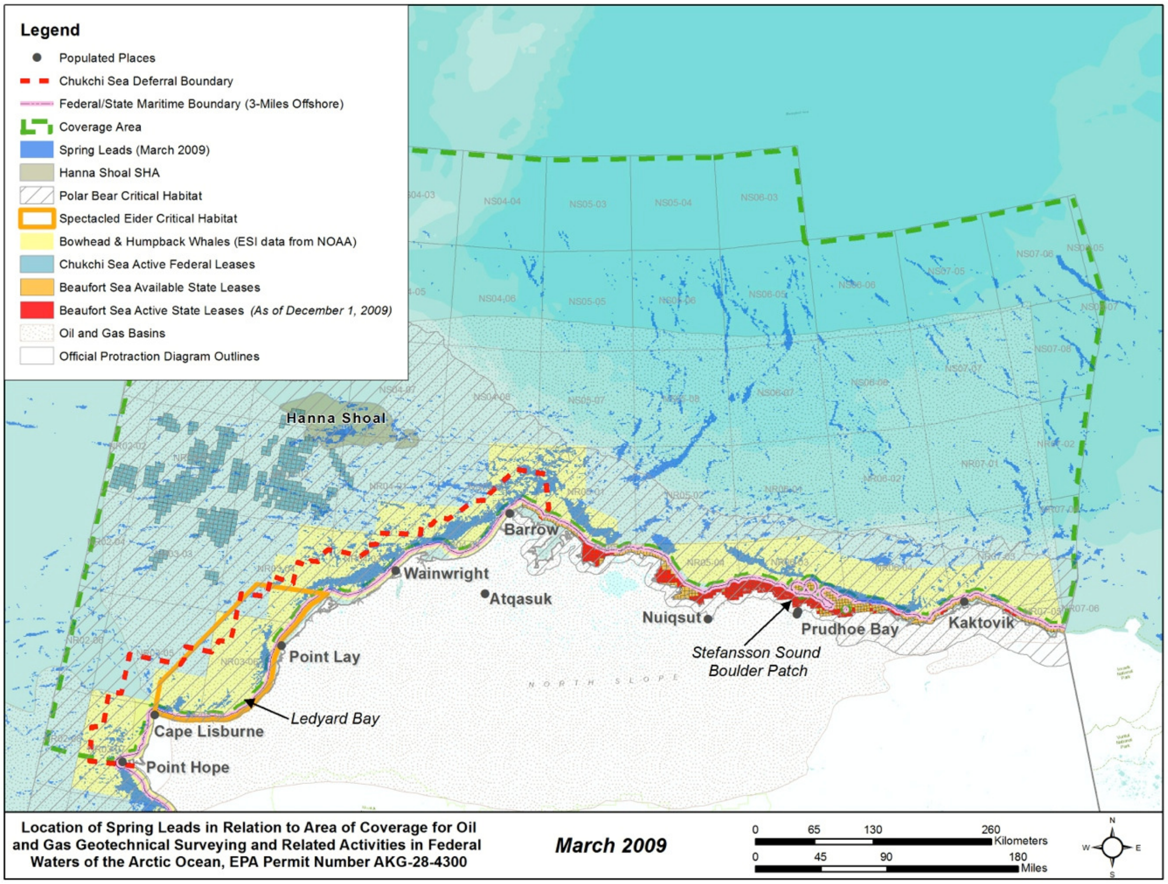

Figure 4-8. Spring Leads for March 2009 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

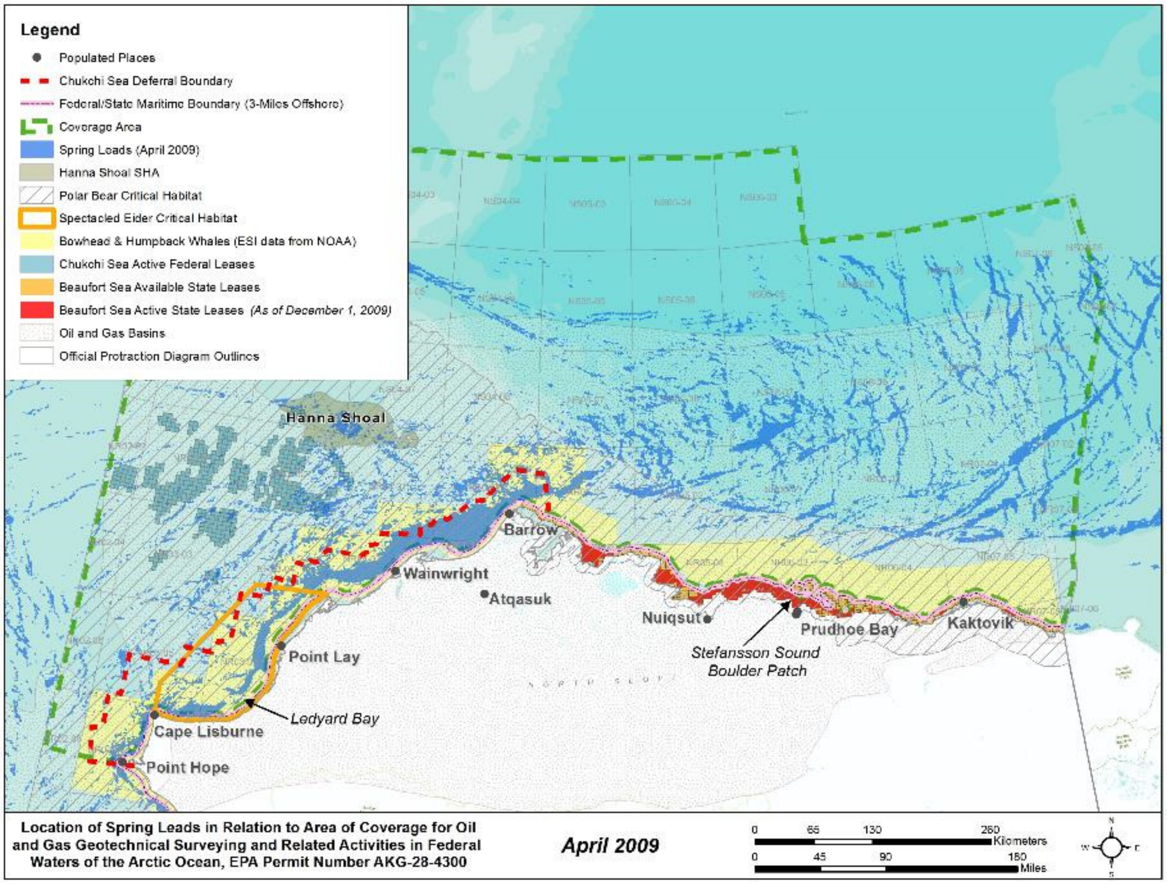

Figure 4-9. Spring Leads for April 2009 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

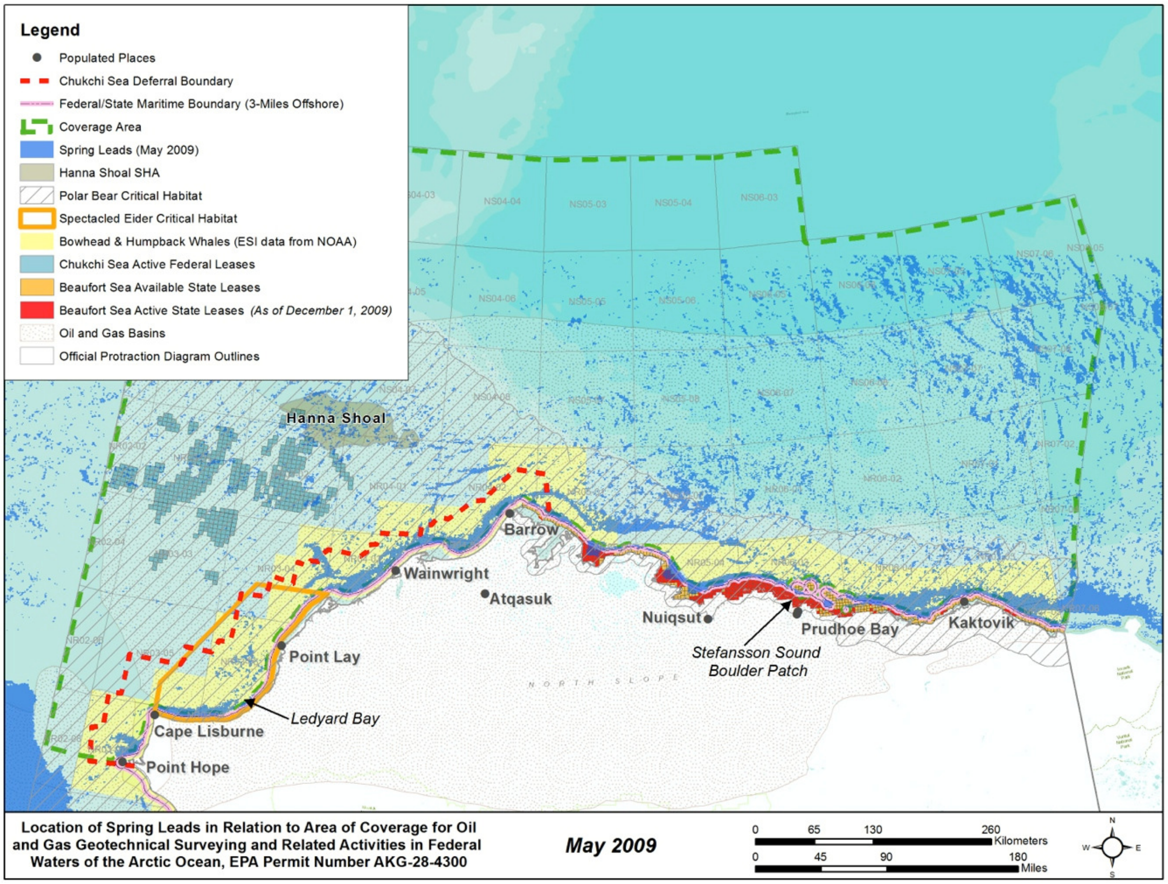

Figure 4-10. Spring Leads for May 2009 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

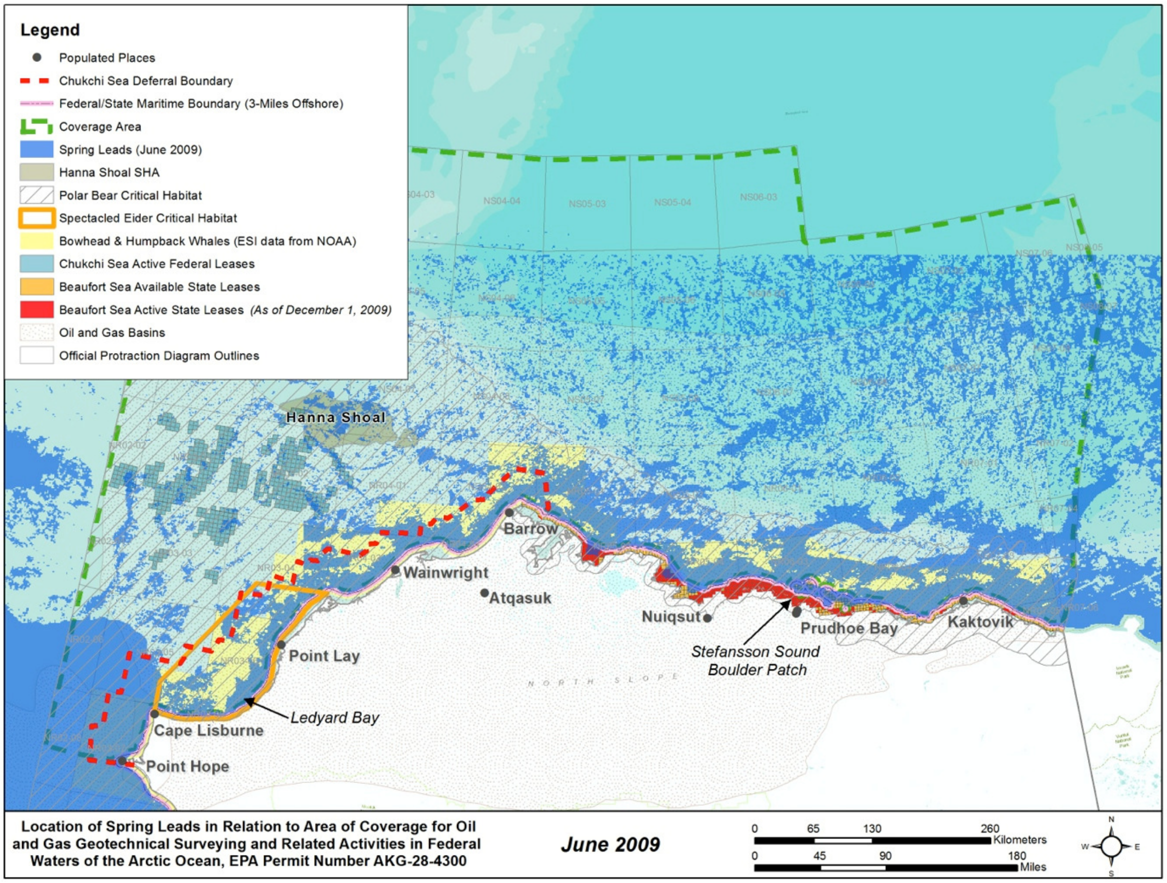

Figure 4-11. Spring Leads for June 2009 in the Area of Coverage for the Oil and Gas NPDES General Permit for Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas.

In the 1970s, Shapiro and Burns (1975 as cited in Braham et al. 1980) found that in March or April, the pack ice reaches its maximum extent in the Bering Sea. Ice breakup begins as temperatures rise and wind direction shifts from northeast to south or southwest, pushing the ice northward. In the northwestern Bering Sea, between the Chukchi Peninsula and St. Lawrence Island, strong currents further help to break up the ice and form an open-water corridor. North of the Bering Strait, a shear or flaw zone forms parallel to the Alaskan coast causing numerous small leads to develop along and near this zone. An intermittent lead system forms from the Bering Strait through outer Kotzebue Sound to Point Hope and on to Point Barrow. This lead system usually consists of a single, major nearshore lead that ties between landfast ice and the pack ice (Braham et al. 1980).

The differences in bathymetry and hydrography between the Chukchi and Beaufort seas lead to marked differences in the character of sea ice in these two regions. Due to its more southerly location and the inflow of heat through Bering Strait, the Chukchi Sea experiences a longer open water season than the Beaufort Sea. In addition, the combination of a thinner ice pack and a coastline that offers the opportunity for open water creation under almost any drift direction, sea ice in the Chukchi Sea is more mobile and changeable than sea ice in the Beaufort Sea. This is reflected in the more varied lead patterns in the

Chukchi Sea and in the greater extent of landfast sea ice in the Beaufort Sea. The Chukchi Sea and to lesser extent the Beaufort Sea are characterized by recurring coastal lead patterns that are particularly prominent in the months of March through May (Mahoney et al. 2012).

Sea ice in the Chukchi Sea is generally newly grown each year (Mahoney 2012). In the Chukchi Sea, there is a net northward flow, which enters through Bering Strait and branches into different bathymetrically constrained currents (Weingartner et al., 2005 as cited in Mahoney et al. 2012). The heat flux associated with this northward flow enhances the early loss of ice in the Chukchi Sea (Woodgate et al. 2010 as cited in Mahoney et al. 2012). The area of the Chukchi Sea that is most consistently open is off the northwest coast of Alaska, where the pack ice is frequently driven away from the shore, leaving behind wide areas of thin ice or open water. The most prominent coastal polynyas and flaw leads form along the eastern Chukchi Coast between Point Hope and Point Barrow, as well as to the north and west of Wrangel Island, with less distinct flaw leads appearing off the northern coast of Chukotka (Mahoney et al. 2012).

The Beaufort Sea retains a significant perennial (or multiyear) ice cover (Mahoney 2012). Circulation in the Beaufort Sea is dominated by the anticyclonic (clockwise) motion of the Beaufort Gyre, which transports some of the oldest and thickest ice in the Arctic from the region north of the Canadian Archipelago into the Beaufort Sea. This motion is driven by atmospheric circulation around a persistent region of high pressure (the Beaufort High). The strength of the Beaufort Gyre can vary from year to year and the ice motion can sometimes reverse for periods of a few days. However, in winter the average drift is approximately parallel to the coastline (Mahoney et al. 2012). The deformation and lead patterns in the Beaufort Sea are mainly determined by the interaction of the pack ice with the coast or landfast ice edge along the North Slope. The predominant pack ice drift direction is to the west, and the infrequent shift to the east or north are generally of small magnitude (Mahoney et al. 2012). Persistent leads and polynyas along the Beaufort coast are observed along the Mackenzie Delta, Herschell and Barter Island (Mahoney et al. 2012).

The spring lead system and spring-migration corridor through the Beaufort Sea extends farther offshore than through the Chukchi Sea (NMFS 2013). Offshore activities, such as geotechnical surveys and related activities, are unlikely to occur within the Beaufort Sea spring lead system during the bowhead migration because the ice at this time of year would be too thick for vessels to get to the location to conduct the activities (NMFS 2008).

Hanna and Herald Shoals and Herald Island play an important role as sources of open water or leads and points of origin for more extended lead systems. They are the only offshore features that are consistently associated with open water and thin ice (Mahoney et al. 2012).

The combination of prevalent open water and an almost exclusively first year ice pack makes the sea ice in the Chukchi Sea more mobile than that in the Beaufort Sea. As a result, winter lead patterns in the Chukchi Sea are characterized by numerous intersecting openings that change rapidly, whereas the Beaufort Sea generally has fewer, more isolated leads (Mahoney 2012).

Mahoney et al. (2012) performed an analysis of all sufficiently cloud-free Advanced Very High Resolution Radiometer imagery from November-June for the period 1993-2010 to evaluate the location, concentration and recurring patterns of leads and openings in the sea ice in the Chukchi and Beaufort seas. This work expanded on a project that they performed under the MMS OCS STUDY 2005-068 project. Under this most recent project, they were able to demonstrate a clear regional contrast in the distribution and seasonality of lead patterns in the Beaufort and Chukchi seas (Mahoney et al. 2012). In the Beaufort Sea, they observed a recurring lead pattern termed the "Barrow Arch," and found that most of the other lead patterns were confined to a relatively narrow zone between the margins of the pack ice and the coast (Mahoney et al. 2012). In the Chukchi Sea, they observed more dynamic ice conditions compared to the Beaufort Sea. They found that the Chukchi coastal polynyas and flaw leads are widespread and represent the most persistent lead pattern in the entire region. This includes lead systems forming off Wrangel Island, which are often linked to the same weather patterns responsible for open water off the Chukchi coast (Mahoney et al. 2012).

Unlike the MMS OCS STUDY 2005-068, which found little change in landfast ice extent since the 1970s, the researchers in this study observed a possible reduction in landfast ice extent since 2006. Analysis of additional data covering more recent years would be required to confirm these findings, but they point toward changes in the coastal ice regime of the Beaufort Sea that are unprecedented during the satellite record (Mahoney et al. 2012).

Mahoney et al. (2012) found that the Arctic Sea ice cover has undergone significant changes in the past two decades. These changes include a reduction in summer ice extent (with four consecutive record minima attained between 2001 and 2005) as well as substantial thinning of the ice pack (Eicken et al. e 2006). Beginning in the 2006 season, compared to previous years with very few leads outside of the Barrow Arch and the Mackenzie flaw zone, they observed that the number density and extent of leads in this region appeared to have increased substantially, mostly as a result of the changing composition of the Beaufort ice pack. Mahoney et al. (2012) noted that they will need to evaluate this area further to assess whether these changes are reversible. Recent climate modeling studies predict that the Arctic could be free or nearly free of sea ice in summer within the next few decades (Mahoney 2012). With more open water and a great influx of shortwave radiation, the changing ice regime is likely to have substantial, but poorly understood to date, ecological impacts (Mahoney et al. 2012).

4.4. Sediment Transport

Sediment transport and distribution in the Chukchi and Beaufort Seas is controlled by several factors, including storms, ice gouging, entrainment in sea ice, wave action, currents, and bioturbation. The bulk of sediment on the Alaskan continental shelf is transported northwards with the prevailing current. Sediment transport in response to severe storms is an important means of sediment transport in the Area of Coverage. Storm transport of sediment is particularly effective in the fall months when storms are associated with fresh ice, which enhances erosion and often entraps sediments in new ice. In the spring, the breakup and melting of this sediment-laden ice can result in sediment being transported far distances from the point of entrapment.

4.5. Water and Sediment Quality

4.5.1. Turbidity and Total Suspended Solids

Turbidity is caused by suspended matter or other impurities that interfere with the clarity of the water. It is an optical property that is closely related to the concentration of total suspended solids in the water. Natural turbidity is caused by particles from riverine discharge, coastal erosion, and resuspension of seafloor sediment, particularly during summer storms (NMFS 2013). Turbidity levels are generally higher during the summer open-water period relative to the winter ice-covered period. Under relatively calm conditions, turbidity levels are likely to be less than 3 Nephelometric Turbidity Units (NTU) and may be in excess of 80 NTU during high wind conditions. Nearshore waters generally have high concentrations of suspended material during spring and early summer due to runoff from rivers. The highest levels of suspended particles are found during breakup (NMFS 2013).

Concentrations of total suspended solids (TSS) from data collected in 2009 and 2010 in the Chukchi Sea study are presented below in Table 4-1 (Shell 2013).

Table 4-1. Summary data for total suspended solids collected from the Chukchi Sea during the 2009 and 2010 surveys (mg/L)

	2009	2010	2009	2010	2009	2010
	<30 m	<30 m	>30 m	>30 m	>30/<30 m	>30/<30 m
Mean	0.29	0.26	2.41	1.55	8.4	5.9
SD	0.19	0.17	0.96	0.55	--	--
N	34	50	14	25	--	--
Max	0.69	0.74	4.29	2.47	--	--
Min	0.08	0.07	1.23	0.73	--	--

SD = standard deviation

4.5.2. Metals

In the marine environment, metals are found in the dissolved, solid, and colloidal phases. The distribution of metals amounts among the three phases depends upon the chemical properties of the metal, the properties of other constituents of the seawater, and physical parameters. Current EPA water quality criteria for metals in marine waters are based on dissolved-phase metal concentrations because they most accurately reflect the bioavailable fraction, and hence the potential toxicity of a metal (NMFS 2013). Although EPA has established water quality criteria for water, there are no comparable national criteria or standards for chemical concentrations in sediment.

The main inputs of naturally-occurring metals to the Arctic Ocean are derived from terrestrial runoff, riverine inputs, and advection of water into the Arctic Ocean via the Bering Strait inflow and the Atlantic water inflow (NMFS 2013). Naturally occurring concentrations of metals are generally higher in the Chukchi Sea relative to those in the Beaufort Sea. Metals from the Bering Sea may be deposited in the Chukchi Sea sediments are Bering Sea water flows over the relatively shallow Chukchi Sea shelf (NMFS 2013).

Table 4-2, below, summarizes sediment metals data collected between 1984 and 2008 in the Beaufort Sea by BOEM (formerly MMS) and oil industry monitoring programs. Most samples were collected some distance in both time and space, from exploratory drilling activities, so the concentrations can be considered to represent the natural background. Concentration ranges are mg/kg dry weight (parts per million (ppm)) (Neff 2010).

Table 4-2. Concentrations of metals collected in Beaufort Sea sediment samples (mg/kg dry weight, ppm).

Years	Arsenic	Barium	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Vanadium	Zinc
1984-1986	--	128-704	0.06-0.27	22-89	7.6-30	--	--	5.7-19	37-142	37-123
1993	10-43	--	0.06-0.43	77-110	11-63	0.04-0.15	21-75	11-26	--	65-160
1997-1999	7-16	116-569	0.11-0.27	13-63	7-27	0.008-0.02	7-34	6-15	24-117	18-96
1999-2001[a]	1.0-23	142-863	0.03-0.75	13-104	3.6-46	0.003-0.11	--	2.8-22	27-173	15-136
1999-2002[a]	4.2-28	155-753	0.03-0.82	13-104	3.6-50	0.003-0.20	6.0-48	3.2-22	27-173	15-157
2001-2002	15-31	525-631	0.14-0.20	91-188	31-37	0.05-0.10[c]	45-52	16-26	147-211	114-146
2003	6.9-20	329-649	0.08-0.45	56-84	16-55	0.005-0.09	26-54	11-29	87-136	48-111
2004-2006	4.7-25	142-863	0.03-0.77	15-100	3.9-46	0.003-0.11	6.9-46	4.3-20	87-156	64-108
2008	9.5-22	456-714	0.16-0.31	59-96	15-27	0.03-0.08	--	9.9-18	87-156	64-108
2008[b]	10-21	585-18,300	0.15-0.24	73-135	21-53	0.04-0.06	--	14-49	113-131	64-108

[a] Brown et al. (2010) summarizes data for 1999 to 2002 MMS ANIMIDA Program; Trefry et al. (2003) summarizes data for 1999 to 2001 for the same program.

[b] Surface sediment samples collected near the Hammerhead exploratory drilling site in Camden Bay in 2008.

[c] Concentration of methylmercury ranged from 0.00001 to 0.00013 ppm.

Trefry et al. conducted an additional chemical and biological study at two sites drilled more than two decades ago in Camden Bay of the Beaufort Sea (Hammerhead 1 and 2). One of the objectives of the study included the location of persistent deposits of drilling fluids and drill cuttings around the two exploratory drilling sites. The study found significantly higher concentrations of barium from discharged drilling fluids within 250 m of the drilling site at approximately 200 times above background. Elevated concentrations of chromium, copper, mercury and lead were found only at two stations within 25 m of one drilling site. Concentrations of total polycyclic aromatic hydrocarbons (TPAH) were not significantly different at reference versus drilling-site stations (Trefry et al. 2013).

More than 300 sediment samples from the northeastern Chukchi Sea have been collected and analyzed for 19 metals. This data set includes 69 samples from the Burger Study Area and 259 samples located outside the Burger Study Area. Table 4-3 summarizes concentrations of metals in sediment and water samples in the 2012 Burger A drill site area. The concentrations of 19 metals in 18 sediment samples collected from the Burger A drill site during 2012 had an average relative standard deviation (RSD) of approximately 7% (Shell 2013).

Table 4-3. Concentrations of metals (mean ± SD) in sediment samples from Burger A.

Parameter (*n* = 18)	Ag (µg/g)	Al (%)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (µg/g)	Total Hg (ng/g)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD[1]	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[2]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

Parameter	MeHg (ng/g)	Mn (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Sn (µg/g)	Tl (µg/g)	V[3] (µg/g)	Zn (µg/g)
Mean	0.115	329	29	12.6	0.70	0.93	2.0	0.44	130	92
SD[1]	0.015	27	1.3	0.6	0.03	0.04	0.2	0.02	8	5
RSD[2]	13	5.2	4.6	4.7	3.6	4.8	10	4.7	5.9	5.5

[1] SD = standard deviation
[2] RSD = (SD/mean) x 100%
[3] V = vanadium

Table 4-4 summarizes the concentrations of dissolved metals from 6 samples from the Burger Study Area and 88 samples from the northeastern Chukchi Sea during 2010.

Table 4-4. Concentrations of dissolved metals (mean ± SD) for water samples

Parameter	As (µg/g)	Ba (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Total Hg (ng/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Tl (µg/g)	Zn (µg/g)	TSS (mg/L
Burger Study Area (2010; *n* = 88)													
Mean	1.16	7.7	0.046	0.13	0.24	0.0005	0.32	0.004	0.13	0.034	0.009	0.33	0.59
SD	0.04	1.2	0.024	0.07	0.04	0.0003	0.08	0.002	0.01	0.002	0.001	0.06	0.52
RSD	3	16	52	54	17	60	25	50	8	6	11	18	--
Northeastern Chukchi Sea (2010; *n* = 88)													
Mean	1.15	8.2	0.046	0.10	0.27	0.0005	0.32	0.006	0.12	0.034	0.010	0.45	0.80
SD	0.12	2.0	0.021	0.02	0.10	0.0003	0.08	0.002	0.01	0.006	0.002	0.26	0.88
RSD	10	24	46	20	37	60	25	33	8	18	20	58	--

4.5.3. Polycyclic Aromatic Hydrocarbons in Surface Sediments

Surface and subsurface sediments collected from the Chukchi shelf during the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) 2009 and 2010 field seasons establish a baseline data set to identify future impacts from oil and gas exploration in this region. Chukchi shelf surface sediments contain both parent and alkyl-substituted PAHs that represent a mixture of pyrogenic, petrogenic and biogenic sources at low concentrations as summarized below in Table 4-5. Multiple transport paths are likely responsible for the distribution and concentrations observed (Dunton 2012).

Table 4-5. Target polycyclic aromatic hydrocarbons (PAHs) measured in COMIDA samples.

PAH Targets	# of rings	MDL[1] (ng/g dry wt.)	PAH Targets (continued)	# of rings	MDL[1] (ng/g dry wt.)
Naphthalene*	2	1.12	Fluoranthene*	4	0.22
2-Methylnapthalene*	2	0.57	Pyrene*	4	0.20
1-Methylnapthalene*	2	0.28	Benzo(a)fluorene	4	0.03
Biphenyl*	2	0.18	Retene*	4	0.15
2,7-Dimethylnapthalene*	2	0.07	Benzo(b)fluorine*	4	0.02
1,3-Dimethylnapthalene*	2	0.08	Cyclopenta(c,d)pyrene	4	0.02
1,6-Dimethylnapthalene*	2	0.09	Benz(a)anthracene*	4	0.03
1,4-Dimethylnapthalene*	2	0.04	Chrysene+Triphenylene	4	0.03
1,5-Dimethylnapthalene*	2	0.03	Napthacene*	4	0.08
Acenapthylene	2	0.02	4-Methylchrysene*	4	0.02
1,2-Dimethylnapthalene	2	0.02	Benzo(b)fluoranthene	4	0.04
1,8-Dimethylnapthalene	2	0.39	Benzo(k)fluoranthene	4	0.02
Acenapthene	2	0.11	Dimethylbenz(a)anthracene	4	0.03
2,3,5-Trimethylnapthalene*	2	0.03	Benzo(e)pyrene	5	0.04
Fluorene	2	0.11	Benzo(a)pyrene*	5	0.08
1-Methylfluorene*	2	0.05	Perylene*	5	0.06
Dibenzothiophene*	3	0.04	3-Methylchloanthrene	5	0.08
Phenanthrene*	3	0.62	Indeno(1,2,3-c,d)pyrene	5	0.01
Anthracene	3	0.03	Dibenz(a,h+ac)anthracene	5	0.02
2-Methyldibenzothiophene*	3	0.09	Benzo(g,h,i)perylene*	6	0.02
4-Methyldibenzothiophene*	3	0.04	Anthanthrene	6	0.01
2-Methylphenanthrene*	3	0.15	Corenene	7	0.00
2-Methylanthracene*	3	0.03			
4,5-Methylenephenanthrene	3	0.04	Internal standards:		
1-Methylanthracene*	3	0.04	Acenaphthene-d10	3	
1-Methylphenanthrene*	3	0.13	Phenanthrene-d10	3	
9-Methylanthracene	3	0.03	Benz(a)anthracene-d12	4	
3,6-dimethylphenanthrene*	3	0.10	Benzo(a)pyrene-d12	5	
9,10-Dimethylanthracene*	3	0.16	Benzo(g,h,i)perylene-d12	6	

[1] MDL = method detection limit values

(*) denotes PAHs that have been detected in COMIDA09/10 sediments.

4.6. Unique Features

4.6.1. Herald and Hanna Shoals

There are several shoals on the Chukchi continental shelf, including two prominent shoals, Herald Shoal to the west and Hanna Shoal to the east. Hanna Shoal and Herald Shoal rise above the surrounding seafloor to approximately 20 m (66 ft) below sea level (BOEM 2012). The abundance and diversity of benthic communities and demersal fish species are found to be higher in study areas near Hanna Shoal and the mouth of Barrow Canyon, coinciding with the patterns of nutrient rich current flows and seasonal movements of water masses (BOEM 2014). Additionally, survey studies and observations over the last several years indicate the preference and presence of walruses for the northern Chukchi Sea, particularly in the Hanna Shoal area, likely due to food availability and proximity to resting habitat. The shoals also provide important benthos-feeding habitat for bearded seals (BOEM 2014).

4.6.2. Herald Canyon and Barrow Canyon

There are also two major sea valleys in the Chukchi Sea: Herald Canyon and Barrow Canyon. The Barrow Sea Valley begins north of Wainwright and trends in a northeasterly direction parallel to the Alaskan coast. Barrow Canyon is a major conduit for Pacific waters, which cross the Chukchi Sea shelf area to enter the Canada Basin. Herald Valley is to the north adjacent to Wrangel Island, outside the Leased Area. Hope Valley, a broad depression, stretches from Bering Strait to Herald Canyon. These topographic features exert a steering effect on the oceanographic circulation patterns in this area (BOEM 2014).

4.6.3. Stefansson Sound Boulder Patch

The nearshore Beaufort Sea seafloor is typically dominated by soft sediments. The benthic communities in those sandy, silty or muddy sediments usually contain a low diversity fauna, dominated by bivalve mollusks, polychaete worms and amphipods. Amidst these relatively low-diversity areas, there are local hotspots of abundant and diverse marine life where boulders provide rare colonisable hard substrate for macroalgae and sessile epibenthic macrofauna (MMS 2009). One of these regions is the Stefansson Sound Boulder Patch. The Boulder Patch, located behind barrier islands in Stefansson Sound, is an isolated macroalgal-dominated rocky bottom habitat characterized by a diverse arctic kelp community. First discovered in 1978, the Boulder Patch sits in about 20 feet (6 m) of water in Alaska's Prudhoe Bay.

The Boulder Patch has been studied extensively, and more than 140 species of invertebrates have been identified including sponges, byrozoans, and hydrozoans with the dominant taxa being red and brown algae. The biodiversity and community structure patterns vary among different locations within the Boulder Patch, mainly due to differences in light levels and substrate type (NMFS 2011). Studies conducted in the past two decades documented that kelp biomass, growth, and productivity in the Stefansson Sound Boulder Patch are strongly regulated by light availability (MMS 2009). In the winter, availability of light limits growth of kelp when nutrient levels are high and lack of nutrients limit summer growth when light levels are high. However, even in summer light levels can be severely compromised locally because of high loads of suspended particles in the water column from river discharge or resuspension due to storm events. Detrimental effects of sedimentation for macroalgae include light reduction, smothering of small stages and abrasion of microscopic life stages important for dispersal and recolonization (MMS 2009). Kelp also has been observed shoreward in an area behind a shoal near Konganevik Point in Camden Bay; although its spatial distribution and density are not known (NMFS 2011).

4.7. Ocean Acidification

Over the last few decades, the absorption of atmospheric carbon dioxide (CO_2) by the ocean has resulted in an increase in the acidity of the ocean waters. The greatest degree of ocean acidification worldwide is predicted to occur in the Arctic Ocean. This amplified scenario in the Arctic is due to the effects of increased freshwater input from melting snow and ice and from increased CO_2 uptake by the sea as a result of ice retreat (NMFS 2013). Experimental evidence suggests that if current trends in CO_2 continue, key marine organisms, such as corals and some plankton, will have trouble maintaining their external calcium carbonate skeletons (Orr et al. 2005).

5. DESCRIPTION OF THE EXISTING BIOLOGICAL ENVIRONMENT

This section provides an overview of the biological communities found in the Chukchi and Beaufort Seas. The general groups of aquatic organisms that inhabit the Area of Coverage include pelagic (living in the water column), epontic (living on the underside of or in the sea ice), or benthic (living on or in the bottom sediments) plants and animals. A multi-disciplinary environmental studies program was initiated in 2008 with support from ConocoPhillips, Shell Exploration and Production Company, and Statoil USA E&P. The program continues to provide ecological baseline conditions within three study areas in the Chukchi Sea. Additionally, the State of Alaska through the Alaska Monitoring and Assessment Program (AKMAP) has been conducting water quality and the ecological status of waters of the northeastern Chukchi Sea from Pt. Hope to Barrow in waters 10–50 meters in depth within the Beaufort/Chukchi coastal-shelf ecosystem. AKMAP partnered with the University of Alaska Fairbanks, School of Fisheries and Ocean Sciences and NOAA's National Status and Trends Bioeffects Program for the 2010–2011 sampling. A final report is due in 2014.

BOEM has also conducted extensive biological studies in the Beaufort and Chukchi Seas, including benthic ecology, fisheries, marine birds, and marine ecological monitoring. Information and reports can be found on BOEM's website at: http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Alaska/Biological/index.aspx.

The categories of the offshore biological environment discussed are:

- Plankton
- Attached macro- and microalgae
- Benthic invertebrates
- Fishes (demersal and pelagic)
- Marine mammals
- Coastal and marine birds
- Threatened and endangered species
- Essential fish habitat (EFH)

Each of those biological resources is described in terms of seasonal distribution and abundance, growth and production, environmental factors that influence the resource's importance in the ecosystem, and habitats. Additional discussions of these resources are found in the Biological Evaluation for the Geotechnical GP (USEPA 2013) and the BEs and EFH Assessments for the Beaufort and Chukchi Exploration NPDES General Permits (Tetra Tech 2012a,b,c&d).

5.1. Plankton

Plankton can be divided into two major classes: phytoplankton and zooplankton. Plankton are the primary food base for other groups of marine organisms found in the Chukchi and Beaufort Seas. The distribution, abundance, and seasonal variation of these organisms are strongly influenced by the physical environment. The distribution, abundance, and seasonal variation of these organisms are strongly influenced by the physical environment. The highest concentrations of phytoplankton in the Beaufort Sea were observed near Barrow (Dunton et al. 2003). The coast near Kaktovik was identified as another productive area with upwelling of nutrient-rich water from offshore areas. The combination of regular upwelling from deep offshore waters in such areas and increased light intensity allow for increased productivity (Dunton et al. 2003). For a full discussion of distribution and abundance of plankton, see the Beaufort Sea BE (Tetra Tech 2012a).

Ongoing research has found that a combination of winds and tides leads to the formation of oceanographic *fronts* between water masses in the Beaufort Sea (Ashjian et al. 2007; Moore et al. 2008 cited in MMS 2008). The fronts concentrate the abundant zooplankton in the coastal water off the Elson Lagoon making it easier for predators to feed on the zooplankton (MMS 2008). No areas or habitats of extraordinary importance have been identified.

The Chukchi Sea represents a complex ecosystem at the Pacific Ocean's gateway into the Arctic where large quantities of Pacific nutrients, phytoplankton and mesozooplankton enter the region through the Bering Strait, in a complicated mixture of water masses (Hopcroft et al. 2014). Surveys of the planktonic communities over the Klondike, Burger and Statoil survey areas in the Chukchi Sea were completed in multiple years, including 2008, 2009, 2010, 2011, 2012, and 2013. The final reports for each of those years are available online at https://www.chukchiscience.com/Downloads.

A comparison by sampling month across the six years showed August 2013 to have the lowest abundances of many prominent taxonomic groups. In contrast, August 2013 was the second strongest year in the last six for copepods, and among the strongest years for larger meroplankton (i.e. decapod larvae). For August biomass, the data in 2013 ranked fourth in terms of copepods and chaetognaths, while the data tied for second in copepods and third in chaetognaths. September 2013 followed the same pattern, with an average abundances of copepods, but low abundances for many other groups. For biomass, September 2013 had the second highest copepod biomass observed within both nets over the six-year period, but average to low biomass for most other groups (Hopcroft et al. 2014).

For simplicity, this ODCE discusses data collected during August 2011 and again as part of a broad scale effort in September/October in 2011, which are generally representative of data from all years. Chlorophyll and nutrient concentrations suggest that August sampling had occurred post-phytoplankton bloom in all study areas, with some elevated concentrations maintained in the winter-water cold pools over Shell's Burger and Statoil's lease prospects. The surveys found a total of 77 taxonomic categories of zooplankton, including 10 meroplanktonic larval categories during the 2011 field season. The greatest taxonomic diversity was observed within the copepods (25 species, plus juvenile categories), followed by the cnidarians (13 species), with most species typical for the region and are seeded from the Bering Sea. A notable exception to previous years occurred in 2011 with the transport of the Arctic basin copepod species *Calanus hyperboreus* into the study area during a period of sustained upwelling in Barrow Canyon. In 2011, Klondike zooplankton could generally be separated from the Burger and Statoil prospects based on community structure, with temporal evolution of the community structure apparent at each location. Differences in ice-melt timing, water temperatures, transport of water masses, nutrients and chlorophyll-*a* are believed to influence the large inter-annual difference observed in the plankton communities over the past 4 years (Hopcroft et al. 2013).

The currents moving north through the Bering Strait exert a strong influence on Chukchi Sea primary and secondary productivity because of the transport of nutrients, detritus, phytoplankton, zooplankton, and larval forms of invertebrates and fishes from the Bering Sea to the Chukchi Sea. Seasonal ice regimes also influence the spatial and temporal variation of primary and secondary productivity. Productivity in the Chukchi Sea decreases from nearshore to offshore waters and is considerably less than the productivity observed at comparable depths in the Bering Strait.

The growth rates of planktonic organisms are relatively rapid, and the generation lengths are relatively short. Plankton production is limited primarily by temperature, available nutrients (particularly nitrogen), and light. The most productive area of Arctic Alaskan waters is the coastal zone. Plankton production is usually limited to the *photic zone*, or the depth to which sunlight penetrates the water. Seasonal variation in nutrient concentration can also affect primary production. Plankton production gradually increases after ice break-up, when light becomes available and declines after September when light availability limits photosynthesis. Peak primary production varies by as much as two to three times from year to year and depends on the relative amount of summer ice cover (Homer 1984).

5.2. Macroalgae and Microalgae

Macroalgae are large, photosynthesizing aquatic plants. Macroalgae populations occur naturally, but an increase in their biomass (especially if it is associated with a decrease in seagrass) might also be an indication of deteriorating water quality. Macroalgal biomass is most commonly limited by dissolved inorganic nitrogen, but it can also be limited if high light attenuation prevents adequate light from reaching the bottom.

Attached macroalgae occur in state waters along nearshore and offshore barrier island areas in the Beaufort Sea containing suitable rocky substrate for attachment. In Arctic Alaskan waters, the distribution of kelp is limited by three main factors: ice gouging, sunlight, and hard substrate. Ice gouging restricts the growth of kelp to protected areas, such as behind barrier islands and shoals. Sunlight restricts the growth of kelp to the depth range where a sufficient amount penetrates to the seafloor, or water shallower than about 11 meters (36 feet). Hard substrates, which are necessary for kelp holdfasts, restrict kelp to areas with low sedimentation rates (Dunton et al. 1982; MMS 1990).

Alaska's Beaufort Sea shelf is typically characterized by silty sands and mud with an absence of macroalgal beds and associated organisms (Barnes and Reimnitz 1974). A diverse kelp community occurs in the Boulder Patch near Prudhoe Bay in Stefansson Sound. Algae in the Boulder Patch contribute to the important food web supporting many epibenthic and benthic organisms in the area. Differences in biomass between surrounding sediment areas and the Boulder Patch demonstrate the importance of this biologically unique area (Konar 2006; Dunton and Schonberg 2000; Dunton et al. 2005).

A study conducted in the Beaufort Sea, found that kelp grows fastest in late winter and early spring because of higher concentrations of inorganic nitrogen in the water column. The presence of macroalgae is considered rare in the Beaufort Sea. Kelp make up between 50 and 55 percent of the available carbon in the Stefansson Sound kelp community; phytoplankton make up between 23 and 42 percent (Dunton 1982). Macroalgae presence is considered rare in the Chukchi Sea, but all potential kelp habitats have not yet been surveyed.

Microalgae are distinguished from phytoplankton in that they are attached rather than free-floating. The distribution of microalgal communities has been noted as patchy on both large and small scales (MMS 1991), and no important critical habitats or areas have been identified. During the spring and summer months, large biomasses of photosynthetic ice algae develop on the lower sections of sea ice. Ice algae contribute organic matter to the water column and are an important part of the Arctic marine food web, contributing an average of 57 percent to total Arctic marine primary production (Gosselin 1997).

5.3. Benthic Invertebrates

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment). Benthic invertebrates in the Beaufort and Chukchi seas can generally be divided into two main categories: epifauna and infauna, based on their relationship with the substrate. Infaunal organisms live within the substrate and, as a result, are often sedentary. Epifaunal organisms, on the other hand, generally live on or near the surface of the substrate. Benthic communities offshore can be quite diverse. Organisms commonly found in surveys include echinoderms, sipunculids, mollusks, polychaetes, copepods, and amphipods (NMFS 2011). Benthic invertebrates are food sources for many marine species, including walruses, seals, eiders, seabirds, and gray whales.

The dominant epibenthic habitat types observed were bioturbated silty sediment with brittle stars and bioturbated silty sediment with mobile epifauna. Sea cucumbers and diverse sessile epifauna, e.g. soft coral *Gersemia rubiformis*, are examples of other epibenthic fauna in the Chukchi Sea. Biologically diverse and dense coral and sea anemone communities are observed at near-shore sites and within Barrow Canyon (Dunton et al. 2012).

The distribution, abundance, and seasonal variation of benthic species in Arctic Alaskan waters are strongly correlated with physical factors (e.g., substrate composition, water temperature, depth, dissolved oxygen concentrations, pH, salinity, sediment carbon/nitrogen ratios, and hydrography). Larger invertebrate communities are found in nearshore lagoons (ADNR 2009). The abundance, diversity, biomass, and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. The biomass of benthic invertebrates declines if communities are affected by prolonged periods of poor water quality especially when anoxia and hypoxia are common.

Benthic communities can change in response to the following:

- Nutrient enrichment leading to eutrophication.
- Bioaccumulation of toxins to lethal levels in mollusks (shellfish), crustaceans, polychaetes and echinoderms can cause the loss of herbivorous and predatory species.
- Lethal and sub-lethal effects of heavy metals and other toxicants derived from oil and gas activities.
- Dislodged epifauna and infauna from trawling and dredging, which could result in the collection and mortality of a substantial invertebrate bycatch.
- Physical smothering of habitat due to deposition of drilling fluids and cuttings materials discharged on the ocean floor.

Benthic invertebrates are important modifiers of the seafloor. Burrowing and tube-building by deposit-feeding benthic invertebrates (bioturbators) help to mix the sediment and enhance decomposition of organic matter. Nitrification and denitrification are also enhanced because a range of oxygenated and anoxic micro-habitats are created. Loss of nitrification and denitrification (and increased ammonium efflux from sediment) in coastal systems are important causes of hysteresis, which can cause a shift from clear water to a turbid state. The loss of benthic suspension-feeding macroinvertebrates can further enhance turbidity levels because such organisms filter suspended particles including planktonic algae, and they enhance sedimentation rates through biodeposition (i.e., voiding of their wastes and unwanted food).

Changes in the macrofauna (and macroflora) causes changes in nutrient storage pools and the flux of nutrients between these species and microfauna (and microflora). Benthic macrofauna are important constituents of fish diets and, thus, are an important link for transferring energy and nutrients between trophic levels and driving pelagic fish and crustacean production. It is for those reasons and others, that benthic invertebrates are extremely important indicators of environmental change.

5.4. Fish

The physical environment, mainly temperature and salinity, of the Arctic waters exerts a strong influence on the temporal and spatial distribution and abundance of fish (MMS 1990, 1991). The Chukchi Sea is an important transition zone between the fish communities of the Beaufort and Bering Seas (MMS 1991); the fauna is primarily Arctic with continual input of southern species through the Bering Strait (Craig 1984). Marine fish in the Chukchi Sea are generally smaller than those in areas farther south, and densities are much lower (Frost and Lowry 1983). The lower diversity, density, and size of fish in the region have been attributed to low temperatures, low productivity, and lack of nearshore winter habitat because of ice formation (MMS 1987b). Table 5-1 lists common fish in the Area of Coverage.

Fish biologists on the Russian-American Long-term Census of the Arctic expedition noted the following qualitative conclusions: (1) the Chukchi benthic community is highly diverse and patchy; and (2) both fish abundance and diversity seem lower in the Chukchi Sea than in the Bering Sea (MMS 2008). The largest catches occurred to the south and were usually at least one order of magnitude higher than those in the north. Pacific salmon (chinook, coho, pink, sockeye, and chum), Arctic cod, saffron cod, and snow crab are addressed in detail in the EFH for the Chukchi Exploration NPDES General Permit (Tetra Tech 2012b).

Table 5-1. Common fishes in the Beaufort and Chukchi Seas.

Freshwater		Anadromous		Marine	
Common name	**Scientific name**	**Common name**	**Scientific name**	**Common name**	**Scientific name**
Arctic blackfish	*Dallia pectoralis*	Arctic cisco*	*Coregonus autumnalis*	Arctic flounder	*Liopsetta glacialis*
Arctic char	*Salvelinus alpinus*	Arctic lamprey*	*Lampetra japonica*	Starry founder	*Platichthys stellatus*
Burbot	*Lota lota*	Bering cisco*	*Coregonus laurettae*	Arctic cod	*Boreogadus saida*
Arctic grayling	*Thymallus arcticus*	Broad whitefish*	*Coregonus nasus*	Saffron cod	*Eleginus gracilis*
Lake chub	*Couesius plumbeus*	Dolly Varden char*	*Salvelinus malma*	Snailfish	*Liparus* sp.
Lake trout	*Salvelinus namaycush*	Humpback whitefish*	*Coregonus pidschian*	Pacific sand lance	*Ammodytes hexapterus*
Longnose sucker	*Catostomus catostomus*	Least cisco*	*Coregonus sardinella*	Pacific Herring	*Clupa harengus*

Table 5-1. Common fishes in the Beaufort and Chukchi Seas (continued).

Freshwater		Anadromous		Marine	
Common name	**Scientific name**	**Common name**	**Scientific name**	**Common name**	**Scientific name**
Ninespine stickleback	*Pungitius pungitius*	Rainbow smelt	*Osmerus mordax dentex*	Slender eelblenny	*Lurnpenus fabricil*
Round whitefish	*Prosopium cylindraceum*			Stout eelblenny	*Lumpenus medius*
Sheefish	*Stenodus leucichthys*			Eelpout	*Lycodes* spp.
Slimy sculpin	*Cottus cognatus*			Arctic sculpin	*Myoxocephalus scorpiodes*
Trout-perch	*Percopsis omiscomaycus*			Whitespotted greenling	*Hexagrammus stelleri*
				Capelin	*Mallotus villosus*
				Fourhorn sculpin	*Myoxocephalus quadricornis*
				Arctic staghorn sculpin	*Gymnocanthus tricuspis*
				Arctic hookear	*Artediellus scaber*
				Bering wolffish	*Anarchichas orientalis*

* The species has populations that can be freshwater only or anadromous (USFWS 2008)

During the open-water season, the nearshore zone of the Beaufort Sea area is dominated by a band of relatively warm, brackish water that extends across the entire Alaskan coast. The summer distribution and abundance of coastal fishes (marine and anadromous species) are strongly affected by this band of brackish water. The band typically extends 1.6 to 9.7 kilometers (1 to 6 miles) offshore and contains more abundant food resources than waters farther offshore. The areas of greatest species diversity within the nearshore zone are the river deltas. Fish distribution and abundance in the Beaufort Sea vary by species and are determined primarily by nutritional and spawning needs. Anadromous fish in the Beaufort Sea spend most of their lives in fresh water and do not travel far into deep ocean waters. In comparison, many marine fish species are pelagic, spending their entire life in deeper ocean waters. The more common anadromous fish species in the Beaufort Sea are Dolly Varden char, whitefish, cisco and salmon.

Freshwater species would be found almost exclusively in nearshore freshwater environments surrounding river deltas and bays (Moulton et al. 1985 as cited in MMS 2008). Juvenile fish prefer the warmer, shallow-water habitats that become available during the open-water period (MMS 2008). Anadromous fish typically leave the rivers and enter the nearshore waters during spring break-up in June. As the ice cover melts and recedes, the fish will migrate along the coast (ADNR 1999). Migration back to rivers varies by species, but most anadromous fish return to fresh water, where they spawn by mid-September (ADNR 1999). Salmon are anadromous but unlike cisco, whitefish, and Dolly Varden char, they rarely return to the ocean after spawning, rather they spawn once and die. Salmon are uncommon along coastal waters (Craig 1984; Augerot 2005 cited in MMS 2008).

A lack of overwintering habitat is the primary factor limiting Arctic fish populations (DNR 1999). Spawning in the Arctic environment can take place only where there is an ample supply of oxygenated water during winter. Because of that and because few potential spawning sites meet that requirement, spawning often takes place in or near the same area where fishes overwinter (MMS 2008). Most marine species spawn in shallow coastal areas during the winter.

Conservative estimates by the U.S. Department of Interior report that at least 17 species of marine fishes, 13 species of freshwater fishes, 5 species of anadromous fishes, and 7 fish species that can have both freshwater (only) and anadromous populations can be found in the waters of the Beaufort Sea (Wiswar 1992; Wiswar et al. 1995; Wiswar and Fruge 2006; Scanlon 2009; MMS 2008). Together, the Beaufort and Chukchi Seas support a large and dynamic Arctic ecosystem that includes as many as 98 fish species representing 23 families (Mecklenburg et al. 2002; MMS 2006:Tables III.B-1 cited in MMS 2008).

5.5. Marine Mammals

Common (at least seasonally) marine mammals in the Area of Coverage are spotted, ringed, and bearded seals (ice seals); bowhead, beluga, killer, and gray whales; polar bears; and walruses. At least six other species of marine mammals (minke whales, fin whales, humpback whales, harbor porpoise, narwhal, and ribbon seals) are found occasionally or rarely in the Area of Coverage. Those species of marine mammals that are protected by the Endangered Species Act are discussed further in the BE for the Geotechnical GP (USEPA 2013).

Ringed Seal. Ringed seals (*Phoca hispida*) are circumpolar in distribution (Angliss and Outlaw 2008). They are found in all seas of the Arctic Ocean including the northern Bering, Chukchi, and Beaufort Seas (ADF&G 1994). Ringed seals live on or near the ice year-round; therefore, the seasonal ice cycle has an important effect on their distribution and abundance (MMS 2008). In winter, highest densities of ringed seals occur in the stable landfast ice. Ringed seals appear to prefer ice-covered waters and remain in contact with ice for most of the year (Allen and Angliss 2010). Ringed seals live on and under extensive, largely unbroken, landfast ice (Frost et al. 2002), and they are generally found over water depths of about 10 to 20 meters (33 to 66 feet) (Moulton et al. 2002). Traditional knowledge workshop participants during development of the Beaufort and Chuckhi Exploration NPDES General Permits identified general areas where seals were reported to congregate included along the pack ice, in merging currents, in bays, lagoons, and river deltas (SRB&A 2011).

The spring lead systems in the Beaufort and Chukchi Seas are also important to ringed seals since these areas allow them to forage for fishes and comfortably rest on an icy platform if needed. Several Environmental Resource Areas for the ringed seal have been identified in the *Alaska Outer Continental Shelf Final Supplemental Environmental Impact Statement for Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska* (BOEMRE 2011):

- Herald Shoal polynya area (January–December)
- Hanna Shoal polynya area (January-December)
- Southern portion of Chukchi spring lead system (April–June)
- Middle portion of Chukchi spring lead system (April–June)
- Northern portion of Chukchi spring lead system (April–June)

Spotted Seal. The Alaska stock of spotted seal (*Phoca largha*) is the only recognized stock in U.S. waters. Spotted seals are found in large numbers along the Bering, Chukchi, and Beaufort Sea coasts; they are common in bays, estuaries, and river mouths and are particularly concentrated along the Chukchi Sea coast from Kasegaluk Lagoon to the mouth of the Kuk River and Peard Bay (MMS 1991).

From September to mid-October, spotted seals that summered in the Beaufort Sea migrate to the Bering Sea and spend the winter and spring periods offshore north of the 200-meter (656-foot) isobath along the ice front, where pupping, breeding, and molting occur (Lowry et al. 2000). Spotted seal is usually a summer visitor and they are usually in the lagoons around the barrier islands or around bays like Admiralty Bay, and Smith Bay. Traditional knowledge workshop participants identified Dease Inlet as important feeding area because of the abundance of fish (SRB&A 2011).

Bearded Seal. The majority of the bearded seal (*Erignathus barbatus*) population in Alaska is found in the Bering and Chukchi Seas with seasonal migrations into the Beaufort Sea. The species usually prefers areas of less-stable or broken sea ice, where breakup occurs early in the year (Burns 1967). They are found in nearshore areas of the central and western Beaufort Sea during summer (MMS 2008). Important feeding grounds for bearded seal include areas along ice edges, in the currents between the barrier islands and near river mouths, and in shallow areas with abundant clam beds. Traditional knowledge workshop participants reported that bearded seals are commonly seen everywhere along the coast near Point Lay but are generally abundant near Kasegaluk Lagoon where smelt and herring are present in high numbers (SRB&A 2011). Additionally, participants reported it is common to see hundreds of bearded seal pups on the spit between Naokuk Pass and the southern end Kasegaluk Lagoon, where the current is not as strong (SRB&A 2011). Participants also indicated that bearded seals are not confined to ice areas. Bearded seals like the feel of moving water, especially during molting (SRB&A 2011).

Walrus. The Pacific walrus (*Odobenus rosmarus divergens*) is most commonly found in relatively shallow water areas, close to ice or land. The majority of the walrus population occurs west of Barrow (Chukchi Sea), although a few walrus can move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season (Fay 1982). Traditional knowledge workshop participants identified that while it is relatively rare to see walruses in the Beaufort Sea, Nuiqsut residents have spotted them near Cross Island, Thetis Island, the area outside the Nigliq Channel of the Colville River. Respondents typically spotted walrus hauled out on Cross Island or feeding near Cross Island when sea ice was far from shore (SRB&A 2011).

Pacific walrus are benthic feeders, foraging in the sediments of the seafloor. Such feeding behavior results in disturbance of wide areas of the seafloor (Nelson et al. 1994). During their fall migration south, walruses (primarily females) haul out on the barrier islands along the entire length of the Kasegaluk Lagoon to Icy Cape, and Cape Lisburne, recently in very large numbers (SRB&A 2011).

Bowhead Whale. The group of bowhead whales (*Balaena mysticetus*) that inhabit the Bering-Chukchi-Beaufort Seas is important to the viability of the species as a whole and is a species of very high importance for subsistence and to the culture of Alaskan Native peoples of the northern Bering Sea, the Chukchi Sea, and the Beaufort Sea. Within or near areas where proposed actions could occur, geographic areas of importance to this stock of bowhead whale include the spring lead system in both the Beaufort and Chukchi Seas (MMS 2006). The best estimate of the abundance of the Western Arctic bowhead whale stock is 10,545 with a minimum population estimate of 9,472. Overall, the stock appears to be healthy and increasing in population (Allen and Angliss 2011 as cited in BOEM 2012).

Bowheads are extremely long lived, slow growing, slow to mature, and currently have high survival rates. They are also unique in their ecology and their obligate use of lead systems to travel to summering grounds. This dependence on the relatively restrictive area comprising of the spring leads, described further below, combined with calving and feeding that occurs during the spring northward migration, further heightens their vulnerability to disturbance and exposure to pollutants in some areas (MMS 2006 and 2006a).

Each spring (mid-March through mid-June, approximately), the bowhead western Arctic stock travel northward through breaks in the sea ice, migrating from their winter grounds in the Bering Sea to their summer grounds in the Canadian Beaufort Sea (Braham et al. 1980). These breaks in the ice, or leads, form when winds blow the moving pack ice away from landfast ice, creating a flaw zone of open water and broken ice generally parallel to the shore (Carroll and Smithhisler 1980). Bowhead whales depend primarily on the lead system as a migratory pathway between wintering and summering grounds (MMS 2006). In spring, ice obstructs feeding opportunities; therefore, bowhead migratory movements are generally predictable and consistent between the Bering Strait and Amundsen Gulf along the lead system (Quakenbush et al. 2010 as cited in BOEM 2012). The breaks in the ice also provide critical opportunities for the bowhead whales surfacing to breathe, as discussed further below. The lead system is therefore considered an obligate pathway for this population to transit to summering grounds (MMS 2006 and 2006a).

Calving occurs from March to early August, with the peak probably occurring during the spring migration between early April and the end of May (MMS 2003). Available information indicates that most or much of the total calving of the bowheads, which comprise most of the bowhead whales in the world, occurs during the spring migration within, and adjacent to, the spring lead system, especially in the eastern Chukchi Sea (MMS 2006 and NMFS 2011). Most calving occurs in the Chukchi Sea during the spring migration from March through June from winter breeding areas in the northern Bering Sea (BOEM 2012). Females give birth to a single calf every 3 to 4 years (MMS 2008b as cited in BOEM 2012). Small calves generally stay close to their mothers' sides and are difficult to see particularly if they are on the offshore side of the mother. On two occasions, very small calves were seen riding their mothers' backs, apparently grasping the mothers with their flippers (Carroll and Smithhisler 1980).

Whales are seen in Barrow in early- to mid-April. The early pulse is dominated by juveniles. The size/age composition of the whales entering the Beaufort Sea gradually switches so that by mid-May to June, large whales and cow/calf pairs are seen. As the whales approach Point Barrow, the nearshore lead narrows and the movement of most whales is correspondingly constricted. After passing Barrow from April through mid-June, the bowhead whales move easterly through or near offshore leads. East of Point Barrow, the lead systems divide into many branches that vary in location and extent from year to year. The spring migration route is far offshore of the barrier islands in the central Alaskan Beaufort Sea. Bowheads arrive on their summer feeding grounds in the Canadian Beaufort in Amundsen Gulf and around Banks Island until late August or early September (MMS 2003). Restriction of ice near Point Barrow and development of offshore leads northeast of the Point provide the migration pathway, a result of converging water masses from the Chukchi and Beaufort Seas and shifting winds, generally from the east and northeast. It is probably advantageous for whales to use these recurring leads, as opposed to those in the southern Beaufort Sea where there is less ice movement and where the availability of open water is less predictable (Carroll and Smithhisler 1980).

During a five-year period (2006-2010), researchers from the Alaska Department of Fish and Game worked with Native whalers from Alaska and marine mammal hunters from Canada to attach 46 satellite transmitters to bowhead whales to document the migratory routes that connect their summering and wintering areas (ADF&G 2010). After passing Point Barrow in spring, bowhead whales migrated through ice that was quantified as 100 percent cover by satellite images. Once past Point Barrow, all tagged whales traveled northeast before turning east and traveling100-200 km offshore of the Beaufort Sea coast. All whales stayed between 71 and 72°N latitude. All tagged whales traveled relatively directly to the

Amundsen Gulf polynya, arriving there by May 26, 2006 and by May 3, 2008. Amundsen Gulf is used by bowhead whales from May until mid-September (ADF&G 2010).

Based on duration of migration for seven individual whales, migration between the Bering Sea and the Canadian Beaufort required an average of 19 days (range of 17-24 days) (ADF&G 2010). During the spring migration, tagged whales generally did not stop between the Bering Strait and Amundsen Gulf, suggesting limited feeding opportunities or obstructions caused by ice. The spring migratory corridor between the Bering Strait and Amundsen Gulf is consistent between years (ADF&G 2010). In some years, parts of the spring lead system in the Chukchi Sea west, northwest, and southwest of Barrow are used as feeding areas over extended periods of time during the spring migration, but this use is inconsistent (MMS 2007). However, several researchers have reported that the region west of Point Barrow seems to be of particular importance for feeding in some years but the whales may feed opportunistically at other locations in the lead system where oceanographic conditions produce locally abundant food (Caroll et al. 1987 as cited in MMS 2006, Moore and Reeves 1993, Moore 2000, Moore et al. 2000a as cited in Mocklin et al. 2012).

Bowheads are filter feeders. They apparently feed through the water column, including bottom feeding (BOEM 2012) as well as surface skim feeding (MMS 2006). Food items most commonly found in stomachs include euphausiids, copepods, mysids, and amphipods. Lowry, Sheffield and George et al. (2004 as cited in MMS 2006) concluded that feeding near Barrow during the spring migration is a relatively common event; however, the amount of food in the stomachs tends to be lower in spring than in autumn (MMS 2006). There is extensive evidence of epibenthic feeding, which indicates that these whales could potentially be exposed to pollutants in the discharges, especially metals constituents and chemical additives associated with drilling fluids and drill cuttings (Discharge 001).

Researchers investigated the olfactory anatomy of bowhead whales and found that these whales have a cribriform plate and small, but histologically complex olfactory bulb. The olfactory bulb makes up approximately 0.13 percent of brain weight, unlike odontocetes where this structure is absent. The relative size of the olfactory bulb in apes (0.06 percent) and humans (0.008 percent) is much smaller than in bowheads. The researchers also determined that 51 percent of olfactory receptor genes were intact, unlike odontocetes, where this number is less than 25 percent. This suggests that bowheads have a sense of smell, and the researchers speculate that the whales may use this to find aggregations of krill on which they feed (ADF&G 2010). This is consistent with traditional knowledge input EPA received from subsistence hunters, who have raised concerns that bowhead whales could be deflected from their migratory pathways by anthropogenic smells associated with the discharges.

Except for land-fast ice, which is generally stable shoreward of the 20 m isobath, the presence of sea ice does not appear to limit the movements of whales in the spring in the Beaufort Sea (Quakenbush et al. 2010 as cited in BOEM 2012). However, sea ice does limit light penetration and wind-driven upwelling, which influences prey availability and thus whale movements (Quakenbush et al. 2010 as cited in BOEM 2012).

When whales encounter a partially closed lead interposed with polynyas, they adjust their diving and surfacing sequences to the size and location of the open water. Whales encountering a small polynya would surface and blow as many times as space allowed while traveling at normal speed; then they would dive at the far edge of the polynya. If another polynya was close, the whales would surface there, take a few more breaths, and continue on. In this way, they were able to negotiate a tenuous system of leads and move steadily through flaw zones that were mostly covered with ice (Carroll and Smithhisler 1980; George et al. 1989).

Occasionally, Carroll and Smithhisler (1980) observed a lead closed so tightly that the whales' progress was hindered, and the polynyas were too far apart to be reached in a single dive. Some whales proceeded though the lead appeared closed, but fewer did so than when the lead was open. It appeared that the whales dove, searched, and, if they did not find another polynya, returned to mill in the available polynya, thus keeping the surface water from freezing. Sea ice is more flexible than freshwater ice, and bowheads and white whales (*Delphinapterus leucas*) have been sighted pushing up young ice, forming hummocks to breathe. The bowhead whales must often utilize very small pools of open water just large enough to accommodate their blowholes (George et al 1989). Certain studies of acoustical and visual comparisons of the spring migration off Barrow indicate that bowheads may migrate under ice and can break through ice 14-18 centimeters (5.5-7 inches) thick to breathe (MMS 2003). However, the whales' primary reliance on breaks in the ice to breathe during this critical migration, feeding, and calving period – further supports a restriction of activities, including discharges in the Chukchi Sea, to ensure minimal disturbance.

The rate of whale travel speed ranges from 1 to 11 km/hour during spring migration. Nearly all the whales traveled northeastwardly. Fewer than 1 percent traveled in the opposite direction. When they traveled southwest, it was usually because of closed leads stopping their progress to the northeast (Carroll and Smithhisler 1980). Of 2,406 bowheads that were observed over 4 years in the 1970s, 1,815 (75.4 percent) were traveling singly; 470 (19.5 percent) were in pairs; 105 (4.4 percent) were in groups of three, and 16 (0.7 percent) traveled in groups of four animals (Carroll and Smithhisler 1980). In the fall, bowheads were presumed to return along a similar general route from the Canadian Beaufort Sea where they spend much of the summer (Allen and Angliss 2011 as cited in BOEM 2012). The return route is closer to shore, in water depths ranging from 15 to 44 m (49.2 to 144.4 ft), across the Beaufort Sea, to the Bering Sea to overwinter in polynyas and along edges of the pack ice (Braham et al. 1980; Moore and Reeves 1993 as cited in BOEM 2012). The first whales to begin the fall migration are typically the larger ones, which establish the migration route in the Beaufort Sea. Migration through the eastern Alaskan portion of the Beaufort Sea continues through September and into October (Huntington and Quakenbush 2009 as cited in BOEM 2012). See Figure 5-1.

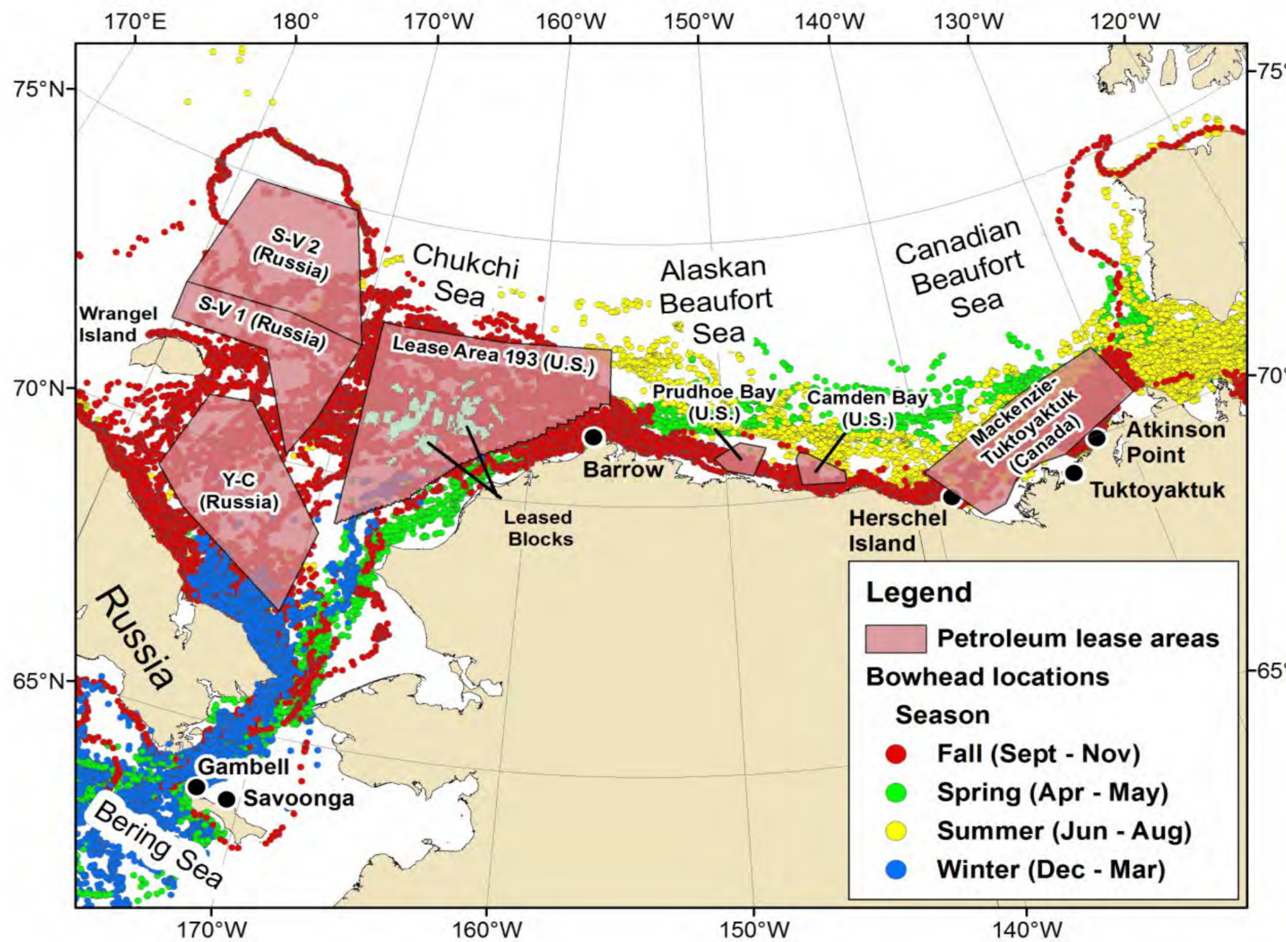

Figure 5-1. Tracks of tagged bowhead whales between July and December, 2006–2012, relative to active and proposed petroleum areas (BOEM 2013).

Beluga Whale. Two stocks of beluga whales (*Delphinapterus leucas*) inhabit the Alaskan Chukchi Sea: the Eastern Chukchi Stock and the Beaufort Stock. Summer breeding concentrations can be found at Kasegaluk Lagoon. The summer Beaufort Sea stock breeds during the summer mostly in the Mackenzie Delta (Hazard 1988) and spends the early fall along the edge of the Beaufort Sea pack ice before they too migrate through the Chukchi to Bering Sea wintering grounds (Allen and Angliss 2010). During the late summer and early fall, both stocks can be found as far north as latitude 80°N in waters deeper than 200 meters (656 feet) (Suydam et al. 2005). Between 2,000 and 3,000 beluga whales annually feed, calve, and molt in Kasegaluk Lagoon and Peard Bay (Seaman et al. 1985; Suydam et al. 2001; MMS 2003). Traditional knowledge workshop participants confirmed that Omalik Lagoon is an important feeding, calving, molting, and resting habitat.

Beluga feeding areas are closer to shore and concentrated in bays and mouths of rivers. Local hunters report that beluga regularly use an area near Cape Beaufort. They indicated that the area experienced a landslide in which a significant portion of a shoreline cliff slid into the sea resulting in a shallow rocky area used by many fish (SRB&A 2011). Traditional knowledge workshop participants identified that feeding areas for beluga are generally closer to shore than feeding areas for bowhead whales and that they tend to concentrate in bays, mouths of rivers, Elson Lagoon, and near reefs (SRB&A 2011). Beluga whales of the Beaufort Sea and eastern Chukchi Sea stocks winter in the Bering Sea and summer in the Beaufort and Chukchi Seas, migrating around western and northern Alaska along the spring lead system in April and May (Richard et al. 2001; Angliss and Outlaw 2005) as cited in BOEMRE 2011). Both bowheads and belugas are associated with the spring lead and polynya system in the Chukchi Sea in the months of March through June (BOEMRE 2011). Beluga use the spring lead system in their northward migration in the spring through the Chukchi Sea and also use the Kasegaluk Lagoon along the Chukchi coast (BOEMRE 2011). Beluga whales also would potentially be vulnerable to disturbance from geotechnical activities and pollutants in the discharges within the spring lead system during the spring migration period.

Gray Whale. The gray whale (*Eschrichtius robustus*) migrates into the Chukchi and Beaufort Seas during spring to feed throughout the late spring, summer, and early fall. They migrate out of the Chukchi and Beaufort Seas with freeze up and migrate south out of the Bering Sea during November to December (Rice and Wolman 1971). The Eastern North Pacific Stock of the gray whale winter and breed in Mexican lagoons and summer in the shallow-watered Bering and Chukchi Seas. Small numbers of gray whales have been observed in the Beaufort Sea east of Point Barrow. Most migrating whales occur within 15 kilometers (9.3 miles) of land (Green et al. 1995) but have been observed up to 200 kilometers (124.3 miles) offshore (Bonnell and Dailey 1993). Traditional knowledge workshop participants noted seeing gray whales in Camden Bay by Collinson Point and stated that the entire area near Kaktovik is an important whale habitat area for several species of whales (SRB&A 2011).

In the Chukchi Sea, whales congregate between Cape Lisburne and Point Barrow (Moore et al. 2000b). Gray whales migrate into the northern Bering and Chukchi Seas starting in late April through the summer open-water months and feed there until October to November (MMS 2003). Most migrating whales occur within 15 kilometers (9.3 miles) of land (Green et al. 1995) but have been observed up to 200 kilometers (124.3 miles) offshore (Bonnell and Dailey 1993). Concentrations of feeding gray whales are found off Wainwright. Traditional knowledge workshop participants along the Chukchi Sea coast noted that gray whales are often observed feeding outside Five-Mile Pass (SRB&A2011). Traditional knowledge workshop participants along the Beaufort Sea coast noted seeing gray whales in Camden Bay by Collinson Point and stated that the entire area near Kaktovik is an important whale habitat area for several species of whales (SRB&A 2011).

Fin Whale. Fin whales (*Balaenoptera physalus*) might occur seasonally in southwestern Chukchi Sea. Their known current summer feeding habitat includes the southern portion, especially the southwestern portion, of the Chukchi Sea along the Alaskan coast. Fin whales feed primarily on euphausiids, or "krill", but also consume substantial quantities of fish. In the North Pacific overall, fin whales preferred euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristus*), followed by schooling fish such as herring, walleye pollock (*Theragra chalcogramma*), and capelin (NMFS 2011b). Fish, especially capelin, walleye pollock, and herring, were the main prey documented in the stomachs from harvested whales taken north of 58° N. latitude in the Bering Sea. Fin whales appear to make long distance movements quickly to track prey aggregations and can switch their diet from krill to fish as they migrate northward (NMFS 2011b).

Fin whales are rarely observed in the eastern half of the Chukchi Sea. Three fin whales (including a cow-calf) were observed together in the southern Chukchi Sea, directly north of the Bering Strait, in July 1981 (Ljungblad et al. 1982 as cited in NMFS 2011b). In 1979-1987, no other fin whale sightings were reported during aerial surveys of endangered whales in summer (July) and autumn (August, September, and October) in the Northern Bering Sea (north of Saint Lawrence Island), Chukchi Sea (north of 66º N. latitude), and east of the International Date Line and the Alaskan Beaufort Sea (157º 01' W. east to 140º W. longitude) and offshore to 72º N. latitude (Ljungblad 1988 as cited in NMFS 2011b). Fin whales were not observed during annual aerial surveys of the Beaufort Sea, conducted in September and October from 1982-2004 (e.g., Treacy 2002; Moore et al. 2000b as cited in NMFS 2011b). Fin whales were also not observed during a 2003 summer research cruise in the Chukchi and Beaufort seas (Bengston and Cameron 2003 as cited in NMFS 2011b). With the resurgence of oil and gas activities in the Chukchi Sea and related monitoring and research, there have been a few fin whale sightings in the eastern half of the Chukchi Sea (NMFS 2011b).

Fin whales are not expected to routinely occur in the Beaufort and Chukchi seas. Continued arctic warming could result in changes in oceanographic conditions favorable to the distribution and abundance of fin whale prey species; and extend their distribution into waters of the Chukchi Sea, and possibly Beaufort Sea (NMFS 2011b).

Polar Bear. Polar bears (*Ursus maritimus*) are widely distributed throughout the Arctic where the sea is ice-covered for large portions of the year. Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for denning, and for long-distance movement. Ringed seals are polar bear's primary food source, and areas near ice edges, leads, or polynyas where ocean depth is minimal are the most productive hunting grounds. While polar bears primarily hunt seals for food, they may occasionally consume other marine mammals, including via scavenging on their carcasses (USFWS 2009).

This behavior was also discussed during the Traditional knowledge workshops, where participants indicated that whale carcasses provide easy feeding opportunities and attract polar bears, making Cross Island, Barter Island, and Point Barrow (areas where butchered whale carcasses are deposited) prime feeding grounds. Additionally, respondents indicated that polar bears follow bearded seals in the fall and are seen near the barrier islands (SRB&A 2011). Traditional knowledge workshop participants reported that during the winter, polar bear dens are found in both offshore and onshore environments. Participants commented that on land, polar bears will den along rivers and in areas with larger snow drifts. They also stated that polar bears will den offshore when there is adequate ice and pressure ridges in which they can make their den (SB&RA 2011).

Two polar bear stocks are thought to exist in Alaska, the Southern Beaufort Sea and the Chukchi/Bering Seas. Polar bears typically occur at low densities throughout their circumpolar range. Population estimates have wide confidence intervals and a reliable estimate does not currently exist (USFWS 2009).

5.6. Coastal and Marine Birds

Migratory birds are a significant component of the marine ecosystem of the Chukchi and Beaufort Seas. Both areas include important foraging, nesting, and rearing areas for several million birds. Descriptions of coastal and marine bird distribution are discussed in detail in the Chukchi and Beaufort BE (Tetra Tech 2012a). Most species in the Chukchi and Beaufort Seas are migratory and present in the Arctic only seasonally, from May through early November. Some species appear only during migration; others nest, molt, feed, and accumulate critical fat reserves needed for migration while in the area (MMS 1987a). The main categories of species include waterfowl (e.g., duck, goose, swan), seabirds (e.g., loon, gull, tern), shorebirds (e.g., sandpiper, plover, crane), and raptors (e.g., hawks, eagles, falcons). Complete lists of all bird species in those groups are presented in Table 5-2 through Table 5-5.

Aerial surveys in the Chukchi and Beaufort Seas have documented that birds are widespread in substantial numbers in both nearshore and offshore waters (MMS 2008) and it is likely that this approximate distribution prevails along most of or the entire Beaufort coastline and into the northern Chukchi Sea during the open-water season. Traditional knowledge workshop participants noted that birds follow open ice leads during spring migration (SRB&A 2011). The Sagavanirktok, Kuparuk, Ikpikpuk, and Colville Rivers that empty into the Beaufort Sea have been identified as important nesting and breeding areas for waterfowl (MMS 1996). Traditional knowledge workshop participants confirmed the Colville River Delta, the mouth of the Kalikpik River, Fish Creek, Teshekpuk Lake, and the barrier islands as important feeding grounds and nesting areas for birds (SRB&A 2011).

The highest pelagic bird density is near Barrow, which contains high amounts of plankton that are a food source for birds and other organisms. Traditional knowledge workshop participants confirmed that Barrow is in the migratory path of several bird species, particularly eiders and brants, and that brants, long-tailed ducks, and Canada geese molt at the various points found along the Beaufort Sea coast, including Beechy Point and the area east of Oliktok Point (SRB&A 2011). Most shorebirds and other waterfowl concentrate in snow-free coastal or inland areas until nest sites are available (MMS 1982). Most birds are along barrier islands or in lagoons rather than seaward from lagoons or along mainland shores (Flint et al. 2000 as cited in MMS 2003). Shorebirds are numerically dominant in most coastal plain bird communities occurring across northern Alaska (including the Arctic National Wildlife Refuge) and Canada (including Kendall Island Bird Sanctuary).

Five types of habitat particularly capable of supporting a variety of marine and coastal avifauna are the barrier islands, coastal lagoons, coastal salt marshes, river deltas, and offshore areas. The coastal waters are primary habitat for nesting, molting, feeding, and resting activities of migratory marine birds. Major concentrations of birds occur nearshore [in waters shallower than 20 meters (66 feet)] and in coastal areas along the Chukchi and Beaufort Seas. Nearshore areas also provide important nesting habitat for loons, waterfowl, and shorebirds and include foraging habitat for seabirds nesting. This was confirmed by traditional knowledge workshop participants (SRB&A 2011).

The highest nesting densities generally occur in areas of mixed wet and dry habitats, whereas birds often move to wetter areas for broodrearing. Islands in river deltas and barrier islands provide the principal nesting habitat for several waterfowl and marine bird species in the Area of Coverage. Shorebirds prefer wet-tundra habitats or well-drained, gravelly areas for nesting, whereas loons use lakes, and geese prefer deeper ponds or wet tundra near lakes. Lagoons formed by barrier islands, bays, and river deltas provide important broodrearing and staging habitat for waterfowl, particularly molting oldsquaws (ADF&G 2008 cited in ADNR 2009).

Important feeding and staging grounds for shorebirds and waterfowl include Kasegaluk Lagoon, the mouth of the Kuk River, Peard Bay, and salt marshes along the mainland coast. Those habitats are critical to waterfowl that regularly pass through or near the Beaufort and Chukchi Seas during migration. Traditional knowledge workshop participants reported that Kasegaluk Lagoon, the barrier islands, spits surrounding the lagoon, and inland areas near Point Lay are all important habitat areas for waterfowl species. The smelt in Kasegaluk Lagoon provide food for nesting waterfowl (SRB&A 2011).

The Ledyard Bay area, located between Cape Lisburne and the village of Point Lay within the deferral area (Figure 5-2
), is part of the spring lead system that is a critical stopover area of foraging and resting during spring migration for a substantial proportion of all seaducks moving to breeding areas on the Arctic Coastal

Plain or western Canada. Similarly, this same area appears important to many of these same birds once they leave breeding grounds and molt or stage prior to migrating to wintering areas (MMS 2007).

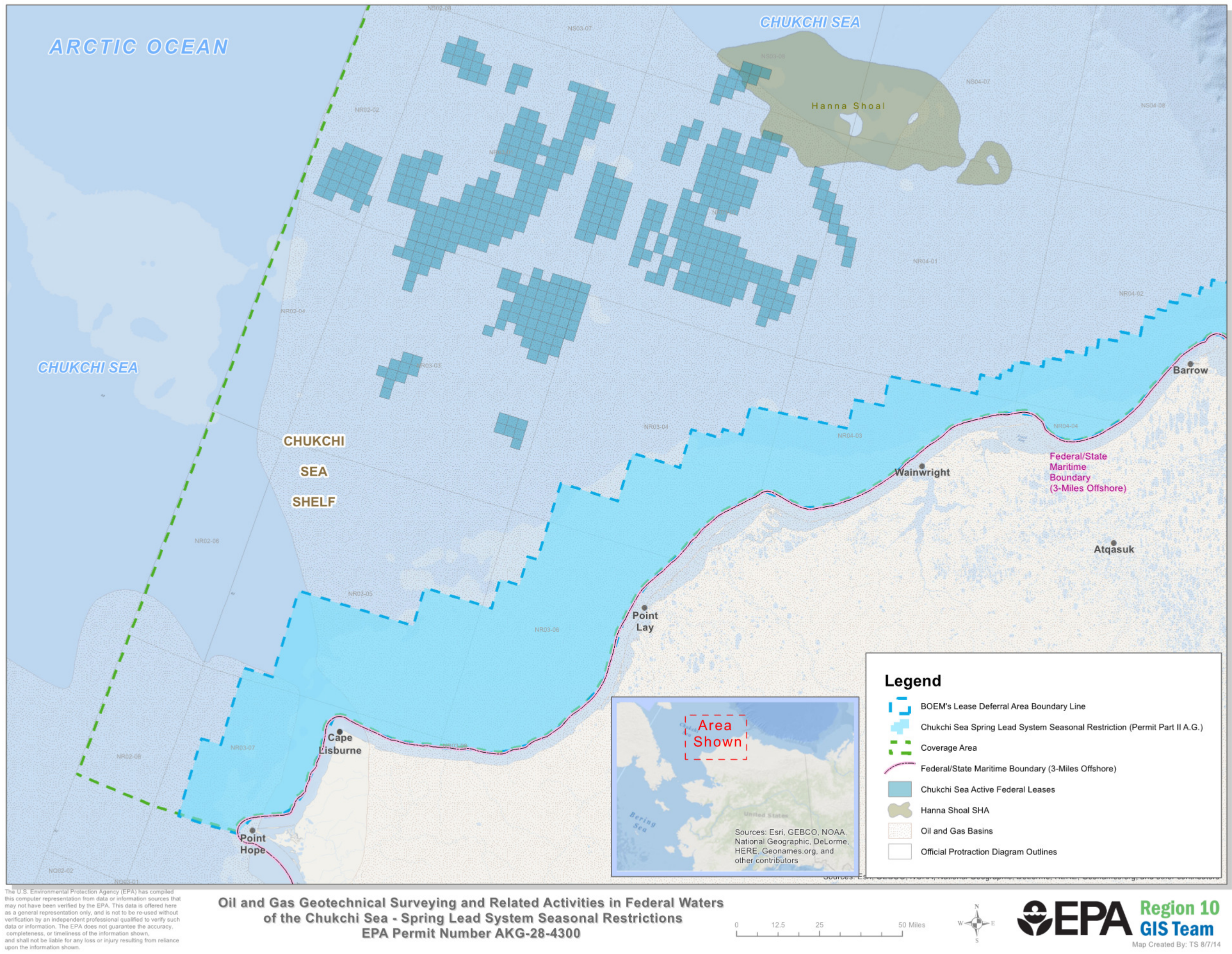

Figure 5-2. Chukchi Sea Spring Lead System Seasonally Restricted Area.

Spectacled eiders (*Somateria fischeri*) make use of the spring lead system when they migrate north from the wintering area into the Chukchi Sea in May and June (BOEMRE 2011). After breeding, male eiders fly to nearshore marine waters in late June where they undergo a complete molt of their flight feathers. In Arctic Alaska, the primary molting area is Ledyard Bay (NMFS 2011). The spring lead system includes the Ledyard Bay Critical Habitat Unit and represents the only open-water area along their migratory path (BOEMRE 2011). Like other eiders, the Spectacled eiders use the spring lead system for feeding and resting. Similarly, the Steller's eiders (*Polsticta stelleri*) return to the Arctic as spring thaw allows, migrating north in May and June (NMFS 2011). Along open coastline, Steller's eiders usually remain within about 400 m (1,312 ft) offshore in water less than 10 m (33 ft) deep but they can also be found in waters well offshore in shallow bays and lagoons or near reefs (USFWS 2000a as cited in NMFS 2011).

Most king eiders (*Somateria spectabilis*) begin to migrate through the Chukchi Sea during spring and arrive in the Beaufort Sea by the middle of May, with males typically preceding females (Barry 1968 as cited in MMS 2007). In the Beaufort Sea, the location and timing of offshore leads along the Chukchi Sea is major factor determining routes and timing of king eider migration (Barry 1986 as cited in MMS 2007). Oppel (2007, pers. commun. as cited in MMS 2007) reported extensive use of the spring lead system by king eiders. According to Oppel (as cited in MMS 2007), 80 king eiders were satellite-tagged between 2002 and 2006. Of these, 23 died or the transmitter failed. Of the remaining 57 birds, 54 (95 percent) were documented to stage in the Ledyard Bay vicinity (nearshore waters between Cape Lisburne and Peard Bay). The typical staging time in Ledyard Bay was 17-24 days (range 1-48 days) (MMS 2007).

Table 5-2. Shorebirds in the Beaufort and Chukchi Seas.

Common name	Scientific name	Breeds in Beaufort Sea	Breeds in Chukchi Sea
Sandhill crane	*Grus Canadensis*	X	X
Black-bellied plover	*Pluvialis squatarola*		
American golden-plover	*Pluvialis dominica*	X	X
Semipalmated plover	*Charadrius semipalmatus*	X	X
Whimbrel	*Numenius phaeopus*	X	X
Hudsonian godwit	*Limosa haemastica*		
Bar-tailed godwit	*Limosa lapponica*	X	X
Ruddy turnstone	*Arenaria interpres*	X	X
Black turnstone	*Arenaria melanocephala*		
Great knot	*Calidris tenuirostris*		X
Sanderling	*Calidris alba*		
Semipalmated sandpiper	*Calidris pusilla*	X	X
Western sandpiper	*Calidris mauri*	X	X
White-rumped Sandpiper	*Calidris fuscicollis*	X	X
Baird's Sandpiper	*Calidris bairdii*	X	X
Pectoral sandpiper	*Calidris melanotos*	X	X
Buff-breasted Sandpiper	*Tryngites subruficollis*		
Dunlin	*Calidris alpine*	X	X
Long-billed dowitcher	*Limnodromus scolopaceus*	X	X
Common snipe	*Gallinago gallinago*	X	X
Red-necked phalarope	*Phalaropus lobatus*	X	X
Red phalarope	*Phalaropus fulicaria*	X	X
Pelagic cormorant	*Phalacrocorax pelagicus*	X	X
Lesser yellowlegs	*Tringa flavipes*		
Wandering tattler	*Heteroscelus incanus (sometimes placed with Tringa incanus)*		X
Red-necked stint (rufous-necked stint)	*Calidris ruficollis*		

Table 5-3. Raptors in the Beaufort and Chukchi Seas.

Common name	Scientific name	Breeds in Beaufort Sea	Breeds in Chukchi Sea
Northern harrier	*Cirus cyaneus*	X	X
Rough-legged hawk	*Buteo lagopus*	X	X
Bald eagle	*Haliaeetus leucocephalus*		
Golden eagle	*Aquila chrysaetos*	X	X
Peregrine falcon	*Falco peregrines*	X	X
Gyrfalcon	*Falco rusticolus*	X	X
Snowy owl	*Bubo scandiacus*	X	X
Short-eared owl	*Asio flammeus*	X	X
Merlin	*Falco columbarius*		

Table 5-4. Seabirds in the Beaufort and Chukchi Seas

Common name	Scientific name	Breeds in Beaufort Sea	Breeds in Chukchi Sea
Red-throated loon	*Gavia stellate*	X	X
Pacific loon	*Gavia pacifica*	X	X
Yellow-billed loon	*Gavia adamsii*	X	X
Arctic loon	*Gavia arctica*		
Common loon	*Gavia immer*		
Red-necked grebe	*Podiceps grisegena*	X	X
Northern fulmar	*Fulmarus glacialis*		
Pomerine jaeger	*Stercorarius pomarinus*	X	X
Parasitic jaeger	*Stercorarius parasiticus*	X	X
Long-tailed jaeger	*Stercorarius longicaudus*	X	X
Mew gull	*Larus canus*	X	X
Herring gull	*Larus argentatus*		
Glaucous gull	*Larus hyperboreus*	X	X
Sabine's gull	*Xema sabini*	X	X
Glaucous-winged gull	*Larus glaucescens*		
Ivory gull	*Pagophila eburnean*		
Ross' gull	*Rhodostethia rosea*		
Black-legged kittiwake	*Rissa tridactyla*	X	X
Arctic tern	*Sterna paradisaea*	X	X
Common murre	*Uria aalge*		X
Thick-billed murre	*Uria lomvia*		X
Black guillemot	*Cepphus grille*	X	X
Pigeon guillemot	*Cepphus Columba*		X
Horned puffin	*Fratercula corniculata*		X
Tufted puffin	*Fratercula cirrhata*		X
Fork-tailed storm-petrel	*Oceanodroma furcata*		
Kittlitz's murrelet	*Brachyramphus brevirostris*		X
Dovekie	*Alle alle*		X
Crested auklet	*Aethia cristatella*		
Least auklet	*Aethia pusilla*		
Parakeet auklet	*Aethia psittacula*		
Short-tailed shearwater	*Puffinus tenuirostris*		

Table 5-5. Waterfowl in the Beaufort and Chukchi Seas.

Common name	Scientific name	Breeds in Beaufort Sea	Breeds in Chukchi Sea
Mallard	*Anas p*latyrhynchos	X	X
Tundra swan	*Cygnus columbianus*	X	X
Greater white-fronted goose	*Anser albifrons*	X	X
Snow goose	*Anser caerulescens*		
Canada goose	*Branta canadensis*	X	X
Emperor goose	*Anser canagicus*	X	X
Green-winged teal	*Anas crecca*	X	X
Black brant (or brent)	*Branta bernicla nigricans*	X	X
Northern pintail	*Anas acuta*	X	X
Northern shoveler	*Anas clypeata*	X	X
American wigeon	*Anas americana*		
Greater scaup	*Aythya marila*	X	X
Common eider	*Somateria mollissima*	X	X
King eider	*Somateria spectabilis*	X	X
Oldsquaw or long-tailed duck	*Clangula hyemalis*	X	X
Black (or Common) scoter	*Melanitta nigra*		
Surf scoter	*Melanitta perspicillata*		
White-winged scoter	*Melanitta fusca*		
Red-breasted merganser	*Mergus serrator*	X	X
Harlequin duck	*Histrionicus histrionicus*		X
Barrow's goldeneye	*Bucephala islandica*		

5.7. Threatened and Endangered Species

The Endangered Species Act requires federal agencies to consult with the USFWS and NMFS if the federal agency's actions could beneficially or adversely affect any threatened and endangered species or their designated critical habitat. In this case, the federal action agency is EPA, and the federal action is the issuance of the Geotechnical GP.

The action could affect listed species under the jurisdiction of both the USFWS and NMFS. This section gives an overview of the listed species (endangered, threatened, proposed, and candidate in the Area of Coverage including reasons for listing. Overviews of potential effects on the species and their critical habitat from the geotechnical discharges are discussed in Section 6.3. The BE for the Geotechnical GP, as well as the BEs for the Beaufort and Chukchi Exploration NPDES General Permits, provide a detailed analysis of the potential effects of the permit action on the listed species. Table 5-6 summarizes the 10 species listed.

Table 5-6. Summary of Endangered Species Act-listed, proposed, and candidate species occurring in the Area of Coverage

Common name	Scientific name	ESA status	Critical habitat designated within the Action Area	Reason for ESA listing
Bowhead whale	*Balaena mysticetus*	Endangered	No	Effects on population due to historic commercial whaling, habitat degradation, and ongoing whaling in other countries and other anthropogenic related disturbances
Fin whale	*Balaenoptera physalus*	Endangered	No	Effects on population due to historic commercial whaling, habitat degradation, and ongoing whaling in other countries and other anthropogenic related disturbances
Humpback whale	*Megaptera novaeangliae*	Endangered	No	Effects on population due to historic commercial whaling, habitat degradation, and ongoing whaling in other countries and other anthropogenic related disturbances
Polar bear	*Ursus maritimus*	Threatened	No	Global climate change and its effects on Arctic sea-ice is the primary threat to polar bear populations
Spectacled eider	*Somateria fischeri*	Threatened	Yes	The causes of the spectacled eider's population decline are currently unknown; however, it is likely due to loss of habitat
Steller's eider	*Polsticta stelleri*	Threatened	No	The causes of the Steller's eider population decline include increased predation, over hunting, ingestion of lead shot, habitat loss, exposure to environmental toxins, scientific exploitation, and the effects of global climate change

Bearded seal, Beringia DPS	*Erignathus barbatus nauticus*	Threatened	No	Effects on bearded seal populations have included direct harvesting, indirect mortalities as a result of fisheries, mortalities resulting from marine mammal research activities, and the effects of global climate change in the Arctic environment
Ringed seal, Arctic subspecies	*Phoca hispida hispida*	Threatened	No	Effects on ringed seal populations have included direct harvesting, indirect mortalities as a result of fisheries, mortalities resulting from marine mammal research activities, and the effects of global climate change in the Arctic environment
Pacific walrus	*Odobenus rosmarus divergens*	Candidate	No	Effects on walrus populations have included historic commercial hunting, pollution and noise disturbances related to the oil and gas industry, and the effects of global climate change in the Arctic environment
Yellow-billed loon	*Gavia adamsii*	Candidate	No	Yellow-billed loons are vulnerable to population decline because of their small population size, low reproductive rate, and specific breeding habitat requirements

EPA has completed the informal ESA Section 7 consultation process with USFWS and NMFS. On December 20, 2013, EPA sent the Biological Evaluation (BE) to the USFWS and NMFS requesting concurrence on the agency's determinations that issuance of the Geotechnical GP may affect, but is not likely to adversely affect the ESA-listed species or their designated critical habitat areas. EPA supplemented the BE on February 11, 2014, with additional analysis for the Pacific walrus, a candidate species, and requested to "conference" on the effects of the Geotechnical GP on this species.

On January 31, 2014, the USFWS concurred with EPA's determinations for the polar bear, spectacled eider, and Steller's eider, and designated spectacled eider critical habitat. In a separate letter on March 13, 2014, the USFWS concluded that the Geotechnical GP is not likely to jeopardize the continued existence of the Pacific walrus. In a letter dated March 19, 2014 NMFS, concurred with EPA's determinations that issuance of the Geotechnical GP may affect, but is not likely to adversely affect the bowhead, fin, and humpback whales, and bearded and ringed seals.

5.8. Essential Fish Habitat

EFH is the waters and substrate (sediments, and the like) necessary for fish to spawn, breed, feed, or grow to maturity, as defined by NMFS for specific fish species. In the Area of Coverage, EFH has been established for snow crabs, Arctic cod, saffron cod, and Pacific salmon (chinook, coho, pink, sockeye, and chum). Juvenile and adult life stages of each EFH species are present within the Area of Coverage. The Magnuson-Stevens Fishery Conservation and Management Act (January 21, 1999) requires EPA to consult with NMFS when a proposed discharge has the potential to adversely affect EFH. Table 5-7 lists the EFH species potentially present in the Area of Coverage. The Geotechnical BE includes an evaluation of EFH and EPA's determination of no adverse effect from the permit action.

Table 5-7. EFH species potentially present in the Area of Coverage.

Common name	Scientific name
Pacific salmon- chinook, coho, pink, sockeye, chum	*Oncorhynchus tshawytscha, O. kisutch, O. gorbuscha, O. nerka, O. keta*
Arctic cod	*Boreogadus saida*
Saffron cod	*Eleginus gracilis*
Opilio snow crab	*Chionoecetes opilio*

5.9. Subsistence Activities and Environmental Justice Considerations

Environmental justice (EJ) is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, and the accompanying Presidential memorandum, directs each federal agency to consider EJ as part of its mission and to develop strategies to achieve environmental protection for all communities to the greatest extent practicable and permitted by law.

EPA's tribal trust responsibilities and government-to-government consultation requirements are covered under a separate Executive Order and agency policies. However, the issues and concerns shared with EPA by tribal governments are also considered in this EJ analysis because of related issues and concerns among all Arctic communities regarding safety of subsistence foods and cultural impacts, including the continuation of the subsistence way of life. The North Slope, Northwest Arctic and Bering Sea communities are predominantly Alaska Native. EPA is taking the approach that if the Geotechnical GP action is protective of subsistence resources, then it will be protective of all residents of the communities. EPA developed an EJ analysis in support of the Beaufort and Chukchi Exploration NPDES General Permits (AKG282100 and AKG2881000, respectively) (USEPA 2012c). As the EJ analysis evaluated and considered the potential impacts to the same communities from similar discharges, EPA believes the EJ analysis is also relevant for the Geotechnical GP. Please refer to the EJ Analysis for additional details.

While there are many subsistence resources harvested in the Area of Coverage, there is one particular traditional cultural activity that is a key component of Inupiat culture and way of life. The bowhead whale hunt involves most of the community in some part of the hunt, and the proceeds are shared and enjoyed in feasts and celebrations. Where in many aspects of Inupiat life cultural changes have taken place at the expense of tradition, the whale hunt remains "key to the survival of [Inupiat] culture" (Brower et. al 1998 as cited in NMFS 2013).

The Western Arctic bowhead whales (*Balaena mysticetus*) migrate annually from wintering areas in the northern Bering Sea, through the Chukchi Sea in the spring, and into the Canadian Beaufort Sea where they spend the summer. In the autumn they return to the Bering Sea to overwinter. Eleven Alaskan coastal communities along this migratory route participate in traditional subsistence hunts of these whales: Gambell, Savoonga, Little Diomede, and Wales (on the Bering Sea coast); Kivalina, Point Lay, Point Hope, Wainwright, and Barrow (on the coast of the Chukchi Sea); and Nuiqsut and Kaktovik (on the coast of the Beaufort Sea). The bowhead whale hunt constitutes an important subsistence activity for these communities, providing substantial quantities of food, as well as reinforcing the traditional skills and social structure.

The Northwest Arctic coastal and Bering Sea communities that participate in the bowhead whale hunt share many common features with the North Slope Borough coastal communities. These include many lifestyle, environmental, social, economic, and cultural conditions that determine health outcomes, such as reliance on subsistence resources, remote location, small population comprised mainly of Iñupiat people, limited infrastructure, housing type, and limited economic opportunities. Seventy-two percent of adults in the Northwest Arctic Borough reported participating in hunting, fishing, and harvesting for subsistence (Poppel et al. 2007; NMFS 2013).

Some villages hunt only in the spring, some only in the fall, and Barrow, Wainwright, and the Saint Lawrence Island villages of Gambell and Savoonga hunt both in the spring and fall/winter. Biologists from NMFS collected harvest data from 1973 until 1981. The North Slope Borough began collecting harvest data in 1982 in collaboration with the Alaska Eskimo Whaling Commission (AEWC) and continues through the present (Suydam and George 2013). Figure 5-3 below depicts the sensitivity areas, by community, during bowhead whale subsistence activities.

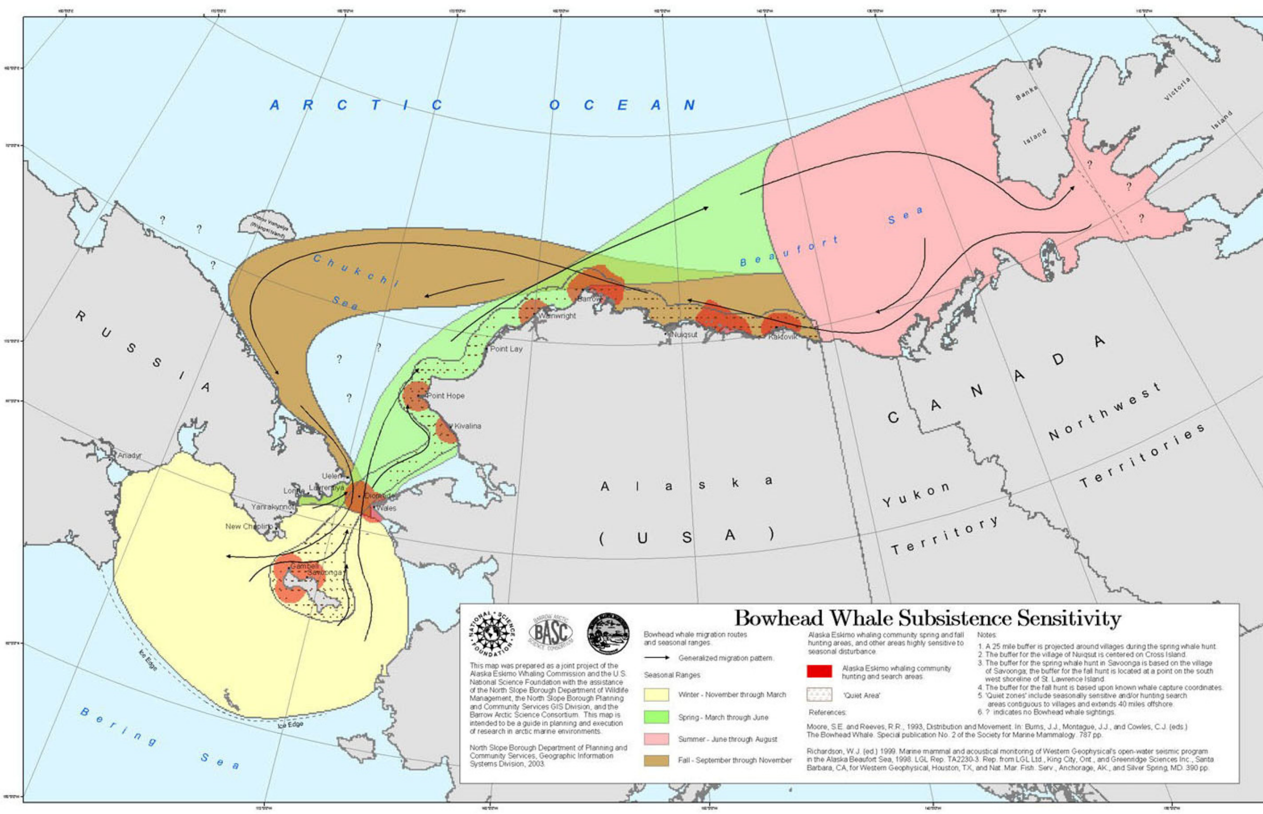

Figure 5-3. Bowhead whale subsistence sensitivity areas by community.

(Source: *http://www.north-slope.org/departments/wildlife-management/studies-and-research-projects/bowhead-whales/bowhead-whale-subsistence-harvest-research#ArtReponSubHarv*)

The spring hunt occurs as whales migrate northeast through the spring lead system along the northwestern coast of Alaska, typically from early April to early June. Barrow also hunts during the fall migration, as do Nuiqsut, and Kaktovik. The fall hunt occurs in open water as whales migrate west along the Beaufort Sea or southwest along northeastern Chukchi Sea coasts of northern Alaska. The fall hunt usually occurs from August through October. Because of difficult environmental conditions during the spring, especially deteriorating sea ice, Wainwright, Point Lay, and Point Hope have expressed interest in hunting in the fall. Crews have gone out hunting but of those three villages only Wainwright landed whales, one in each fall of 2010 and 2011. Recently Savoonga and Gambell, villages on Saint Lawrence Island, have been hunting more frequently during the late fall and early winter (Suydam and George 2013).

Nuiqsut. Nuiqsut whalers only conduct bowhead whaling during the fall. Nuiqsut whalers search for whales on areas north and east of Cross Island, usually in water depths greater than 66 feet. These whalers primarily use Cross Island as their base while they are hunting bowhead whales. Nuiqsut whalers usually land 3 or 4 whales per year. Currently, beluga whales are not a prevailing subsistence resource in Nuiqsut. Spotted seals are typically hunted in the nearshore waters off the Colville River Delta in the summer months. Bearded seals are generally hunted during July, with some hunting occurring also in August and September. Ringed seals are primarily hunted in the winter or spring. Other subsistence activities include fishing, waterfowl and seaduck harvests, and hunting for walrus, polar bears, caribou, and moose (NMFS 2013a).

Kaktovik. Kaktovik whalers conduct bowhead whaling during the fall. Kaktovik whalers hunt for whales east, north, and occasionally west of Kaktovik. Beluga whales are not a prevailing subsistence resource; Kaktovik hunters may harvest one beluga whale in conjunction with the annual bowhead hunt. It appears that most Kaktovik residents obtain beluga through exchanges with other communities. Bearded seals are generally hunted during July, with some hunting also occurring in August and September. Ringed seals are primarily hunted in the winter or spring. Other subsistence activities include fishing, waterfowl and seaduck harvests, and hunting for walrus, polar bears, caribou, and moose (NMFS 2013a).

Barrow. Spring bowhead whale hunting generally occurs from April to June. Barrow whalers hunt from ice leads from Point Barrow southwestward along the Chukchi Sea coast to the Skull Cliff area. Fall bowhead whale hunting occurs in August to October from approximately 10 miles west of Point Barrow to the east side of Dease Inlet. The northern boundary of the fall whaling area is 30 miles north of Point Barrow and extends southeastward to a point approximately 30 miles off Cooper Island. Beluga whaling occurs from April to June in the spring leads between Point Barrow and Skull Cliff; later in the season, belugas are hunted in open water around the barrier islands off Elson Lagoon. Walrus are harvested from June to September from west of Barrow southwestward to Peard Bay. Polar bear are hunted from October to June generally in the same vicinity used to hunt walrus. Seal hunting occurs mostly in winter, but some open-water sealing is done from the Chukchi coastline east as far as Dease Inlet and Admiralty Bay in the Beaufort Sea (MMS 2007).

Wainwright. Spring bowhead whaling occurs from April to June in the spring leads offshore of Wainwright. Wainwright whalers hunt beluga whales in the spring lead system from April to June, but only if no bowheads are in the area. Later in the summer, from July to August, belugas can be hunted along the coastal lagoon systems. Walrus hunting occurs from July to August at the southern edge of the retreating pack ice. From August to September walrus can be hunted at local haulouts with the focal area from Milliktagvik north to Point Franklin. Polar bear hunting occurs primarily in the fall and winter around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island (MMS

2007). Beginning in 2010, for the first time in many decades, Wainwright successfully landed bowheads during the fall. They landed another whale in the fall of 2011 (Suydam et al. 2014).

Point Lay. Because Point Lay's location renders it unsuitable for bowhead whaling, beluga whaling is the primary whaling pursuit. Beluga whales are harvested from the middle of June to the middle of July. The hunt is concentrated in Naokak and Kukpowruk Passes south of Point Lay where hunters use boats to herd the whales into the shallow waters of Kasegaluk Lagoon. If the July hunt is unsuccessful, hunters can travel as far north as Utukok Pass and as far south as Cape Beaufort in search of whales. When ice conditions are favorable, Point Lay residents hunt walrus from June to August along the entire length of Kasegaluk Lagoon, south of Icy Cape, and as far as 20 miles offshore. Polar bears are hunted from September to April along the coast rarely more than 2 miles offshore (MMS 2007). In 2009, Point Lay landed its first bowhead whale in more than 70 years. Another whale was landed in 2011 (Suydam and George 2013).

Point Hope. Bowhead whales are hunted from March to June from whaling camps along the ice edge south and southeast of the point. The ice lead is rarely more than 6 to 7 miles offshore (MMS 2007). Until recently, there was no fall bowhead hunt in Point Hope because the whales migrate on the west side of the Bering Strait, out of range of the Point Hope whalers (NMFS 2013b). Beluga whales are harvested from March to June in the same area used for the bowhead whale hunt. Beluga whales can also be hunted in the open water later in the summer from July to August near the southern shore of Point Hope close to the beaches, as well as areas north of the point as far as Cape Dyer. Walrus is harvested from May to July along the southern shore of the point from Point Hope to Akoviknak Lagoon. Point Hope residents hunt polar bears primarily from January to April and occasionally from October to January in the area south of the point and as far out as 10 miles from shore (MMS 2007).

5.9.1. Importance of Subsistence

The Inupiat consider subsistence to be more than just a "way of life," and for the people who live along the Beaufort Sea and Chukchi Sea coasts, subsistence is their life (Maclean 1998). Subsistence defines the essence of who they are, and it provides a connection between their history, culture, and spiritual beliefs. An essential component of Inupiat values is the sharing of subsistence resources among families, friends, elders, and those in need. "[V]irtually all Inupiat households depend on subsistence resources to some degree" (NSB 2004, NMFS 2013).

Subsistence activities are assigned the highest cultural value by the Inupiat and provide a sense of identity in addition to the substantial economic and nutritional contributions. Many species are important for the role they play in the annual cycle of subsistence resource harvests, and each subsistence food resource plays an important role. Loss of access to any subsistence food resource could have serious effects. When a subsistence resource is unavailable for any reason, families will adapt and redirect harvest effort towards other species, but the contribution of some resources to the annual food budget would be very difficult to replace. Besides their dietary benefits, subsistence resources provide materials for family use and for the sharing patterns that help maintain traditional Inupiat family organization. Relationships between generations, among families, and within and between communities are honored and renewed through sharing, trading, and bartering subsistence foods. The bonds of reciprocity extend widely beyond the permit areas of coverage and help to maintain ties with family members elsewhere in Alaska. Subsistence resources provide special foods for religious and ceremonial occasions; the most important ceremony, Nalukataq, celebrates the bowhead whale harvest (NMFS 2008 and 2013).

The use of traditional food in the subsistence way of life provides important benefits to users. Subsistence foods are often preferable as they are rich in many nutrients, lower in fat, and healthier than purchased foods. Subsistence foods consist of a wide range of fish and wildlife and vegetable products that have substantial nutritional benefits. According to the state Division of Subsistence, about 38.3 million pounds of wild foods are taken annually by residents of rural Alaska, or about 316 pounds per person per year. This compares to 23 pounds per year harvested by Alaska's urban residents. Fish comprise 55 percent of subsistence foods taken annually. Ninety-two to one-hundred percent of rural households consume subsistence-caught fish, according to the state (ADF&G 2010).

Subsistence harvesting of traditional foods, including preparation, eating, and sharing of resources contributes to the social, cultural, and spiritual well-being of users and their communities (NMFS 2013). Communities express and reproduce their unique identities based on the enduring connections between current residents, those who used harvest areas in the past, and the wild resources of the land. Elders' conferences, spirit camps, and other information exchange and gathering events serve to solidify these cultural connections between generations and between the people and the land and its resources (NMFS 2013).

Participation in the harvesting and sharing of subsistence foods goes beyond the family and the community. There is an extensive network of exchange that occurs between communities of the Beaufort and Chukchi Seas and further to relatives residing in larger towns such as Anchorage and Fairbanks. For instance, the shares of bowhead whale that each crew member receives after whaling are involved in secondary redistribution among local relatives and those in other communities. Social and cultural identity is strengthened by serving subsistence foods at home and at feasts and sharing subsistence foods, particularly with elders. The foods that are exchanged strengthen family and regional ties (NMFS 2013).

5.9.2. Subsistence Participation and Diet

Diets include both traditional, or subsistence foods, and non-traditional, or store foods. Traditional diets are associated with numerous health benefits and reduced risk of many chronic diseases including diabetes, high blood pressure, high cholesterol, heart disease, stroke, arthritis, depression, and some cancers (Reynolds et al. 2006; Murphy et al. 1995; Adler et al. 1996; Ebbesson et al. 1999, Bjerregaard et al. 2005). Data from the 2003 North Slope Borough census show that virtually all Iñupiat households report relying on subsistence resources to some extent, and that subsistence foods make up a large proportion of healthy meals (Circumpolar Research Associates 2010, NMFS 2013). The North Slope Borough also has among the highest per capita harvests of subsistence food in Alaska (McAninch 2010).

Residents have expressed concerns about environmental contamination, particularly as it relates to contamination of subsistence food sources. In a recent survey, 44 percent of Inupiat village residents reported concern that fish and animals may be unsafe to eat (Poppel et al. 2007, NMFS 2013). Environmental contaminants have the potential to affect human health in a number of ways. First exposure to contaminants via inhalation, ingestion, or absorption may induce adverse health effects, depending on a number of factors, including the nature of the contaminant, the amount of exposure, and the sensitivity of the person who comes in contact with the contaminant.

Aside from actual exposure to environmental contamination, the perception of exposure to contamination is also linked to known health consequences. Perception of contamination may result in stress and anxiety about the safety of subsistence foods and avoidance of subsistence food sources (CEAA 2010, Joyce 2008, Loring et al. 2010), with potential changes in nutrition-related diseases as a result. It is important to note that these health results arise regardless of whether or not there is any real contamination at a level that could induce toxicological effects in humans; the effects are linked to the perception of contamination, rather than to measured levels (NMFS 2013).

Below is a brief summary of subsistence resources harvested by the North Slope coastal communities and generally represented of other Bering Sea and Arctic communities. Subsistence foods include fish, seal, walrus, beluga and bowhead whale from the Beaufort and Chukchi Seas, as well as land-based animals and certain migratory birds and eggs. More information can be found in the ODCEs for the Beaufort and Chukchi Exploration NPDES General Permits. Table 5-8 below summarizes the percent total subsistence harvest by species (NMFS 2013).

Table 5-8. Percent total subsistence harvest by species

Species	Barrow (1987–1989)	Wainwright (1987–1989)	Point Lay (1987)	Point Hope (1992)	Kaktovik (1992–1993)	Nuiqsut (1993)
Bowhead whale	38%	35%	63%	6.9%	63%	29%
Beluga whale	--	--	1%	40.3%	--	--
Seals	6%	6%	6%	8.3%	3%	3%
Walrus	9%	9%	27%	16.4%	--	--
Fish	11%	11%	5%	9%	13%	34%
Polar bear	2%	2%	2%	--	1%	--
Waterfowl	4%	4%	2%	2.8%	2%	2%

Bowhead Whale. Historically, the bowhead whale was hunted by the Chukchi communities in the spring; however, since 2010, Wainwright has hunted in both the spring and fall. Point Lay and Point Hope have also attempted the fall hunt. Barrow residents consistently hunt the bowhead whale during the spring and the fall (Suydam et al. 2014). Nuiqsut and Kaktovik conduct hunting activities in the Beaufort Sea in the fall. Bowhead whale hunting can occur anywhere from 1 miles to more than 10 miles offshore depending on the location of open leads and weather conditions (SRB&A 2011). In 1977 the International Whaling Commission established an overall quota for subsistence hunting of the bowhead whale by the Alaskan Iñupiat. The Alaska Eskimo Whaling Commission regulates the quota, and it annually decides how many bowheads each whaling community may take.

Bowhead whales are hunted from open leads in the ice (e.g., areas of open water) during the spring months of March and April when pack-ice conditions deteriorate and during the fall in open water, typically between late August and early October. No other marine mammal is harvested with the intensity and concentration of effort that is expended on the bowhead whale (MMS 2008).

Beluga Whale. Beluga whales hunting begins at the spring whaling season through June and occasionally in July and August in ice-free waters. Belugas are generally harvested incidental to the bowhead hunt or after the spring bowhead season ends. Beluga whales are harvested in the leads, in the lagoon systems along the coast, and in the outer coast of the barrier islands.

Seals. Seals are hunted year-round, but the bulk of the seal harvest takes place during the open-water season, with breakup usually occurring in June. In spring, seals can be hunted once the landfast ice has retreated. While seal meat is eaten, the dietary significance of seals primarily comes from seal oil, served with almost every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Also, sealskins 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 making clothing, because the harvest of this species is more abundant (MMS 2008; SRB&A 2011).

Ringed seals are the most common hair seal species harvested, and spotted seals are harvested only in the ice-free summer months. Ringed seal hunting is concentrated in the Chukchi Sea, although some hunting occurs off Point Barrow and along the barrier islands that form Elson Lagoon. The hunting of bearded seals is an important subsistence activity because the bearded seal is a preferred food and because bearded seal skins are the preferred covering material for the skin boats used in whaling. Six to nine skins are needed to cover a boat. For those reasons, bearded seals are harvested more than the smaller hair seals.

Walrus. The major walrus hunting effort coincides with the spring bearded seal harvest. The walrus is hunted primarily during June to August by the Chukchi communities, but it also is hunted by boat during the rest of the summer along the northern shore, especially along the rocky capes and other points where they tend to haul out (MMS 2008; SRB&A 2011). Walruses are incidentally taken during whaling and seal hunting by Nuiqsut and Kaktovik (MMS 2008); though they are rarely seen because the communities are located east of the walruses' optimum range.

Fishes. The harvesting of fish is not subject to seasonal limitations, a situation that adds to their importance in the communities' subsistence diet. A variety of fishes are harvested in the marine and freshwater habitats along the coast, within the shores of barrier islands, and in lagoons, estuaries, and rivers. Fish are eaten fresh or frozen. Because of their important role as an abundant and stable food source, and as a fresh food source during the midwinter months, fish are shared at Thanksgiving and Christmas feasts and given to relatives, friends, and community elders. Fish also appear in traditional sharing and bartering networks that exist among North Slope communities. Because it often involves the entire family, fishing serves as a strong social function in the community.

Waterfowl. Since the mid-1960s, waterfowl and coastal birds as a subsistence resource have been growing in importance. The most important subsistence species of birds are the black brant, long-tailed duck, eiders, snow goose, whitefronted goose, Canada goose, and pintail duck. Other birds, such as loons, occasionally are harvested. Waterfowl hunting occurs mostly in the spring, from May through early July; normally, a less-intensive harvest continues throughout the summer and into the fall. In the summer and early fall, such hunting usually occurs as an adjunct to other subsistence activities, such as checking fishnets (MMS 2008).

Eggs from a variety of species still are gathered occasionally, especially on the offshore islands where foxes and other predators are less common. Waterfowl, hunted during the whaling season (beginning in late April or early May) when their flights follow the open leads, provide a source of fresh meat for whaling camps.

Polar Bear. Polar bears are harvested during the winter months on ocean ice and along ocean leads (MMS 2008), although they are hunted less actively than in the past (MMS 2008).

5.10. Climate Change and Effects on Subsistence

Climate in the Arctic is showing signs of rapid change; nevertheless further study is needed to better understand the changes that have been observed and their significance to the Arctic Climate Region as well as global climate change (NMFS 2013). Evidence of climate change in the past few decades, commonly referred to as global warming, has accumulated from a variety of geophysical, biological, oceanographic, atmospheric, and anthropogenic sources. Since much of this evidence has been derived from relatively short time periods, and climate itself is inherently variable, the recent occurrence of unusually high temperatures may not necessarily be abnormal since it could fall within the natural variability of climate patterns and fluctuations. However, with that possibility, it should be noted that evidence of climate changes in the Arctic have been identified and appear to generally agree with climate modeling scenarios. Such evidence suggests (NMFS 2013):

- Air temperatures in the Arctic are increasing at an accelerated rate
- Year-round sea ice extent and thickness has continually decreased over the past three decades
- Water temperatures in the Arctic Ocean have increased
- Changes have occurred to the salinity in the Arctic Ocean
- Rising sea levels
- Retreating glaciers
- Increases in terrestrial precipitation
- Warming permafrost in Alaska
- Northward migration of the treeline

The implications of climate change on subsistence resources are difficult to predict, although some trends are consistent and anticipated to continue. The North Slope communities and their reliance on subsistence resources will be stressed to the extent the observed changes continue. Those stressors could include alterations to traditional hunting locations, increases in subsistence travel and access difficulties, shifts in migration patterns, and changes to seasonal availability of subsistence resources (MMS 2008).

Through the traditional knowledge gathering process for the Beaufort and Chukchi Exploration NPDES General Permits, the following observations regarding changes in ice conditions and effects on wildlife and subsistence activities were shared (SRB&A 2011):

- Marine mammals such as seals and walrus are congregating in large groups because of lack of ice, becoming skinnier from having to travel farther, and more frequently coming to shore when no offshore ice is available on which to rest.
- Changes in timing and nature of break up (earlier) and freeze up (later) have caused the hunting season to be shorter and residents to have fewer opportunities, such as increased difficulty harvesting from the ice. Additionally, hunters might have to travel farther, which increases overall risks, costs, and dangers from rotten ice.
- Warming of the temperatures and permafrost has contributed to spoiling of harvested meat.
- At the same time, some subsistence activities in certain areas have become easier because of open leads closer to shore than in the past.
- Lack of ice and the habitat it provides affects marine mammal distribution, particularly bearded seals, walruses, and polar bears.

The main impacts of climate change on cetaceans would result from habitat changes (e.g., ice melting) that might impact prey migration, location, or availability as well as potentially impacting existing migratory routes and breeding or feeding grounds. Because of the Arctic Ocean's relatively low species diversity, it may be particularly vulnerable to trophic-level alternations caused by global warming (Derocher, Lunn, and Stirling 2004 as cited in MMS 2007). For example, Mecklenburg et al. (2005 as cited in MMS 2007) show that changes in the arctic ice cover are affecting arctic fish (Loeng 2005 as cited in MMS 2007). In Hudson Bay, Gaston, Woo, and Hipfner (2003 as cited in MMS 2007) concluded that the decline in arctic cod and increase in capelin and sand lance were associated with a general warming of the waters and a significant decline in the amount of ice cover. Their evidence suggests that the fish community in northern Hudson Bay shifted from Arctic to Subarctic from 1997 onwards, which was reflected in dramatically altered diets of thick-billed murres (*Uria lomvia*) in the region. Likewise, fish assemblages and populations in Alaska have undergone observable shifts in diversity and abundance during the last 20-30 years. Changes in distributions of important prey species, such as arctic cod, could have cascading effects throughout the ecosystem. The arctic cod is a pivotal species in the arctic food web, as evidenced by its importance as a prey item to belugas, narwhals, ringed seals, and bearded seals (Davis, Finley, and Richardson 1980 as cited in MMS 2007). In arctic regions, no other prey items compare with arctic cod in abundance and energetic value. Arctic cod are believed to be adapted to feeding under ice and ice-edge habitat is critical to cod recruitment (Tynan and DeMaster, 1997 as cited in MMS 2007).

As described earlier in this document, the group of bowhead whales (*Balaena mysticetus*) that inhabit the Bering-Chukchi-Beaufort seas is important to the viability of the species as a whole and is a species of very high importance for subsistence and to the culture of Alaskan Native peoples of the northern Bering Sea, the Chukchi Sea, and the Beaufort Sea (MMS 2006). While data do not yet exist to quantitatively predict how changes in sea ice will affect the population dynamics of Bering-Chukchi-Beaufort bowhead whales, the importance of sea ice to the Arctic ecosystem suggests that the changes determined through predictive modeling will have a significant impact on the ecology of this species. Moore and Laidre (2006) constructed a conceptual model of the influence of sea ice cover on bowhead prey composition and availability, based on the underlying pathways that affect zooplankton. Bowhead whales feed on zooplankton produced locally within a foraging area (i.e., *Calanus* spp.) and on zooplankton advected to foraging areas from elsewhere (*Calanus* spp. and *Thysanosessa* spp.) (Lowry et al. 2004 as cited in Moore and Laidre 2006). Moore and Laidre (2006) noted that sea ice can influence both: (1) the production path through impacts on predictable solar forcing (i.e., the seasonal light cycle) and water stratification, and/or (2) the advective path through impacts on the dynamics of water flow (i.e., currents and upwelling), driven by highly variable atmospheric (wind) forcing. Increased primary production will augment the bowhead prey base only if it remains well coupled with zooplankton life cycles (Hansen et al. 2002 as cited in Moore and Laidre 2006).

While bowhead whales do not appear to be food limited at present, if primary production becomes decoupled with the vertical migration of zooplankton (e.g., Niehof 2000 as cited in Moore and Laidre 2006), or the increasing fetch of open water enhances storm-driven mixing and retards stratification required for peak production in the Arctic (e.g., Yang et al. 2004 as cited in Moore and Laidre 2006), any gain in bowhead prey base could be short lived. Some ecosystem models suggest that reductions of ice cover over the deep Canada Basin may ultimately result in less energy transfer to higher trophic levels (Walsh et al. 2004 as cited in Moore and Laidre 2006). Ultimately, any decoupling of the system that reduces secondary production will have negative effects on upper trophic levels, including bowhead whales (Moore and Laidre 2006).

Potential impacts on bowhead whales from climate change (MMS 2007) include:

- Decreases in ice cover with the potential for resultant changes in prey-species concentrations and distribution; related changes in bowhead whale distributions; changes in subsistence-hunting practices that could result in smaller, younger whales being taken and, possibly, in fewer whales being taken.
- More frequent climatic anomalies, such as El Niños and La Niñas, with potential resultant changes in prey concentrations.
- A northern expansion of other whale species, with the possibility of increased overlap in the northern Bering and/or the Chukchi seas.

A diminishing ice pack actually might increase the range of certain whales, such as the bowhead; alternatively, this same situation could diminish phytoplankton production, which would lead to declines in key cetacean prey species, such as copepods and plankton-feeding fish that are preferred food for narwhals and beluga whales. A reduced ice pack also could expose whales to increased Arctic ship traffic (Burns 2000 as cited in MMS 2007). The timing and sequence of whale migration also may be a function of ice cover and could negatively affect the feeding and reproduction of ice-associated cetaceans, such as bowheads and belugas. Changes to polynyas and ice leads, important in the distribution and migration of bowheads in winter and spring, could have a major impact on bowhead behavior (Huntington and Mymrin 1996; Lowry 2000; Parson et al. 2001; NRC 2003; USEPA 1998; National Assessment Synthesis Team 2000; Environment Canada 1997; IPCC 2001; BESIS Project Office 1997 as cited in MMS 2007).

6. DETERMINATION OF UNREASONABLE DEGRADATION

This section presents a discussion of EPA's evaluation of the 10 ocean discharge criteria and EPA's determinations regarding unreasonable degradation.

Under EPA's regulations, no NPDES permit may be issued if it is determined to cause unreasonable degradation of the marine environment. EPA considers the 10 ocean discharge criteria and other factors specified in 40 CFR 125.122(a)-(b) when evaluating the potential for unreasonable degradation. Unreasonable degradation of the marine environment means:

- Significant adverse changes in ecosystem diversity, productivity and stability of the biological community within the area of discharge and surrounding biological community.
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms.
- Loss of aesthetic, recreational, scientific or economic values, which is unreasonable in relation to the benefit derived from the discharge.

According to EPA's regulations, when conducting its evaluation, EPA may presume that discharges in compliance with CWA section 301(g), 301(h), or 316(a), or with state water quality standards, do not cause unreasonable degradation of the marine environment, 40 CFR 125.122(b). In addition, EPA may impose additional permit conditions to ensure that a discharge will not result in unreasonable degradation.

In cases where sufficient information is available to determine whether unreasonable degradation of the marine environment will occur, 40 CFR 125.123(a) and (b) governs EPA's actions. Discharges that cause unreasonable degradation will not be permitted. Other discharges may be authorized with necessary permit conditions to ensure that unreasonable degradation will not occur.

In the circumstances where there is insufficient information to determine, before permit issuance, that a discharge will not result in unreasonable degradation, EPA may permit the discharge, if EPA determines on the basis of available information that:

- Such discharges will not cause irreparable harm to the marine environment during the period in which monitoring is undertaken.
- There are no reasonable alternatives to the on-site disposal of these materials.
- The discharge will be in compliance with all permit conditions established pursuant to 40 CFR 125.123(d).

Based on the information provided Sections 1–5 above and the evaluation provided below, EPA has determined that the discharges authorized by the Geotechnical GP will not cause unreasonable degradation of the marine environment. EPA's ocean discharge criteria evaluations, related findings and determinations are discussed in this section.

6.1. CRITERION 1

The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

Based on information provided by AOGA (2013), EPA estimates that approximately 100 geotechnical boreholes will be drilled per year in federal waters within the Area of Coverage of the Beaufort and

Chukchi Seas during the 5-year term of the general permit. Additionally, for purposes of the ODCE, EPA assumes four equipment feasibility testing activities would occur each year (two per sea), for a period of 7–10 days per event, totaling 20 events during the term of the permit. Each related activity would result in a seafloor disturbance of approximately half of a typical mudline cellar dimension; therefore, EPA's assumption is the area of disturbance from equipment testing would disturb an area that is approximately 10 by 20 feet, generating a total of approximately 235,000 gallons of cuttings materials to be discharged during the 5-year permit term. EPA also assumes drilling fluids would not be used for geotechnical related activities. Section 3 of this ODCE characterizes the types and quantities of discharges that would occur during the geotechnical surveys and related activities. The potential impacts of those discharges are the focus of this section.

While water-based drilling fluids are not expected to be used to drill shallow geotechnical boreholes, they may be used for deeper holes to lubricate the drill bit and stabilize the borehole. The limitations and conditions of the permit ensure that drilling fluids and drill cuttings do not contain persistent or bioaccumulative pollutants. For example, if barite is added to the drilling fluids, then mercury and cadmium in stock barite must meet the limitation of 1 mg/kg and 3 mg/kg, respectively, which indirectly controls the levels of other metal constituents in the discharge. The drilling fluids must also meet the suspended particulate phase toxicity testing requirements and cannot be discharged if an oil sheen is detected. During spring and fall bowhead hunting activities in the Chukchi and Beaufort Seas, respectively, the Geotechnical GP restricts the discharges of drilling fluids and drill cuttings (Discharge 001). In addition, the Geotechnical GP requires an inventory and reporting of all chemicals added to the system, including limitations on chemical additive concentrations.

Discharges of cuttings not associated drilling fluids, cement slurry and the miscellaneous discharges (i.e., deck drainage; sanitary and domestic wastes; desalination unit waste; bilge water; boiler blowdown; fire control system test water; non-contact cooling water; and uncontaminated ballast water) are not expected to carry pollutants that are bioaccumulative or persistent.

Finally, the Geotechnical GP includes a seasonal restriction that prohibits all discharges in the Chukchi Sea in the 3-25 nautical mile corridor prior to July 1. EPA has included this restriction based on the relative nearshore location of the spring lead system in the Chukchi Sea, its particular importance for feeding, migration, and calving of bowhead whales, and its importance to numerous marine mammal species and coastal and marine birds, as discussed in detail above in Sections 4.3.4, 5.5 and 5.6. This seasonal restriction provides protection for this critical area during a sensitive period in a manner consistent with protections provided by BOEM, NMFS, and USFWS.

This seasonal restriction corresponds with BOEM's geographic restriction on all oil and gas leasing activities within the 3-25 nautical mile deferral area to protect important bowhead whale habitat used for migration, feeding, nursing calves, and breeding. BOEM's deferral decision was designed, in part, to protect environmentally sensitive areas, such as the polynyas and important near-shore habitat, and areas known to be important for subsistence hunting, from oil and gas related activities (MMS 2007, BOEM 2011). BOEM's analysis supporting Chukchi oil and gas leasing addressed several potential alternatives, including conducting leasing in the entire Chukchi Sea OCS with no deferral area. BOEM ultimately determined, however, that deferring leasing entirely within the 3-25 mile corridor, known as the Corridor II Deferral, would further reduce potential impacts to bowhead whales and numerous other species while ensuring that any impacts that do occur remain temporary, localized, and minor (BOEM 2011).

EPA's seasonal restriction also corresponds with timing restrictions on oil and gas activities in the Chukchi Sea imposed by NMFS and USFWS. In particular, NMFS has applied a restriction under the Marine Mammal Protection Act (MMPA) on vessel entry into the Chukchi Sea through the Bering Strait prior to July 1, which is considered the end of the spring bowhead whale migration. NMFS included this restriction in its 2012 Incidental Harassment Authorizations for Shell's exploration activities in the Beaufort and Chukchi Seas as a mitigation measure to minimize impacts to marine mammals and subsistence activities. (NMFS 2011, NMFS 2012). In addition, in 2013, USFWS issued a final rule authorizing the incidental take of Pacific walruses during oil and gas exploration activities in the Chukchi Sea. Among other things, the rule authorizes activities only during the open-water season, not to exceed July 1 to November 30. This condition is intended to minimize impacts to walruses during the spring migration and minimize interference with subsistence hunts (USFWS 2013). The USFWS' 2012 Biological Opinion for Oil and Gas Activities in the Beaufort and Chukchi Seas prohibited all vessels from entering the spring lead system between April 1 and June 10 of each year (USFWS 2012). With regard to Criterion 1, EPA's seasonal restriction further reduces any potential for unreasonable degradation by removing discharges and activity from the sensitive spring lead system during the critical spring migration, feeding, resting, and calving period.

EPA's selection of the July 1 date is based on many factors, including consideration of the traditional start of oil and gas activities in the offshore Arctic, which usually occurs on or after July 1, with activity continuing for approximately 120 days during the open water (ice-free) season (Shell 2014).

6.1.1. Seafloor Sedimentation

The water-based drilling fluids and drill cuttings, including materials from the mud pit cleanup (Discharge 001), cuttings not associated with drilling fluids (Discharge 011), and cement slurry (Discharge 012) are discharged at the seafloor. In low-energy environments within shallower waters, currents do not play a role in moving deposited material from the bottom or mixing it into sediments, as shown by the modeling results discussed in Section 3.4. However, the deposited materials may be mixed vertically with natural sediments by physical resuspension processes and by biological reworking of sediments by benthic organisms or marine mammals. Ice gouging could also mix deposited materials into seafloor sediments. The relative contribution of those processes to sediment mixing has not been quantified.

6.1.2. Benthic Communities

While the scale and scope of geotechnical surveys and related activities are much less than drilling of exploration wells, data from Dunton et al. (2009) investigations at old drill sites were reviewed for the ODCE. Benthic habitats in Camden Bay in the Beaufort Sea to characterize baseline conditions at the Sivulliq prospect and recovery at a former exploratory drill site (Hammerhead) were investigated. At 45 sites, 10 of which were in the area of the Hammerhead former drill site, the species composition of the infaunal community along with density, biomass, and stable isotopic composition (C-13 and N-15) were determined through sediment grab samples. Comparison of results from the other 35 Sivulliq sites to the 10 Hammerhead sites indicated that previous drilling activities (which were conducted in 1985) did not have a measurable impact on the occurrence or trophic structure of the infaunal community after 23 years.

Marine invertebrates were also collected by Battelle et al. (2010) in the Burger and Klondike survey areas of the Chukchi exploration area, where exploration drilling occurred in 1989, to measure metals concentrations in tissue. Comparison of metal (arsenic, barium, chromium, copper, iron, mercury, lead, and zinc) concentrations in the *Astarte* clam in the Chukchi Sea, to concentrations in clams collected in the Beaufort Sea in 2008 were not significantly different. Concentrations of arsenic, cadmium, mercury, and manganese were significantly higher in crabs collected in the Klondike survey area than crabs collected in the Burger survey area. The study did not determine a reason for the difference, but it suggests that differences in metal concentrations were from differences in the water column or food.

Measurable effects on benthic communities have the potential to impact fish resources, particularly benthic feeders. However, scientific evidence suggests that drilling discharges and cuttings have minor effects on adult fish health (NMFS 2013, Hurley and Ellis 2004). Based on these results and the numbers of projected boreholes, spacing of the boreholes, and estimated discharges from geotechnical surveys and related activities (see Section 2.0), it is not expected that sedimentation would be persistent or produce irreversible effects on benthic structure and diversity.

6.1.3. Trace Metals

Several studies have evaluated the solubility of trace metals found in barite, a key ingredient in drilling fluids. Crecelius et al. (2007) evaluated the release of trace components from barite to the marine environment, including seawater and sediment pore water, under varying redox conditions. Solubility of barium and other metals in barite were tested under specific laboratory conditions, where salinity was 30 ppt; temperature was 40 °F to 68 °F (4 °C and 20 °C); pH ranged from 7 to 9; and pressure was 14 and 500 pounds per square inch. In containers with static seawater from the Gulf of Mexico, concentrations of cadmium, copper, mercury manganese, and zinc gradually increased through leaching over time. Results showed that temperature and pressure had little effect on solubility; however, pH had the greatest effect on concentrations of mercury and zinc, which increased as pH increased. When exposed to flowing seawater (by passing seawater through the containers at a constant rate), at pH 8 for 24 hours, the release rate of cadmium, copper, mercury, lead and zinc were greatest during the first several hours. Dissolved concentrations of those metals in the flowing seawater approached concentrations found in coastal seawater after 24 hours. The addition of natural sediment, however, reduced the release of metals to the static water column compared to barite alone, indicating that organisms living on or near the sediment would not be exposed to the elevated concentrations of dissolved metals. Crecelius et al. also notes that the static experiments are worst-case scenarios because in open water, natural systems field currents and diffusion would further dilute metals.

Crecelius et al. (2007) also investigated leaching of metals from barite in anoxic sediment. Barium, iron, manganese, and zinc were found to be more soluble under anoxic conditions in pore water, but concentrations of cadmium, copper, mercury, methylmercury, and lead were not significantly different from un-amended sediment. The results suggest that metals would form insoluble sulfide minerals under anoxic conditions, and therefore, would not be bioavailable to benthic organisms.

Neff (2008) used the results from Crecelius et al. (2007) to determine the bioavailable fraction of metals. Neff used a distribution coefficient, which is the factor that predicts partitioning of the metal between the solid phase and dissolved in a liquid phase, for each metal between barite and seawater, and barite and pore water. The distribution coefficients indicate that metals (barium, cadmium, chromium, copper, mercury, lead, and zinc) are more likely to remain associated with barite by a minimum of 2.5 orders of magnitude than to dissolve in seawater. Distribution coefficients for metals between barite and pore water, at pH levels similar to the pH of digestive fluids of benthic organisms, show that all metals other than cadmium were more likely to remain associated with barite particles. Cadmium was the most bioavailable metal for bottom-dwelling organisms that could ingest barite particles. Likewise, MacDonald

(1982) also concluded that metal solubility from barite is low according to thermodynamics and that low solubility results in metal concentrations are comparable to coastal ocean dissolved metal concentrations.

Those studies demonstrate that trace metals are generally unavailable to marine organisms in detrimental concentrations. Furthermore, the studies suggest that trace metal concentrations in a mixture of barite and seawater are close to natural coastal concentrations, although a number of metals precipitate out as insoluble metal sulfides.

6.1.4. Persistence

Snyder-Conn et al. (1990) studied the persistence of trace metals in low-energy, shallow Arctic marine sediments. In that study, sediment samples were collected at three exploratory well sites in the shallow, nearshore Beaufort Sea and compared to four control locations. Exploratory drilling had occurred at the experimental sites between 1981 and 1983, and sediment samples were collected in 1985. Samples were collected at five stations (at approximately 25-meter (82-foot) intervals) along three to four transects established at sites where drilling fluids and cuttings had been discharged. Average sediment concentrations for aluminum, arsenic, barium, chromium, lead, and zinc were elevated compared to the average reference station concentrations. The author suggested that the persistence resulted from poor dispersion because of the low energy of the marine environment in those shallow locations.

Long et al. (1995) applied the sediment guidelines to the concentration samples obtained in the Snyder-Conn study. They concluded that concentrations for chromium, lead and zinc were below the effects range median, and arsenic was below the effects range low. Concentrations below the effects range low represent a low risk for aquatic toxicity, and an effects range median concentration means concentrations greater than the effects range low, which could result in adverse effects.

In order to help establish a baseline data set, Trefry and Trocine (2009) collected samples at a total of 46 stations in the Beaufort Sea. These included surface and subsurface sediment samples as well as water samples. Samples were collected at 10 locations near the former Hammerhead exploratory well drilled in 1985 and 1986 in the Beaufort Sea, 19 random background stations collected north and south of the former Hammerhead drill site, 12 locations in the areas of the Sivulliq drill site and 5 locations along a possible pipeline corridor. Surface sediment samples were collected at all 46 locations and analyzed for total trace metals and polynuclear aromatic hydrocarbons. Additionally, 19 samples from 4 sediment cores were analyzed for total trace metals. Results indicate surface and subsurface sediment concentrations of aluminum, iron, cadmium, mercury, vanadium and zinc were at background values at all 10 locations near the former Hammerhead exploratory well, whereas maximum concentrations of silver (0.40 micrograms per gram (µg/g)), chromium (135 µg/g), copper (58.3 µg/g), lead (49.2 µg/g), and selenium (2.0 µg/g) were above background concentrations at one surface sediment Hammerhead station. Sediment concentrations for cadmium, mercury, zinc and silver were all below the minimum recommended sediment quality guidelines (effects range low).

Concentrations of barium were at background levels for 42 of the 46 stations. However, concentrations from four surface samples collected within ~100 meters of the former Hammerhead drill site, plus samples from sediment cores at two stations at the former drill site contained elevated barium concentrations. It was concluded that the barium enrichment was most likely due to the presence of barite from residual drilling mud and cuttings.

In 2008, a Chemical Characterization Program, a component of the Chukchi Sea Environmental Studies Program, sampled and analyzed baseline concentrations of metals and hydrocarbons in sediments and tissues at 34 stations at the Burger survey area and 31 stations at the Klondike survey area. Five of the stations in each survey area were at the historical drill sites. A total of 80 sediment samples were analyzed for hydrocarbons and metals while a total of 79 marine invertebrate samples also were analyzed for hydrocarbons and metals.

The study also found that all sediment concentrations of silver, aluminum, cadmium, chromium, iron, manganese, and zinc were at background values; however, concentrations of barium were elevated at three sampling sites at the historic drill sites at stations approximately 0.2 nautical miles (nmi) from the original discharge location (Battelle et al. 2010). The study noted slight elevations in concentrations of lead at two sites, and elevated concentrations of copper and mercury at one site at historic drill sites, which is consistent with the presence of residual barite. Metal concentrations at all sites were not present at concentrations higher than the effects range low derived by Long et al. (cited in Battelle et al. 2010).

In conclusion, the relatively high energy currents in both the federal waters of Chukchi and Beaufort Seas are expected to disperse trace metals that could be discharged during geotechnical surveys and related activities. In addition, studies of sediment metal concentrations in areas where previous exploration drilling activities occurred—which produce much higher discharge volumes when compared to geotechnical activities—show that metal concentrations are not persistent and decrease to levels below risk-based sediment guideline concentrations. Finally, hydrocarbons are not expected to be present as a result of geotechnical surveys or related activities. The maximum depth of boreholes drilled under the Geotechnical GP is 500 feet below the seafloor, which is well above the known depths of hydrocarbon-bearing zones.

6.1.5. Bioaccumulation

Heavy metals, such as mercury, cadmium, arsenic, chromium, and lead can bioaccumulate depending on their chemical speciation. Dissolved metals are more reactive and bioavailable than solid metals. Therefore, the kinetics of dissolution and precipitation of metals in waters of different hardness and salinity has a strong influence on the bioaccumulation and toxicity of the metals to aquatic plants and animals (Neff 2010). Existing data are not adequate to quantify the potential bioaccumulation from exposure to exploratory oil drilling operations. Available data suggest, however, that because the bioavailability of trace metals from barite is quite low, the bioaccumulation risks are also expected to be low (Crecelius et al. 2007; Neff 2008, 2010). Additionally, several field studies show that metals in water-based drilling fluids and drill cuttings are not bioavailable (i.e., the extent to which a chemical can be adsorbed by a living organism) because they are present almost exclusively as extremely insoluable materials (Neff 2010).

Studies conducted with cold-water amphipods evaluated their absorption of metals when exposure to water-based fluids for a period of 5 days. In that study, Neff removed one-half of the amphipods for analysis after 5 days of exposure, while the remaining half were placed in clean flowing seawater for 12 hours. All the exposed amphipods accumulated small amounts of copper and lead but not chromium, mercury, or zinc during exposure. The amphipods lost some of the accumulated copper and lead during 12 hours in clean seawater, suggesting that the accumulated metals are released rapidly due to lack of absorption beyond the external body surfaces (Neff 2010). That suggests that bioaccumulation of metals from water-based drilling fluids is low. Neff (2010) cites bioaccumulation studies conducted by Northern Technical Services (NTS) in 1981 using species present in the Beaufort Sea, which shows a small amount of accumulation of chromium and iron in fourhorn sculpin, and a small amount of iron in saffron cod that were exposed to mixtures of water-based fluids at concentrations of 4 to 17 percent.

Table 6-1 lists concentration of metals in Beaufort Sea amphipods before and after exposure to a 20% mixture of XC-polymer drilling fluids for five days and after return to clean seawater for 12 hours. Metals concentrations are mg/kg dry weight (ppm) (From NTS 1981 as cited by Neff 2010).

Table 6-1. Concentrations of metals in Beaufort Sea amphipods (in ppm)

Exposure	Chromium	Copper	Mercury	Lead	Zinc
Unexposed	2.7	5.1	0.07	11.0	123
5 Days	2.7 – 3.6	8.0 – 9.3	0.05 – 0.07	11.8 – 13.6	107 – 137
5 Days & 12 Hour Purge	3.0 – 3.2	6.9 – 7.1	0.04 – 0.05	10.2 – 12.3	110 – 114

Metals concentrations could occur in the Beaufort and Chukchi Seas during discharges of water-based drilling fluids (if used) to conduct geotechnical surveying activities, but discharge volumes would be limited in volume, the metals have low bioavailability to marine organisms. While a small fraction may be bioaccumulated by marine plants and animals and transferred through marine food webs, their concentrations are expected to decrease with each trophic step and the concentrations would not be expected to persist in the environment.

6.1.6. Control and Treatment

EPA utilized best professional judgment to incorporate technology-based effluent limitations required by the ELGs in 40 CFR Part 435, Subpart A, to the discharges of water-based drilling fluids and cuttings from geotechnical surveying activities. Those ELGs include an acute (96-hour) effluent toxicity limit of a 50 percent lethal concentrations (LC_{50}) of a minimum 30,000 ppm suspended particulate phase (SPP) on discharged drilling fluids. The 30,000 ppm SPP concentration (3 percent by volume) would be lethal to 50 percent of organisms exposed to that concentration. That limit is a technology-based control on the toxicity of drill cuttings and fluids. The 30,000 ppm SPP limitation is both technologically feasible and economically achievable, and it is the best available technology established nationally (USEPA 1993). Under the ELG, if SPP concentrations less than 30,000 ppm result in a LC_{50} response, then additives to drilling fluids would be substituted to ensure a less toxic discharge.

The Geotechnical GP establishes the ELG limits for mercury and cadmium concentrations (1 mg/kg and 3 mg/kg, respectively) in stock barite. EPA has determined that the limitation indirectly controls the levels of toxic pollutant metals because barite that meets the mercury and cadmium limits is also likely to have reduced concentrations other metals (USEPA 1993). Additional permit requirements include no discharge during bowhead hunting activities in the Beaufort and Chukchi Seas and no discharge if an oil sheen is detected. Finally, the Geotechnical GP also includes a requirement to conduct a post-activity environmental monitoring for boreholes that utilize water-based drilling fluids and where an EMP has not been completed pursuant to the Beaufort and Chukchi Exploration NPDES General Permits. For these reasons and based on the discussions above and the provisions included in the Final Permit, it is not expected that the Geotechnical GP would result in discharges of pollutants in quantities or composition that would bioaccumulate or persist in the marine environment.

6.2. CRITERION 2

The potential transport of such pollutants by biological, physical, or chemical processes.

6.2.1. Biological Transport

Biological transport processes include bioaccumulation in soft or hard tissues, biomagnification, ingestion and excretion in fecal pellets, and physical reworking to mix solids into the sediment (bioturbation). Biological transport processes occur when an organism performs an activity with one or more of the following results:

- An element or compound is removed from the water column
- A soluble element or compound is relocated within the water column
- An insoluble form of an element or compound is made available to the water column
- An insoluble or particulate form of an element or compound is relocated

The ODCE supporting the Arctic general permit (AKG280000) provides a detailed literature review of bioaccumulation, biomagnifications, and bioturbation (USEPA 2006) and updated in this ODCE. While little information is available to assess the biomagnification of drilling fluid discharges components, one study suggests that barium and chromium could biomagnify. In an in vitro experiment, the mean barium level in contaminated sea worms was 22 µg/g, whereas the controls contained 7.1 µg/g. Chromium levels were 1.02 µg/g in contaminated worms and 0.62 µg/g in controls. In both cases, concentrations in depurated worms were not significantly different from controls (Neff et al. 1984). Trace metals studies indicate a frequent linear correlation between sorption of lead, another metal found in drilling fluid discharges, by invertebrate and its concentration in sediments. However, biomagnification of lead is not likely (Snyder-Conn et al. 1990). Studies on biological transport show that depuration (removal of the organism from the contaminate source) can reduce concentrations of contaminants in tissue.

Bioturbation, the process of benthic organisms reworking sediment and mixing surface material into deeper sediment layers, is another mode of biological transport. Whereas sea worms and other benthic organisms have the ability to move material locally, gray whales and walrus move tremendous amounts of sediment in the Beaufort and Chukchi Seas. Nelson et al. (1994) analyzed feeding pits created by gray whales and furrows created by walruses. Combined, the two species are estimated to move more than 700 million tons per year of sediment according to current population estimates. The study acknowledges some limitations in the analysis, but it estimates that walruses disturb between 24 and 36 percent of the Chukchi seafloor annually (Nelson et al. 1994). No research was identified to quantify the extent of effects resulting from bioturbation of discharges associated with drilling discharges, particularly those from geotechnical surveys and related activities, although bioturbation is expected to dilute any effects of the solids component of the discharges.

6.2.2. Physical Transport

Physical transport processes include currents, mixing and diffusion in the water column, particle flocculation, and discharged material settling to the seafloor. Pacific Ocean currents dictate the direction of transport in the Arctic Ocean: generally moving northward from the Bering Sea through the Chukchi Sea (Weingartner and Okkonen 2001). Flow is divided along the near-shore, the Central Channel (between Herald and Hanna shoals), and the Herald Canyon (Woodgate et al. 2005). Spall (2007) estimates the residence time of water in the Chukchi Sea to be less than 1 year. Water temperature factors into the localized effects of mixing and diffusion. The effect of temperature changes associated with large-scale currents are beyond the scope of this evaluation. Localized diffusion and mixing of the discharges covered under the Geotechnical GP are driven by the depth of the receiving water, rate of discharge, speed of local currents, and depth of the outfall beneath the surface.

The depth, rate, and method of the individual discharges influence their physical transport in the environment. The majority of geotechnical surveys and related activities in the Chukchi and Beaufort Seas would occur in the open water season (i.e., July to October) and during the winter months when landfast or bottom-fast ice is present, particularly in the Beaufort Sea. The Geotechnical GP prohibits all discharges on the ice surface. The water-based drilling fluids and drill cuttings, and cuttings not associated with drilling fluids, would be deposited on the seafloor during open water periods.

EPA's depositional modeling calculated the depositional thickness of drilling fluids and drill cuttings (Discharge 001) at 1-meter, 10-meter, and 100-meter distances from the discharge location based on certain assumed discharge rates and current speeds (Table 6-2). Based on a discharge rate of 1,093 gal/day and current speeds ranging from 0.02 to 0.40 m/s, the depositional thickness ranges from 1.52 mm to 30.33 mm (0.06 to 1.19 inches) at a 1 meter (3.3 feet) distance from the discharge location. At 10 meters (32.8 feet) and 100 meters (328 feet) distances from the discharge location, and assuming the same discharge rate and ranges of current speeds, the thickness of drilling fluids and drill cuttings are 0.48–9.59 mm (0.02–0.38 inches) and 0.15–3.03 mm (0.006–0.38 inches), respectively.

Table 6-2. Deposition thickness for combined drilling fluids and cuttings discharges from geotechnical surveys

Case ID	Current Speed (m/s)	Discharge Rate (gal/day)	Discharge Rate (cm/s)	Thickness at 1 m (mm)	Thickness at 10 m (mm)	Thickness at 100 m (mm)
1	0.02	322	14.17 E-6	8.94	2.83	0.89
2	0.02	651	28.64 E-6	18.07	5.71	1.81
3	0.02	1093	48.08 E-6	30.33	9.59	3.03
4	0.10	322	14.17 E-6	1.79	0.57	0.18
5	0.10	651	28.64 E-6	3.61	1.14	0.36
6	0.10	1093	48.08 E-6	6.06	1.92	0.61
7	0.30	322	14.17 E-6	0.60	0.19	0.06
8	0.30	651	28.64 E-6	1.20	0.38	0.12
9	0.30	1093	48.08 E-6	2.02	0.64	0.20
10	0.40	322	14.17 E-6	0.45	0.14	0.04
11	0.40	651	28.64 E-6	0.90	0.29	0.09
12	0.40	1093	48.08 E-6	1.52	0.48	0.15

Resuspension or deposition processes tend to occur near the seafloor with some particles gradually being dispersed by currents and waves (Hurley and Ellis 2004 cited in MMS 2007). Regional and temporal variations in physical oceanographic processes that determine the degree of initial dilution and waste suspension, dispersion, and drift, have a large influence on the potential zone of influence of discharged materials.

Ice gouging occurs by sea ice grounding against the seafloor occurring highest in the stamukhi ice zone. The amount and effect of ice gouging activity in the Area of Coverage is not well documented; however, a study in the Beaufort Sea shows that ice gouging plays a greater role in the reworking of bottom sediments than depositional processes. The deepest water depth where ice gouging has been observed in the Canadian Beaufort Sea is 38 m. Ice gouge survey data in the Chukchi Sea are sparse (MMS 2008). Reimnitz et al. (1977) found that portions of a study area experienced a complete reworking of sediments to a depth of 20 centimeters (7.9 inches) over a 50-year period. Ice gouging is not expected to play a substantial role in the transport of sediments resulting from discharges authorized under the Geotechnical GP because of the relatively small volumes and the ocean depths and current speeds at the locations of the expected discharges would contribute to quick dispersion of the discharges.

6.2.3. Chemical Transport

Chemical processes related to the discharges are the dissolution of substances in seawater, complexing of compounds that might remove them from the water column, redox/ionic changes, and adsorption of dissolved pollutants on solids. Chemical transport of water-based drilling fluids is not well described in the literature. However, despite limitations in quantitative assessment, some studies of other related materials suggest broad findings that are relevant. Those studies show that chemical transport will most likely occur through oxidation/reduction reactions in native sediments, and in particular, changes in redox potentials will affect the speciation and physical distribution (i.e., sorption-desorption reactions) of water-based drilling fluid constituents.

6.2.3.1. Metals

Most research on chemical transport processes affecting offshore oil and gas discharges focuses on trace metal and hydrocarbon components. The water-based drilling fluids associated with geotechnical surveys include seawater, viscosifier, and barite. Bentonite clays are generally used to provide viscosity to suspend barite and cuttings, as well as for filtration control (Neff 2010). Barite is a weighting agent that contains several metal contaminants, including arsenic, cadmium, lead, mercury, and zinc. Those trace metals are discussed below as they pertain to chemical transport processes.

Trace metal concentrations are elevated in the Chukchi Sea compared to those in the eastern Arctic Ocean; it is thought that the naturally elevated concentrations are from Bering Sea water that passes through the Chukchi Sea (MMS 2008).

Barite solubility in the ocean is controlled by the sulfate solubility equilibrium. And in particular, the calculated saturation levels for barium sulfate in seawater range from concentrations of 40 to 60 micrograms per liter (µg/L) at temperatures from 34 to 75 °F (Houghton et al. 1981; Church and Wolgemuth 1972). Background sulfate concentrations in seawater are generally high enough for discharged barium sulfate to remain on the seafloor upon discharge.

Kramer et al. (1980) and MacDonald (1982) found that seawater solubilities for trace metals associated with powdered barite generally result in concentrations comparable to coastal ocean dissolved metal levels. Exceptions were lead and zinc sulfides, which could be released at levels sufficient to raise concentrations in excess of ambient seawater levels. MacDonald (1982) found that less than 5 percent of metals in the sulfide phase are released to seawater. Other trace metals are associated with the metal sulfides inclusions in the barite solids (Neff 2008). Neff (2008) estimates partitioning coefficients (the ratio of concentrations of a substance in two separate components of a mixture) for metals between barite and seawater, which suggest that cadmium and zinc were the most soluble metals in seawater; however, those metals were still relatively unavailable with the likelihood of the dissolved fraction being nearly 2.5

orders of magnitude more likely to be associated with barite solids than dissolved, therefore not available for chemical transport.

Dissolved metals tend to form insoluble complexes through adsorption on fine-grained suspended solids and organic matter, both of which are efficient scavengers of trace metals and other contaminants. Laboratory studies indicate that a majority of trace metals are associated with settleable solids smaller than 8 micrometers (Houghton et al. 1981).

Trace metals, adsorbed to clay and silt particles and settling to the bottom, are subject to different chemical conditions and processes than metals suspended in the water column. Adsorbed metals can be in a form available to bacteria and other organisms if at a clay lattice edge or at an adsorption site (Houghton et al. 1981). The water-based drilling fluids discharges from geotechnical surveying activities, when used, are expected to occur at small volumes, be short term in duration and conducted intermittently, and the majority of the trace metals are expected to adsorb to fine sediment particles and remain settled on the seafloor.

There is particular concern about mercury in Arctic marine food webs; however, there is no evidence that mercury concentrations in the Arctic is coming from onshore or offshore oil and gas operations (Neff 2010). Concentrations of total and methylmercury are high in liver and muscle tissues of several marine mammals collected off Barrow, AK, as summarized in Table 6-3. Fish and mammal-eating marine carnivores, such as polar bears, beluga whales, and some seals, contain high concentrations of total and methylmercury in liver tissue, with lower concentrations in muscles and other organs. Bowhead whales do not bioaccumulate high concentrations of mercury because they feed at a lower trophic level on large copepods and euphausiids, which contain low concentrations of methylmercury (Neff 2010).

Table 6-3. Concentrations of total mercury and methylmercury in muscle and liver of marine mammals collected off Barrow, Alaska. Concentrations are ng/g dry weight, converted from wet weight by multiplying by 5 (Dehn et al. 2005, 2006a,b, as cited by Neff 2010).

Species	Tissue	Total Mercury	Methylmercury
Polar Bear *Ursa maritimus*	Liver	7500 - 272,000	No data
Ringed Seal *Pussa hispida*	Muscle	50 - 53,000	50 - 1900
	Liver	300 - 82,500	50 - 2500
Beluga Whale *Delphinapterus leucus*	Muscle	650 - 61,500	650 - 12,000
	Liver	1400 - 362,000	950 - 19,400
Bowhead Whale *Balaena mysticetus*	Muscle	<5 - 50	No data
	Liver	5 - 3000	No data

6.2.3.2. Organics

Organic substances, such as oil and grease or petroleum hydrocarbons, are not expected to be present in the marine environment as a result of discharges from geotechnical surveys and related activities. The Geotechnical GP does not apply to geotechnical activities greater than 500 feet below the seafloor surface, which is well above the known hydrocarbon-bearing zones in the Beaufort and Chukchi Seas. The Geotechnical GP also requires waste streams known to have potentially oily wastes, such as deck drainage and bilge water to be treated with an oil-water separator prior to discharge. Discharges that have an oil sheen are prohibited. Effluent limits and monitoring requirements are also established for all discharges.

6.3. CRITERION 3

The composition and vulnerability of the biological communities that might be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.

6.3.1. Water Column Effects

The solid component of water-based drilling fluids and cuttings (001), cuttings not associated with drilling fluids (011), and cement slurry (012) are not expected to contribute significantly to turbidity in the water column as the discharges occur at the seafloor. Section 3.4 summarizes the estimated the area of seafloor that might be covered with drilling fluids and drill cuttings given different assumed rate of discharge and current speeds.

Miscellaneous discharges from stationary vessels conducting geotechnical surveys and related activities are not expected to cause effects within the water column as concentrations in the effluent are limited. For example, discharges of sanitary waste water must meet quality and technology-based effluent limits for fecal coliform bacteria, total residual chlorine, pH, total suspended solids, and biochemical oxygen demand. The requirements and limitations established in the Geotechnical GP ensure protection of the receiving water quality within the water column.

6.3.2. Benthic Habitat Effects

Solids in the discharges of water-based drilling fluids and cuttings (001), cuttings not associated with drilling fluids (011), and cement slurry (012) would accumulate on the seafloor near the activity locations (see Table 6-3). The extent of solids accumulation would vary depending on the diameter and depths of the geotechnical boreholes and on the nature and extent of the related activity. It is possible that benthic communities (algae, kelp, invertebrates) would be impacted near the immediate areas of discharge.

Drilling fluid (if used) and cuttings deposition will not result in significant discharges to the seafloor.

Table 6-4 summarizes the amount of water-based drilling fluids and drill cuttings discharged for each borehole, based on average size borehole diameters and three general depths of each borehole. The estimates include a conservative assumption that water-based drilling fluids would be used to collect all boreholes during the open water season.

Table 6-4. Summary of water-based drilling fluids and drill cuttings produced per borehole, by depth (AOGA 2013).

Drill Season	Borehole Diameter[2]	Cuttings and Drilling Fluids Discharged[1] per Borehole by Depth								
		Depth: 50 feet			Depth: 200 feet			Depth 500 feet		
		Cuttings	Drilling Fluids[3]	Total	Cuttings	Drilling Fluids	Total	Cuttings	Drilling Fluids	Total
Open Water	7 inches	11 ft^3	22 ft^3	33 ft^3	48 ft^3	89 ft^3	137 ft^3	124 ft^3	223 ft^3	347 ft^3
	8 inches	15 ft^3	22 ft^3	37 ft^3	64 ft^3	89 ft^3	154 ft^3	165 ft^3	223 ft^3	388 ft^3
	9 inches	20 ft^3	23 ft^3	43 ft^3	85 ft^3	89 ft^3	174 ft^3	213 ft^3	223 ft^3	437 ft^3
On-Ice	8 inches	15 ft^3	--[4]	15 ft^3	65 ft^3	--	65 ft^3	166 ft^3	--	166 ft^3

1 Conversion: 1 cubic foot (ft^3) = 7.480 U.S. gallons.

2 Borehole diameters range between 4 and 12 inches. This table reflects discharge volumes for an average size diameter borehole.

3 Drilling fluids are not expected to be used for boreholes drilled at 50 feet or less below the seafloor surface; however, the volumes are included here to provide estimates sufficient to cover all possible scenarios.

4 Water-based drilling fluids are not expected to be used for this activity.

Lethal and sub-lethal adverse effects on benthic organisms could potentially result from burial under the accumulated materials within a short distance from the individual geotechnical borehole. Due to the short duration of geotechnical borehole drilling and related activities (i.e., 1–3 days per borehole; 7–10 days per equipment testing event), the relatively small volumes of drilling fluids (if used) and cuttings generated when compared to exploration well drilling, the expected areas of deposition and thickness, and the distances between geotechnical and related activities, benthic habitat effects are likely to occur in a limited area and the extent and durations of effects are expected to be short-term.

6.3.3. Threatened and Endangered Species

Eight threatened and endangered species occur in the Area of Coverage: two avian species (spectacled eider, and Steller’s eider), three cetacean species (bowhead, fin, and humpback whales), two pinnipeds (bearded and ringed seals) and one carnivore (polar bear). The Pacific walrus is a candidate species. The potential effects on these species include behavioral changes resulting from noise, vessel activity, and potential limited exposure to contaminants. The BE developed in support of the permit addresses the potential impacts associated with geotechnical surveys and related activities. As discussed under Criterion 1, bioaccumulation within prey is not expected to be an exposure pathway to those species. On the basis of the transient use of the area by the species, the limited areal extent of the potential impacts, and the overall mobility of the species, impacts from geotechnical surveys and related activities will not cause unreasonable degradation of the marine environment.

6.4. CRITERION 4

The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

The Area of Coverage provides foraging habitat for a number of species including marine mammals and birds. Bowhead whale migrations occur through the southeastern portions of the area by following open water leads generally in the shear zone as they move from the Bering Sea to the Beaufort Sea in the spring. Participants in the traditional knowledge workshops in Barrow identified an important bowhead feeding habitat area in the Beaufort Sea area north of the barrier islands, Cooper Island, Nuwuk, Tulimanik Island and the area northeast of Barrow (SRB&A 2011). The importance of habitat for beluga feeding areas closer to shore and concentrated in Kugrua Bay, Smith Bay, the Big Colville River, and Elson Lagoon were noted as well as the importance of habitat and migratory paths in Simpson Cove, Camden Bay, Kaktovik Lagoon, Bernard Harbor, Griffin Point and Demarcation Bay for beluga, bowhead, orca, narwhal, and gray whales (SRB&A 2011). The spring migration of bowhead whales would generally be over before the discharges from geotechnical activities begin, the earliest of which would occur in July. Bowhead whales traverse back through the area in the fall at greater distances from shore with their path crossing through the active leases (see Figures 6-1 and 6-2). Fin whales feed throughout the Chukchi Sea during the summer months, although little is known about their migratory pathways.

The ice patterns are a major determinant of the distribution of marine mammals in the Area of Coverage. The importance of pack ice (which extends poleward), fast ice (which is attached to shore), and the flaw zone or leads, (between the pack and fast ice, also called the spring lead due to its seasonal characteristics) changes over the course of the year. Polar bear dens are found near fast ice and pack ice. Fast ice provides optimum habitat for ringed seal lair construction and supports the most productive pupping areas. While geotechnical surveying activities may occur during the winter months when landfast ice is present, the Geotechnical GP prohibits all discharges onto ice.

The Geotechnical GP prohibits all discharges within the 3-25 nautical mile corridor in the Chukchi Sea prior to July 1. As discussed above, the spring lead system occurs within the Area of Coverage, most prominently along the coast between Point Hope and Point Barrow. Each spring, beginning in March until June, bowhead whales use the spring leads to migrate from their winter grounds in the Bering Sea to their summer grounds in the Canadian Beaufort Sea. This period is also an important calving and feeding period. The spring lead system also provides important habitat for beluga whales and other marine mammals such as seals species, and coastal and marine birds. The seasonal restriction ensures that the discharges would not have the potential to interfere with the migration, feeding and calving activities or affect the habitat areas within the deferral area.

Macroalgae, including kelp beds are important habitats for various fish species within the Area of Coverage. Areas of concentrated macroalgal growth that have been identified include Skull Cliff and an area approximately 25 kilometers (13.5 nmi) southwest of Wainwright in water depths of 11 to 13 meters (36 to 43 feet).

Larger river systems and estuaries provide important spawning and rearing areas for anadromous fishes. Most marine species spawn in shallow coastal areas during the winter. Shallow coastal areas, barrier islands, and offshore shoals provide rich benthic feeding habitat for whales, seals, walruses and other species, as well as marine birds and waterfowl. Shallow coastal areas and barrier islands are located outside the Area of Coverage for the Geotechnical GP.

Designated critical habitat (molting areas) for spectacled eider in the Area of Coverage includes Ledyard Bay within 40 nmi from shore (see Figure 6-3). The region surrounding Barrow has been identified as being important to the survival and recovery of the Alaska-breeding population for Steller's eiders; however, that area is not designated as critical habitat. Seasonal bowhead whale migration routes also occur within the Area of Coverage. On January 10, 2013, the U.S. District Court for the District of Alaska issued an order vacating and remanding to the USFWS the December 7, 2010 Final Rule designating critical habitat for the polar bear. Therefore, at this time, there is no critical habitat designated for the polar bear (http://www.fws.gov/alaska/fisheries/mmm/polarbear/esa.htm).

EPA's inclusion of the Chukchi Sea spring lead system seasonal restriction ensures protection for this important environment and the many ecological services it provides during the critical spring migration period. With regard to Criterion 4, by not authorizing any discharges within the 3-25 nautical mile deferral corridor in the Chukchi Sea prior to July 1, EPA ensures that the potential for unreasonable degradation of biological communities, migratory pathways, and sensitive habitat areas is avoided. See also Section 6.1. of the ODCE.

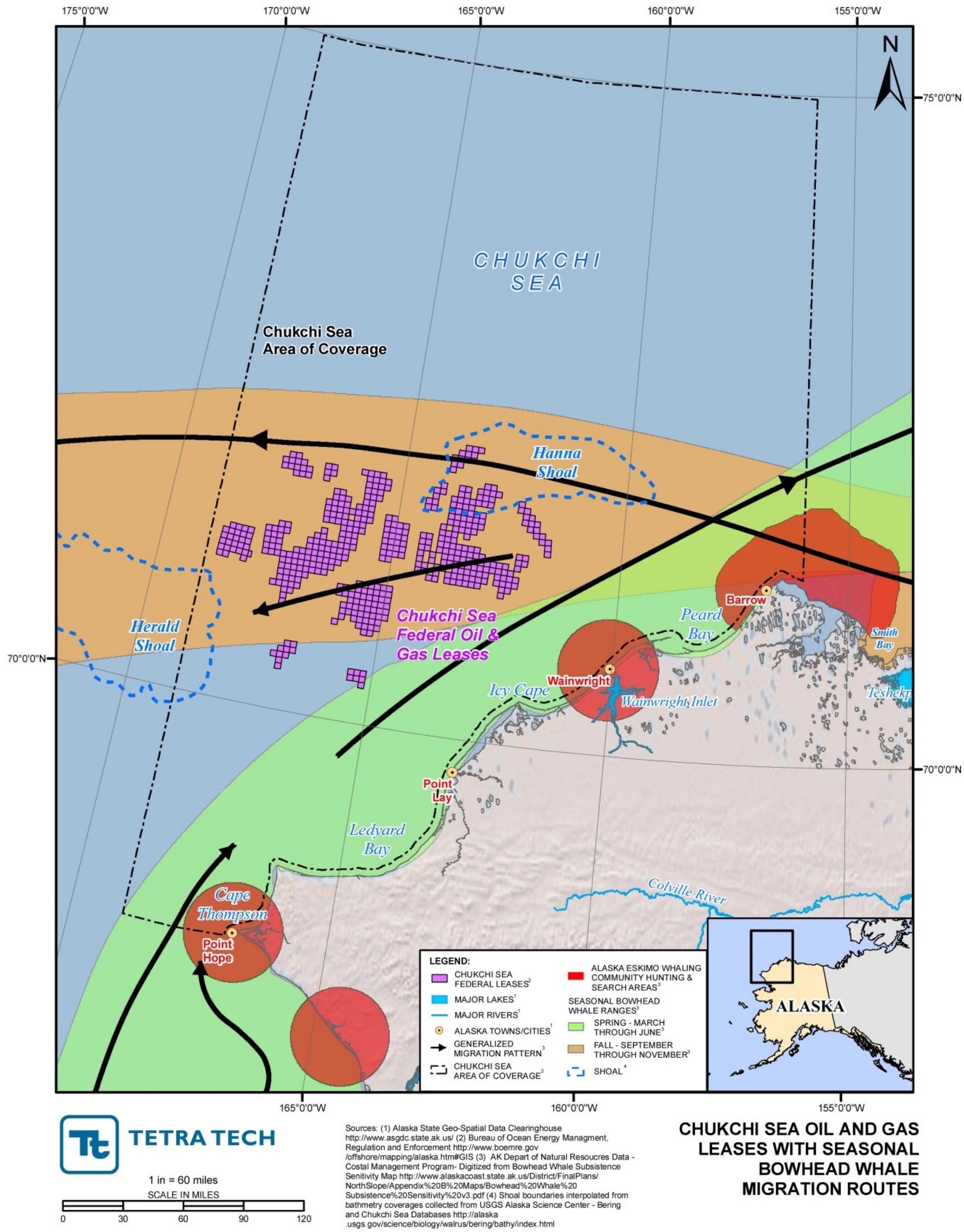

Figure 6-1. Seasonal bowhead whale migration routes in the Chukchi Sea.

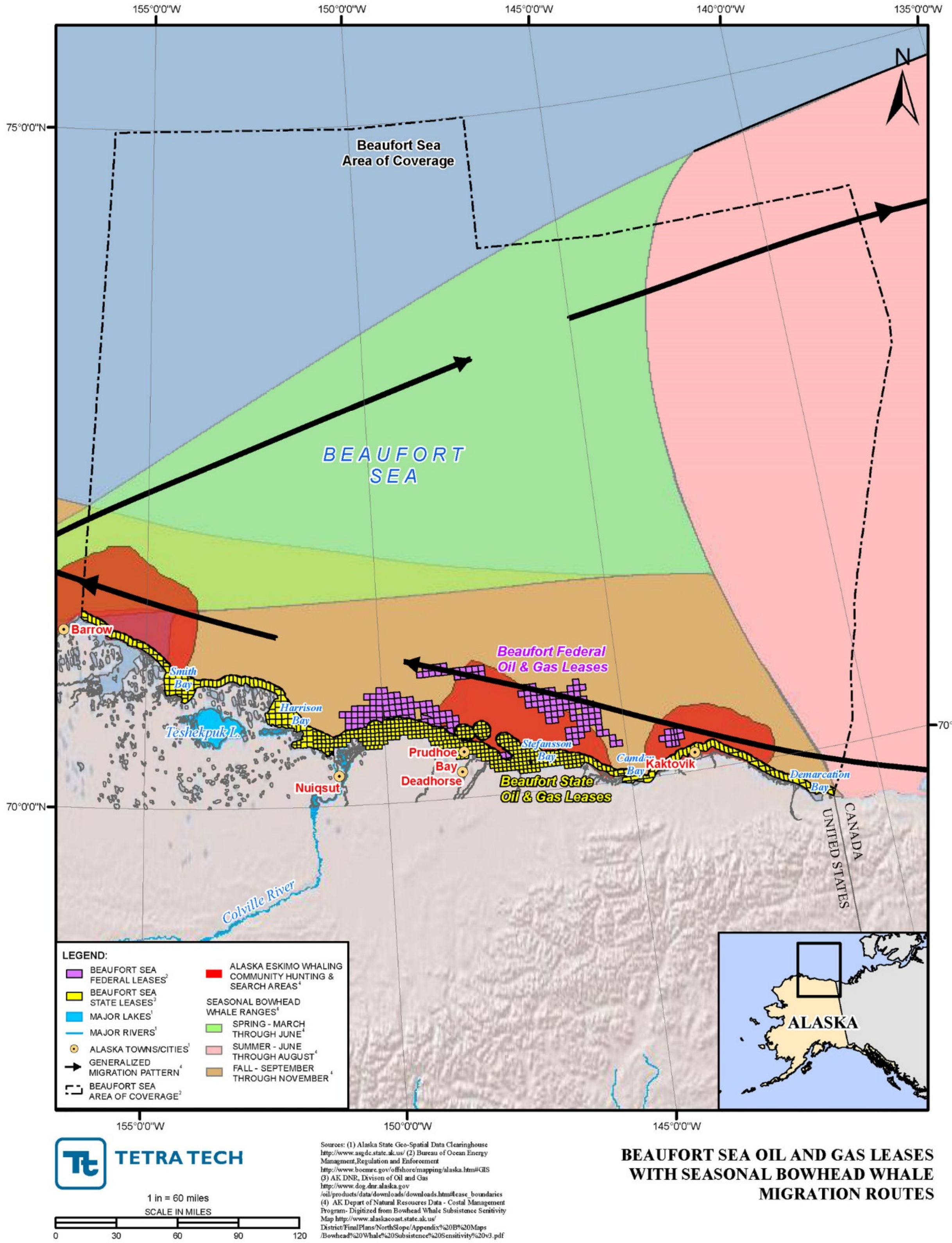

Figure 6-2. Seasonal bowhead whale migration routes in the Beaufort Sea.

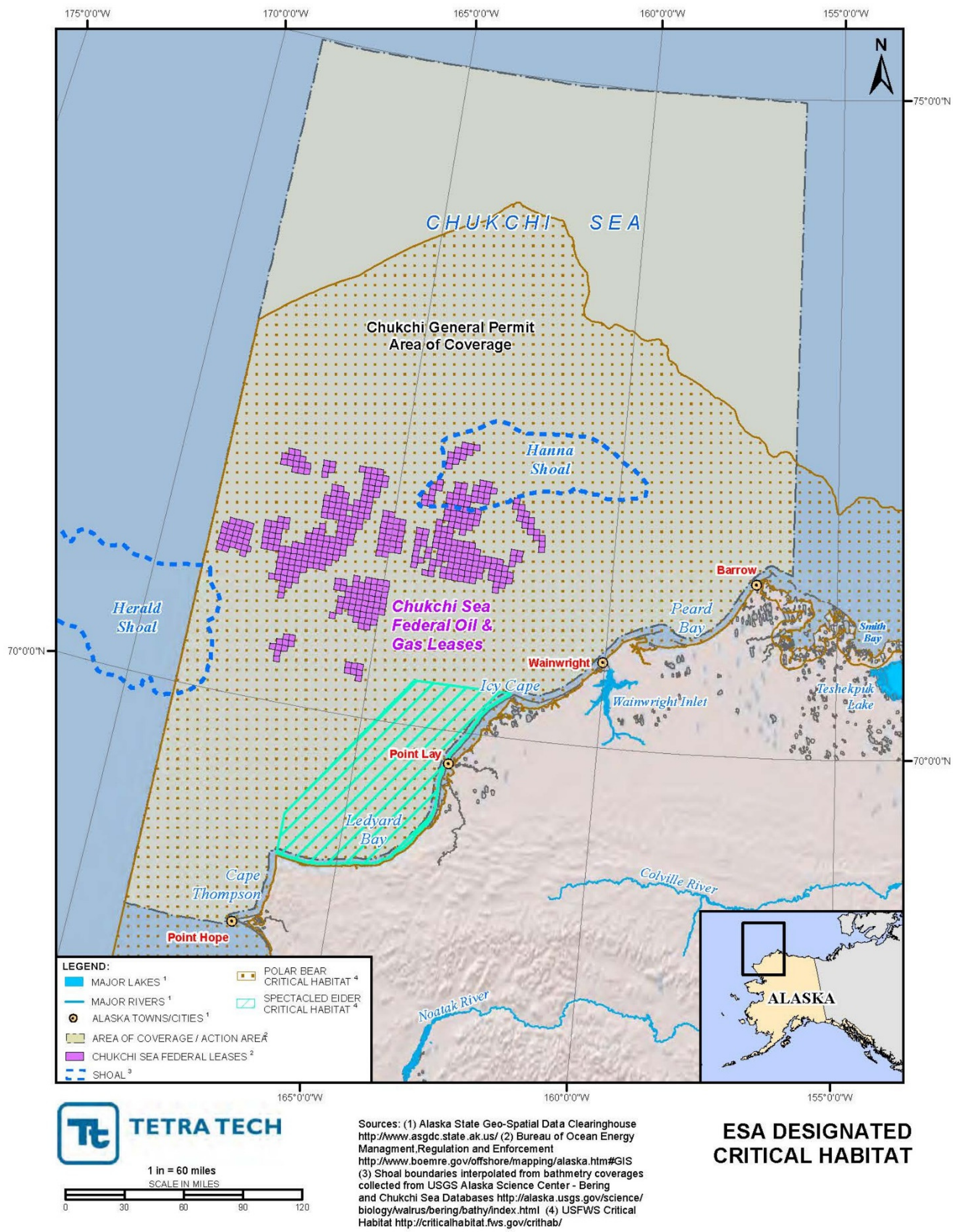

Figure 6-3. Designated critical habitat areas in the Chukchi Sea.

6.5. CRITERION 5

The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.

No marine sanctuaries or other special aquatic sites, as defined by 40 CFR 125.122, are in or adjacent to the Geotechnical GP Area of Coverage. The nearest special aquatic site—the Alaska Maritime National Wildlife Refuge (Chukchi Unit)—is approximately 60 miles to the southeast of the Chukchi Sea. The refuge provides habitat to a number of arctic seabird species and encompasses shoreline areas from south of Cape Thompson (located approximately 26 miles to the southeast of Point Hope) to Cape Lisburne. No other marine sanctuaries or other special aquatic sites are in or adjacent to the Area of Coverage. Based on the analysis of Criteria 1, 2, and 3, the Alaska Maritime National Wildlife Refuge would not be affected by authorized discharges.

The NHPA requires federal agencies to ensure that any agency-funded and permitted actions do not adversely affect historic properties that are included in the National Register of Historic Places or that meet the criteria for the National Register. The Geotechnical GP requires a baseline site characterization at each location or submission of existing, representative baseline data. Information gathered from the baseline site characterization or existing data will assist EPA with compliance with Section 106 of the NHPA and ensure potential historic properties are not affected by the permit.

6.6. CRITERION 6

The potential impacts on human health through direct and indirect pathways.

Human health within the North Slope and Northwest Arctic Boroughs is directly related to the subsistence lifestyle practiced by the residents of the villages along the Chukchi and Beaufort Sea coasts. In addition to providing a food source, subsistence activities support important cultural and social connections. While a wide variety of species are harvested, marine mammals compose an essential part of the diet providing micronutrients, omega-3 fatty acids, and anti-inflammatory substances (MMS 2008). A number of studies have documented the increase in adverse health effects with the reduction in subsistence foods and subsequent increases in store-bought food (MMS 2008).

Exposure to contaminants through consumption of subsistence foods and through other environmental pathways is a well-documented concern. Concern has also been expressed over animals swimming through plumes containing drilling fluids, cuttings, and other effluent (SRB&A 2011). Concerns have also been voiced about krill and other small species taking up drilling fluids and then passing contaminants up the food chain (SRB&A 2011).

O'Hara et al. (2006) reported on the essential and non-essential trace element status of eight bowhead whale tissue samples that were collected during 2002–2003. This study focused on comparing whale tissue metal concentrations to published national and international food consumption guidelines. Using these guidelines, calculations of percent (%) Recommended Daily Allowance of essential elements in 100 g portion of bowhead tissues were provided. Results were also compared to element concentrations from store purchased food.

Three non-essential metals important for toxicological assessment in the arctic food chain include cadmium (Cd), mercury (Hg), and lead (Pb). For most arctic residents Hg is a major concern in fish and seals. However, Hg concentrations in bowheads are relatively small compared to other marine mammals, and are below levels used by regulatory agencies for marketed animal products. Compared to other species of northern Alaska, bowhead whale tissue samples from this study had similar or lower concentrations of Hg. Liver and kidney are rich in essential and non-essential elements and have the greatest concentration of Cd among the tissues studied, while Hg, Pb, and arsenic (As) are relatively low. The kidney of the bowhead whale is consumed in very limited amounts (limited tissue mass compared to muscle and *maktak);* and liver is consumed rarely.

The study concluded that, as expected, most of the tissues from bowhead whales used as foods are rich in many elements, with the exception of blubber. While a broad range of Cd was found in kidney and liver samples, data is lacking with respect to bioavailability of Cd and the effects of food preparation techniques on Cd concentrations. Lastly, the bowhead tissues studied had element concentrations similar to those found in store-bought meat products.

Species of interest from a subsistence standpoint are expected to spend minimal amounts of time, if any, in the plume for miscellaneous discharges because of its rapid dilution (see Section 3.4.3). Additionally, since the discharges of water-based drilling fluids and drill cuttings will occur at the seafloor, only localized and short-term physical effects to benthic communities are expected. The Geotechnical GP also prohibits the discharge of drilling fluids and drill cuttings during spring and fall bowhead whale hunting activities and requires baseline site characterization at each location or submission of existing, representative baseline data, and post-activity environmental monitoring for activities that utilize drilling fluids. Based on the preceding discussions, the discharges under the Geotechnical GP are unlikely to create pathways that could result in direct or indirect human health impacts.

6.7. CRITERION 7

Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

The Arctic Management Area, as it pertains to fisheries management, covers the Beaufort and Chukchi Seas from the Bering Strait north and east to the Canadian border (NPFMC 2009). The Northwest Pacific Fishery Management Council developed a fisheries management plan (FMP) for fish resources in the Arctic Management Area in 2009. The FMP governs all commercial fishing including finfish, shellfish, and other marine resources with the exception of Pacific salmon and Pacific halibut (NPFMC 2009). The policy prohibits commercial fishing in the area until sufficient information is available to enable a sustainable commercial fishery to proceed (74 FR 56734). The FMPs applicable to salmon and Pacific halibut fisheries likewise prohibit the harvest of those species within the Arctic Management Area. Amendment 29 of the Bering Sea/Aleutian Islands King and Tanner Crabs FMP prohibits the harvest of crabs in the area as well (74 FR 56734). Because commercial fishing is not permitted in the area, that aspect of Criterion 7 would not be affected by the discharges authorized under the permit.

The Magnuson-Stevens Fishery Conservation and Management Act (January 21, 1999) requires EPA to consult with the NMFS when a proposed discharge has the potential to adversely affect (reduce quality or quantity or both of) EFH. EPA has determined, based on the EFH assessment, that the discharges will not adversely affect EFH.

Subsistence fishing, defined as, "noncommercial, long-term, customary and traditional use necessary to maintain the life of the taker or those who depend upon the taker to provide them with such subsistence," is not affected by the FMP (50CFR216). The most recent subsistence data (ADF&G Subsistence Community Profile Database) for North Slope Borough communities indicate that subsistence fishing occurred in the past (and might be ongoing) with the harvest of salmon species, flounder, cod, and smelt. Considering that the discharges would meet federal water quality along with the findings presented for Criteria 1 through 4, EPA does not anticipate significant adverse direct or indirect effects resulting from the authorized discharges on subsistence fishing.

6.8. CRITERION 8

Any applicable requirements of an approved Coastal Zone Management Plan.

The Alaska Coastal Management Program expired on June 30, 2011. As of July 1, 2011, there is no longer a CZMA program in Alaska. Because a federally approved CZMA program must be administered by a state, the National Oceanic and Atmospheric Administration withdrew the Alaska Coastal Management Program from the National Coastal Management Program. See 76 FR 39,857 (July 7, 2011). As a result, the CZMA consistency provisions at 16 U.S.C. 1456(c)(3) and 15 CFR Part 930 no longer apply in Alaska. Accordingly, federal agencies are no longer required to provide Alaska with CZMA consistency determinations.

6.9. CRITERION 9

Such other factors relating to the effects of the discharge as may be appropriate.

6.9.1. Environmental Justice

EPA has determined that the discharges authorized by the Geotechnical GP will not have a disproportionately high or adverse human health or environmental effects on minority or low-income populations living on the North Slope, Northwest Arctic, and Bering Sea. In making that determination, EPA considered the potential effects of the discharges on the communities, including subsistence areas, and the marine environment. EPA's determination is based on the Environmental Justice analysis for the Beaufort and Chukchi Exploration NPDES General Permits (October 2012) while taken into consideration the much smaller scale of geotechnical activities. EPA's evaluation and determinations are discussed in more detail in the EJ Analysis for the Beaufort and Chukchi Exploration NPDES General Permits. Since the EJ Analysis evaluated and considered the potential impacts to the same communities from similar discharges, EPA believes the EJ Analysis is also relevant for the Geotechnical GP. Consistent with the EJ Analysis, EPA has concluded that if the Geotechnical GP is protective of Inupiaq subsistence resources, then it is protective of all residents on the North Slope, Northwest Arctic, and Bering Sea communities as they rely on the same marine resources.

Executive Order 12898 titled, *Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations states,* in part, that "each Federal agency shall make achieving environmental justices 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 . . . ." The order also provides that federal agencies are required to implement the order consistent with and to the extent permitted by existing law. In addition, EPA Region 10 adopted its *North Slope Communications Protocol: Communications Guidelines to Support Meaningful Involvement of the North Slope Communities in EPA Decision-Making* in May 2009. Consistent with the order and agency policies, EPA has taken efforts to provide tribal entities and North Slope, Northwest Arctic, and Bering Sea communities with information about the Geotechnical GP development process, and to simultaneously seek early input into the EPA evaluations.

The Geotechnical GP implements existing water pollution prevention and control requirements to ensure compliance with CWA requirements, including preventing unreasonable degradation of the marine environment. As discussed in this ODCE, EPA evaluated the potential for significant adverse changes in ecosystem diversity, productivity, and stability of the biological communities within the Area of Coverage.

This ODCE evaluates the potential for bioaccumulation, pollutant transport, and significant adverse changes in ecosystem diversity, productivity and stability of biological communities in the Area of Coverage. The ODCE also evaluates environmentally significant or sensitive areas that are necessary for critical stages of marine organisms, the roles of these areas in the larger biological community and the vulnerability of these areas to potential discharges. The ODCE further evaluates the potential for loss of esthetic, recreational, scientific and economic values, and impacts to recreational and commercial fishing. Each of these criteria relate directly to concerns raised regarding availability of subsistence resources, potential bioaccumulation and food tainting, human health, and overall species impacts. Overall, based on the analysis in the ODCE, the geotechnical surveying discharges authorized will not result in adverse impacts under each of these criteria, as defined by the CWA.

The ODCE also evaluates the threat to human health through the direct physical exposure to discharged pollutants and indirect threats through consumption of aquatic organisms exposed to pollutants discharged under the Geotechnical GP. Human health is directly related to the subsistence practices of native communities. Subsistence areas and related subsistence activities provide food and support cultural and social connections. EPA considered the information obtained from residents and participants in the Traditional Knowledge workshops (conducted during development of the Beaufort and Chukchi Exploration NPDES General Permits) related to these important factors. These factors were a part of the overall evaluation framework of this ODCE and the Geotechnical GP development processes. Based on the input received, EPA included provisions, requirements, and restrictions in the Geotechnical GP to ensure impacts would not occur through direct or indirect pathways. Additionally, under the CWA, EPA has the authority to make modifications or revoke permit coverage if it identifies a basis to conclude that discharges will cause an unreasonable degradation of the marine environment.

The following are the permit terms and conditions that address the issues and concerns resulting from the EPA's community outreach efforts, and have also been incorporated into the Geotechnical GP:

1. Prohibit all discharges (Discharges 001–012) within the 3-25 nautical mile corridor in the Chukchi Sea prior to July 1. This seasonal restriction is unique to the Geotechnical GP because, unlike the Beaufort and Chukchi Exploration General Permits, the Area of Coverage for geotechnical surveys and related activities includes the lease sale deferral area in the Chukchi Sea.

2. Prohibit the discharges of water-based drilling fluids and drill cuttings (Discharge 001) to federal waters of the Chukchi Sea during the spring bowhead hunting activities, starting on March 25. The spring bowhead whale hunting restriction is unique to the Geotechnical GP because the area of coverage includes the 3-25 nautical mile lease sale deferral area in the Chukchi Sea, in which bowhead whale hunting activities occur.

3. Prohibit the discharges of water-based drilling fluids and drill cuttings (Discharge 001) to federal waters of the Beaufort Sea during the fall bowhead hunting activities, starting August 25. Under prohibitions 2 and 3, discharges may not be resumed until bowhead whale hunting has been completed by the respective villages.

4. Include chemical additive inventory and reporting requirements, with reporting and limits on chemical additive concentrations.

5. Incorporate environmental monitoring requirements that include collection of baseline site characterization data for each location, or submission of existing, representative baseline data for all geotechnical surveys and related activities locations, and post-activity monitoring when water-based drilling fluids are used.

6. Require effluent toxicity characterization of the following waste streams if chemicals are added to the system: deck drainage (Discharge 002), desalination unit wastes (Discharge 005), bilge water (Discharge 006), boiler blowdown (Discharge 007), fire control system test water (Discharge 008), and non-contact cooling water (Discharge 009).

7. Prohibit the discharge of all waste streams (Discharges 001–012) to stable ice. Concerns raised through Traditional Knowledge workshops include potential direct contact by marine mammals, birds, and possibly humans regarding discharges to the ice surface. Several workshops participants expressed concerns that on-ice discharges would have an adverse effect on seals since they are present year round.

Additionally, the Geotechnical GP includes a provision to monitor for potential deflection of marine mammals during periods of discharge of non-contact cooling water. Non-contact cooling water is anticipated to be the largest-volume discharge under the Geotechnical GP and could cause avoidance behavior in marine mammals because of temperature increases in the vicinity of the discharge. Any observations of potential marine mammal deflection during discharge of non-contact cooling water must be reported in the following month's Discharge Monitoring Report. The intent of this provision is to gather information to inform future decisions regarding potential deflection of bowhead whales that may result from of non-contact cooling water discharge.

In summary, EPA carefully considered the potential environmental justice impacts related to the Geotechnical GP's authorized discharges, especially the potential for disproportionate effects on communities and residents that engage in subsistence activities. Based on EPA's analysis and the permit conditions described above, EPA has determined that the discharges authorized by the Geotechnical GP will not cause unreasonable degradation of the marine environment, as defined by the CWA. For similar reasons, EPA concludes that that there will be no disproportionately high and adverse human health or environmental effects on minority or low-income populations residing on the North Slope, Northwest Arctic, and Bering Sea communities.

6.9.2. Combined Effects with Exploration Discharges

The discharges proposed to be authorized under the Geotechnical GP are similar to the discharges from exploration activities, but at lower volumes. Since discharges from geotechnical surveys and related activities may occur within the same geographic areas as exploration well drilling, this ODCE evaluates the potential effects from the combined discharges to ensure unreasonable degradation does not occur. Table 6-5 compares anticipated discharge volumes from geotechnical surveying activities with discharge volumes evaluated for the Chukchi Exploration NPDES General Permit (AKG-28-8100). The discharge volumes for geotechnical surveying activities are presented as per shallow and deep borehole, as well as estimated activity level of 100 boreholes per year in federal waters. The discharge rates are based on maximum pumping capacity of the units associated with each waste stream; actual discharges are expected to be at lower volumes. The estimated cuttings discharges from geotechnical related activities are captured in Discharge 011.

Table 6-5. Estimated discharge volumes of waste streams associated with geotechnical surveys per borehole and per year compared with discharges associated with a single exploration well in the Chukchi Sea.

Discharge	Estimated Discharge Volume[1] per Shallow Borehole	Estimated Discharge Volume[2] per Deep Borehole	Estimated Discharge Volumes per Year[3]	Estimated Discharge Volumes[5] per Exploration Well[6] in the Chukchi Sea
		U.S. Liquid Gallons (gal)		gal/Well
Water-based drilling fluids and drill cuttings (001)[7]	7,000[8]	21,000[8]	1,232,000[8]	741,378[9]
Deck drainage (002)	2,000	6,000	352,000	61,740
Sanitary wastes (003)	2,473	7,418	435,186	67,199
Domestic wastes (004)	21,000	63,000	3,696,000	700,009
Desalination unit wastes (005)	109,631	328,892	19,294,977	846,713
Bilge water (006)	3,170	9,510	557,927	42,000
Boiler blowdown (007)	N/A	--	--	16,380
Fire control system test water (008)	2,000	6,000	352,000	6,594
Non-contact cooling water (009)	2,726,234	8,178,703	479,817,254	197,398,473
Uncontaminated ballast water (010)	504	1,512	88,704	4,829,963
Drill cuttings not associated with drilling fluids (011)[10]	N/A[11]	--	--	--
Cement slurry (012)	1	3	114	42,000

[1] Source: Shell's NPDES Permit Application Form 2C (April 3, 2013) and L. Davis (personal communication, August 7, 2013).
[2] Source: AOGA Geotechnical Activities Information Paper (5/14/2013 and Revised 9/17/2013)
[3] Shallow boreholes: Depth ≤ 50 feet
[4] Deep boreholes: Depth > 50 and ≤ 500 feet
[5] Source: ODCE for the Chukchi Exploration General Permit (AKG-28-8100, USEPA 2012b)
[6] Two to three exploration wells could potentially be completed in one open water drilling season with one well completed between 30 and 45 days.
[7] Discharged at the seafloor and may include mud pit cleanup materials. As a conservative estimate, EPA assumes all 100 boreholes would utilize water-based drilling fluids, which would result in approximately 4,800 gallons of mud pit materials discharged per year.
[8] Conservative estimates that include entrained seawater and do not account for boring sample removal.

[9] For purposes of comparison, this volume represents Discharge 001 (water based drilling fluids and drill cuttings) and Discharge 013 (muds, cuttings and cement at the seafloor) under the Chukchi Exploration NPDES General Permit (AKG-28-8100).

[10] Discharge 011 includes the cuttings materials generated from geotechnical related activities. For purposes of the ODCE, EPA assumes one equipment feasibility testing activity would result in a seafloor disturbance of approximately half of a typical mudline cellar dimension, generating a total of approximately 235,000 gallons of cuttings materials would be discharged during the 5-year permit term.

[11] Discharge 011 may also include cuttings from shallow boreholes. While the majority of shallow boreholes may not use water-based drilling fluids, to provide a conservative estimate, EPA assumes drilling fluids would be used and the volumes are captured above under Discharge 001.

While exploration activities occur within active lease locations, geotechnical surveys and related activities may occur within the lease locations as well as areas between the leases and shore. While it is possible that an exploration well and geotechnical surveys and related activities could occur within the same lease area (each lease block is the size of 3 square miles), it is unlikely that they would occur at the same time. For example, geotechnical surveying would occur at certain lease locations to evaluate the stability of the subsurface for potential placement of a jack up rig prior to the actual exploration activity. Similarly, the feasibility testing of mudline cellar equipment (i.e., geotechnical related activities) would be conducted prior to the technology being used for construction of a mudline cellar at that location in support of exploration activities.

Also, as discussed in Section 2.1, the spacing of the geotechnical survey boreholes will vary, with some as close as 10 to 15 feet apart to others as far as 32,800 feet apart, depending on the specific goals of the geotechnical activity (i.e. jack up rig spud can or pipeline). Approximately 10 geotechnical borings could be conducted in federal waters of the Chukchi Sea within the area deferred from leasing by BOEM 3 to 25 nautical miles from the shoreline. Discharges from geotechnical surveys within the deferral area (only authorized after July 1) would not cause a “combined effect” as there are no active leases in this area. The federal waters lease deferral boreholes are expected to be shallow (< 50 feet) borings to investigate the physical properties of the sediments along potential pipeline routes (AOGA 2013). The spacing of geotechnical related activities is not expected to cause an overlap in deposition as the scope of those activities are limited (i.e., two events per sea per year), resulting in a relatively small volume of discharges.

EPA modeled discharge scenarios from exploration activities in both the Beaufort and Chukchi Seas to support the Exploration NPDES General Permits (Hamrick 2012). Using the Chukchi Sea as an example, the expected discharge scenarios from exploration drilling are assumed as follows:

- Exploration activities would be conducted at water depths of 40–50 meters (131–164 feet);
- Discharges would occur near the surface;
- Current speeds are assumed at 0.05 meters per second (m/s) to 0.3 m/s where discharges are likely to occur.

For the 51 model scenarios modeled by EPA at the acceptable water depth (deeper than 5 meters), 8 scenarios fall within those conditions. The model results for those scenarios indicate maximum deposition thicknesses ranging from 0.008 to 0.024 centimeters (0.003 to 0.009 inches) along the current direction. Those scenarios, however, include total discharges of drilling fluids and drill cuttings ranging from 750 to 1,000 barrels (bbl). Scaling the results upward to reflect total discharges of up to 5,000 bbl, the maximum deposition thicknesses would range from 0.03 to 0.13 centimeters (0.01 to 0.05 inches). For all scenarios, the maximum predicted deposit was approximately 2 centimeters (0.8 inches), and the median for all scenarios was a deposit of approximately 0.2 centimeters (0.07 inches). Under most conditions, the majority of the solids are deposited within 1,000 meters (3,280 feet) of the discharge (Hamrick 2012). Even though geotechnical surveys and related activities are not expected to occur within the same general area as exploration drilling, in most cases, it is not expected that the discharges would cause a depositional overlap.

Additionally, miscellaneous discharges will also occur from geotechnical vessels that are similar to those from exploration facilities. Those discharges must meet the effluent limits established by EPA in compliance with technology-based and state and federal water quality standards (see Section 6.10, below).

The effects from discharges from geotechnical surveys and related activities combined with discharges from exploration drilling are not expected to result in unreasonable degradation of the marine environment for the reasons discussed in Criteria 1 through 8, as well as the following:

- The timing of geotechnical surveys and related activities likely will not coincide with exploration well drilling within the same general area.
- The anticipated areal extent and depositional thicknesses of the drilling fluids and drill cuttings materials from both activities will not cause long-term effect by the receiving biological and physical marine environment.
- The effluent limitations, restrictions, and monitoring requirements established by the Geotechnical and Beaufort and Chukchi Exploration NPDES General Permits ensure protection of the marine environment (see discussion under Criterion 10, below).

6.10. CRITERION 10

Marine water quality criteria developed pursuant to CWA section 304(a)(1)

Parameters of concern for effects on water quality in discharges from geotechnical surveys and related activities, include metals, oil and grease, chlorine, and TSS. EPA has promulgated recommended marine criteria (objectives) pursuant to CWA section 304(a)(1). Current criteria are summarized in tabular form at http://water.epa.gov/scitech/swguidance/waterquality/standards/current/index.cfm and summarized in Table 6-6 below.

This ODCE evaluates discharges to the Chukchi and Beaufort Seas authorized under the Geotechnical GP in reference to those criteria. The following discussion addresses each parameter and notes the clarifications EPA has made to the Geotechnical GP.

Table 6-6. Marine water quality criteria developed pursuant to CWA section 304(a)(1).

Pollutant[1]	Saltwater Aquatic Life CMC[2] (Acute) µg/L	Saltwater Aquatic Life CCC[3] (Chronic) µg/L	Human Health Consumption (Organisms Only) µg/L
Cadmium[5]	40	8.8	--[4]
Chlorine	13	7.5	--
Mercury[5]	1.8	0.94	--
Methylmercury[5]	1.8	0.94	0.3
Oil and Grease	Narrative[6]		--
pH	--	6.5 – 8.5	--

TSS	Narrative[7]	--
Temperature	Species Dependent[8]	--

[1] Source: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

[2] Criterion maximum concentration

[3] Criterion continuous concentration

[4] EPA has not calculated criteria for contaminants with blanks

[5] A priority pollutant, defined by EPA as a set of regulated pollutants for which the agency has developed analytical test methods. The current list of 126 priority pollutants can be found in Appendix A to 40 CFR Part 423.

[6] For aquatic life: (a) 0.01 of the lowest continuous flow 96-hour LC50 to several important freshwater and marine species, each having demonstrated high susceptibility to oils and petrochemicals; (b) levels of oils or petrochemicals in the sediment which cause deleterious effects to the biota; (3) surface waters shall be virtually free from floating nonpetroleum oils of vegetable or animal origin, as well as petroleum-derived oils (USEPA 1986).

[7] The depth of light penetration not be reduced by more than 10 percent (USEPA 1986).

[8] (a) The maximum acceptable increase in the weekly average temperature resulting from artificial sources is 1°C (1.8°F) during all seasons of the year, providing the summer maxima are not exceeded; and (b) daily temperature cycles characteristic of the water body segment should not be altered in either amplitude or frequency (USEPA 1986).

6.10.1. Oil and Grease

For oil and grease, the permit contains requirements that prohibit the discharges if oil is detected through a static sheen test and/or visual observation. Furthermore, the permit requires treatment of certain discharges, such as deck drainage, bilge, and ballast water, treated through an oil-water separator before discharge. Therefore, the water quality criterion for oil and grease is expected to be met. This requirement remains unchanged.

6.10.2. pH

The permit requires pH monitoring for Discharges 001, 002, 004, 005, 006, 007, 008, and 010 as well as limiting pH to 6.5–8.5 for the discharges of sanitary wastes (Discharge 003) and non-contact cooling water (Discharge 009) if chemicals are added to the system. EPA has provided clarification that pH testing for Discharge 001 must occur once per season; however, a new test is required if a new drilling fluid formulation is used during the season to conduct geotechnical activities. This clarification is not expected to affect the quality of the receiving water or applicable water quality criteria.

6.10.3. Metals

The source of metals in drilling fluids is barite; therefore, a concern for effects on water quality in discharges of the drilling fluids and drill cuttings. To control the concentration of heavy metals, EPA promulgated limitations for cadmium and mercury in stock barite. These limitations are applied on the discharges of drilling fluids and drill cuttings. Metals concentrations in discharges including drilling fluids and drill cuttings are therefore expected to also meet water quality criteria. EPA has provided clarification that stock barite testing for Discharge 001 must occur once per season; however, a new test is required if a new lot or supply of barite is used during the season to conduct geotechnical activities. This clarification is not expected to affect the quality of the receiving water or applicable water quality criteria. Table 6-7 summarizes the federal water quality criteria for metals.

Table 6-7. Federal water quality criteria for metals.

Pollutant	Marine (Aquatic Life) Acute Criteria (µg/L)	Marine (Aquatic Life) Chronic Criteria (µg/L)	Human Health Criteria (Consumption of Organisms) Acute Criteria (µg/L)
Arsenic	69	36	0.14
Cadmium	40	8.8	NA
Chromium (VI)	1,100	50	NA
Copper	4.8	3.1	NA
Lead	210	8.1	NA
Mercury Methylmercury	1.8	0.94	0.3
Nickel	74	8.2	4,600
Zinc	90	81	26,000

6.10.4. Chlorine

Chlorine is a parameter of concern because it is used to disinfect sanitary effluent. The applicable effluent limitation guidelines require that discharges of sanitary effluent from facilities that are continuously manned by 10 or more people meet the effluent limitation of 1 milligrams per liter (mg/L) as the maximum daily limit for residual chlorine, which should be maintained as close as possible to this concentration. The Geotechnical GP requires monthly testing for total residual chlorine. In addition, the Geotechnical GP establishes fecal coliform bacteria limits of to ensure consistency with the Alaska water quality standards and the regulations at 40 CFR 140.3.

6.10.5. TSS

Discharges of drilling fluids and discharges of sanitary effluent are expected to contain settleable solids and TSS, which contribute to turbidity. The Geotechnical GP applies the maximum daily and average monthly effluent limitations for TSS according to secondary treatment standards for discharges of sanitary effluent based on best professional judgment. The permit also contains an effluent toxicity limitation for suspended particulate phase material in discharges of water-based drilling fluids and cuttings. Those effluent limitations remain unchanged and are expected to also be protective of water quality.

6.10.6. Temperature

The permit authorizes discharges of non-contact cooling water (Discharge 009), which has higher temperatures than the receiving water body. In order to assure protection of the characteristic indigenous marine community of a water body segment from adverse thermal effects: (a) the maximum acceptable increase in the weekly average temperature resulting from artificial sources is 1° C (1.8° F) during all seasons of the year, providing the summer maxima are not exceeded; and (b) daily temperature cycles characteristic of the water body segment should not be altered in either amplitude or frequency. It is expected that complete mixing will occur within a short distance from the discharge point and the temperature of the discharge will not exceed any temperature water quality objectives. The Geotechnical GP's requirements for temperature monitoring of Discharge 009 remain unchanged.

6.11. Determinations and Conclusions

EPA has evaluated the 12 discharges for the Geotechnical GP against the ocean discharge criteria. Based on this evaluation, EPA concludes that the discharges will not cause unreasonable degradation of the marine environment under the conditions, limitations, and requirements established by the permit.

With regard to discharge of drilling fluids and drill cuttings, this ODCE identifies recent studies that show that trace metals commonly associated with water-based drilling fluids and drill cuttings are not readily adsorbed by living organisms (see Section 6.1.3). In addition, data suggest that bioaccumulation risks are expected to be low because the bioavailability of trace metals in drilling fluid components (i.e., barite) is low. Furthermore, another study shows that amphipods exposed to metals that are bioavailable will accumulate small amounts of copper and lead; but copper and lead levels are quickly reduced in those individual amphipods exposed to 12 hours of seawater without elevated metal concentrations. Other studies show that bioaccumulation of barium and chromium can occur in benthic organisms; but pollutant accumulation decreases once organisms are removed from the contamination source (see Section 6.1.5). Together, those studies suggest that bioaccumulation of trace metals from water-based drilling fluids is low and reversible.

In addition, while increased sedimentation from drilling fluids and cuttings can affect benthic organisms in the discharge area, the effects are limited to the small discharge area and have been shown to have few long-term impacts. Several studies document the resilience of affected benthic communities in reestablishing affected areas within months after discharges cease. Also, other studies of former offshore exploration drilling locations show that trace metal concentrations in seafloor sediment are not persistent, and decrease to levels below risk-based sediment guideline concentrations (see Section 6.1.4). These studies demonstrate that discharge of drilling fluids and cuttings will not result in an unreasonable degradation of the marine environment during or after discharge activities. Finally, the discharges from geotechnical surveys and related activities are very short in duration and long-term widespread impacts are not anticipated.

The ODCE also addresses concerns related to the consumption of subsistence resources and public health (see Sections 5.9, 6.6, and 6.9). EPA has evaluated the discharges and does not anticipate a threat to human health through either direct exposure to pollutants or consumption of exposed aquatic organisms. EPA is also mindful of concerns about the potential changes in the behavior of subsistence-related marine resources, i.e., their avoidance of drilling discharges and deflection from traditional migratory paths might result in adverse effects on subsistence communities. For example, if the subsistence-related marine resources move farther away from subsistence-based communities, there is the potential for increased risks to hunter safety because of the additional time and farther distances traveled offshore in pursuit of the marine resources. Likewise, deflection of subsistence-related marine resources could reduce subsistence harvest and reduced consumption of subsistence resources, which could cause adverse effects on human health. To address these concerns on an ongoing basis and to ensure that no unreasonable degradation of the marine environment occurs, EPA requires depositional data to be collected if drilling fluids are used and assessment of the potential deflection and avoidance effects on marine resources during periods of discharge of non-contacting cooling water.

All other waste streams that will be authorized by the Geotechnical GP (e.g., sanitary and domestic wastes, deck drainage, bilge water, ballast water) do not contain pollutants that are bioaccumulative or persistent. The Geotechnical GP contains effluent limitations and requirements that ensure protection of the marine environment.

Finally, in accordance with 40 CFR 125.123(d)(4), the Geotechnical GP states that EPA can modify or revoke permit coverage at any time if, on the basis of any new data, EPA determines that continued discharges might cause unreasonable degradation of the marine environment Thus, EPA will be able to assess new data that is submitted in the required monthly and annual reports for each operator as a means to continually monitor potential effects on the marine environment and to take precautionary actions that ensure no unreasonable degradation occurs during the permit term.

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8. GLOSSARY

Refer to the National Pollutant Discharge Elimination System (NPDES) for Oil and Gas Geotechnical Surveys and Related Activities in Federal Waters of the Beaufort and Chukchi Seas (Permit No. AKG-28-4300) and Fact Sheet for a complete list of defined terms.