SECTION 4.0
ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This section provides an analysis of potential impacts to the natural and human environment that could result from implementation of the proposed action and alternatives and FFD alternatives. The analysis is based upon consideration of existing conditions in the affected environment and potential effects of construction, operation, and abandonment of project components such as roads, bridges, production pads, processing facilities, airstrips, pipelines, and power lines. Potential mitigation measures that could be used to avoid or reduce impacts are also introduced and described.

Portions of the analysis have required development of predictive models to simulate potential impacts. The assumptions, guidelines, and methods used to conduct such analysis are stated to provide the reader with a basis for understanding and judging the reliability of the analysis. Other parts of the analysis have been conducted through consideration of government regulatory standards, available scientific documentation, and the professional judgment of resource specialists.

4.1.1 Organization of Impact Analysis

Section 4.2

Section 4.2 introduces existing and potential additional mitigation measures that may be applicable to portions of the proposed action and alternatives and FFD alternatives through lease stipulations or applicability of the ROD for the Northeast NPR-A IAP/EIS.

Section 4.3

Section 4.3 presents an analysis of the probability and potential impacts of oil and seawater spills. Although spills are not a part of the proposed action or alternatives and FFD alternatives for the Plan Area, they could occur as a result of the proposed action and alternatives and result in impacts to the environment.

Sections 4A, 4B, 4C, and 4D

Sections 4A, 4B, 4C, and 4D present the impact analysis for Alternative A, Alternative B, Alternative C, and Alternative D, respectively. Each of these sections first presents an analysis of the CPAI Development Plan alternative, followed by analysis of the FFD alternative that is based upon the same theme. For the purpose of analysis, production pads and processing facilities associated with FFD alternatives have been organized into three facility groups:

Colville River Delta Facility Group

CD-11, CD-12, CD-14, CD-15, CD-19, CD-20, CD-21

Fish-Judy Creeks Facility Group

CD-8, CD-9, CD-10, CD-13, CD-16, CD-17, CD-18, CD-22, CD-23, CD-24, CD-26, APF-2

Kalikpik-Kogru Rivers Facility Group

CD-25, CD-27, CD-28, CD-29, APF-3

Section 4E

Section 4E presents an analysis of the No-Action Alternative. Under this alternative, the proposed action (Alternative A) or Alternatives B, C, or D would not be authorized and would therefore not be constructed or operated.

Section 4F

Section 4F presents an analysis of cumulative impacts. By definition, cumulative impacts are impacts that would result from the proposed action or alternatives in combination with other past, present, and reasonably foreseeable actions in the affected environment.

Section 4G

Section 4G presents a disclosure of other impact considerations, including unavoidable adverse impacts; relationship between local short-term uses and maintenance and enhancement of long-term productivity; and irreversible and irretrievable commitment of resources.

4.2 EXISTING AND POTENTIAL ADDITIONAL MITIGATION MEASURES

Any oil development in the ASDP Area would incorporate design and operation measures that would protect the environment. These measures would reflect the applicant’s proposal, applicable federal, state, and NSB laws and regulations, and requirements of the leases that the applicant plans to develop. In addition, the federal RODs issued following completion of this EIS, the State of Alaska Coastal Consistency Review, and any federal, state, and borough permits necessary to authorize development could impose additional mitigation measures.

In their proposal, CPAI includes several measures to protect the environment. The most significant are provisions for pipeline valves on either side of larger river channels to minimize spill size in the event of a leak or break, placement of gravel roads downhill from the pipeline to aid in control of potential pipeline leaks, and installation of bridges rather than culverts across major waterways to ensure fish passage and minimize changes to riparian habitat. Additionally, CPAI proposes to minimize the size of gravel pads at production sites to reduce the project footprint, places a heavy reliance in their proposal on winter construction and ice road use to minimize tundra damage, proposes a winter-only drilling plan for their lower Colville River Delta drill site to minimize impacts to nesting or molting bird populations, and maintains and enforces company rules against employees hunting, fishing, or disturbing wildlife.

Federal, state, and NSB laws and regulations also mitigate impacts. Many laws and regulations mandate certain protections for the environment. For example, regulations pursuant to the federal Clean Water Act establish limits for the discharge of pollutants. Regulations promulgated to enforce the National Historic Preservation Act and its Alaska counterpart mandate cultural resource surveys and avoidance measures to protect important archaeological and historic resources. State law and regulations prohibit habitat degradation in anadromous waters. The NSB requires that pipelines be no less than 5 feet above the tundra. (See Table 1.1.4-1 and Appendix C for a more complete list of authorities that provide environmental protection.)

In addition, the applicant is bound by the conditions of the leases they purchased. Federal lease stipulations are listed in Appendix D. These include a wide variety of provisions, such as restrictions on oil development activities in certain areas and at certain times. Stipulated state mitigation measures vary by lease, but generally include restrictions on development during snow-free seasons, restrictions on development near or in critical habitat or use areas, and requirements for agency review and approval of development and operation plans.

The following analysis of impacts assumes the protections provided for in the applicant's design; in federal, state, and NSB law and regulation; and in lease stipulations. Impacts identified under each alternative could occur despite these protections. In order to further mitigate impacts, this section also identifies potential additional mitigation measures. These mitigation measures are identified under each alternative following the discussion of potential impacts for each resource or use. The BLM ROD will identify which mitigation measures the BLM will adopt. Cooperating agencies could adopt mitigation measures as part of their RODs.

Unless granted an exception or a modification of the Northeast NPR-A IAP/EIS as part of this EIS, activities on BLM-managed lands must be conducted and facilities sited in accordance with the ROD for the Northeast NPR-A IAP/EIS development stipulations (Appendix D). These stipulations were developed to minimize environmental impacts that could result from oil and gas development activities on federal lands within the Northeast NPR-A. Measures presented in the Northeast NPR-A stipulations are actions that could also minimize impacts to the environment on state and private lands included in the ASDP Area and could be applied by the cooperating agencies to the proposed action and alternatives and FFD alternatives as mitigation measures. The Northeast NPR-A stipulations that would also mitigate impacts on state and private lands are hereby incorporated by reference into the mitigation sections of the EIS.

4.3 IMPACTS OF OIL, SEAWATER, AND HAZARDOUS MATERIALS SPILLS

4.3.1 Summary

In summary, this section describes the risk, behavior, and potential impacts that could result in a variety of spill scenarios. Spills[1] of produced fluids, crude or refined oil, seawater, and other chemicals from the proposed five-satellite CPAI Development Plan or from the FFD have a finite probability, or risk of occurrence, might affect the environment to varying degrees, and are of concern to all of the stakeholders. The spill scenarios used in this EIS, especially for the larger volume spills, are likely to overestimate, in some cases substantially, the risk or probability of a spill, and/or the potential impacts.

The risk and impacts of oil and hazardous materials spills on the North Slope have received extensive analysis and review in several recent EISs, environmental assessments, and other reports. Though the details differ among several of the documents, the basic data and conclusions are generally similar. We incorporate these documents by reference and summarize the key points in this EIS. Referenced documents include the following:

- Northwest NPR-A Draft Integrated Activity Plan/Environmental Impact Statement (BLM and MMS 2003)

[1] Spills, in various documents, could also be referred to as *releases, blowouts, uncontrolled releases, leaks*, and *accidental spills*. We use spills in this section to include all these terms, as well as any spill that results from sabotage, vandalism, and any other unauthorized release during construction, drilling, and production of the CPAI Development Plan and FFD.

- Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement (BLM and MMS 1998a) Alaska Outer Continental Shelf, Liberty Development and Production Plan, FEIS (MMS 2002)
- Final Environmental Impact Statement, Beaufort Sea Oil and Gas Development/Northstar Project (USACE Alaska District 1999)
- Final Environmental Impact Statement: Renewal of the Federal Grant for the Trans-Alaska Pipeline Right-of-Way (BLM 2002a)
- Environmental Report for Trans-Alaska Pipeline System Right-of-Way Renewal (TAPS Owners. 2001a)
- Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope (NRC 2003)
- A review of Oil Spill Risk Estimates Based on Current Offshore Development Technologies. Prepared by North Slope Borough Science Advisory Committee. NSB-SAC-OR-130 (NSB 2003b)
- Environmental Evaluation Document, Colville River Unit- Satellite Development, Revised June 2002 (CPAI 2002)
- Oil Discharge Prevention and Contingency Plan (ODPCP) April (CPAI 2003)

This section identifies the primary causes and sources of spills and refers back to Section 2.0 for the construction, drilling, operation, and maintenance procedures, facility design, and CPAI training programs that are designed to mitigate these causes. Section 2.0 is also referenced for the response plans required by state, federal, and borough agencies and detailed by CPAI in their ODPCP (CPAI 2003f). However, accidental spills will still occur. This section also describes the risk and impacts of those potential spills.

Where appropriate, this EIS considers the risk and impacts of spills that occur during construction, drilling, and operations activities separately. The majority of construction spills tend to be relatively small, and most result from vehicle and construction equipment fueling and maintenance (NRC 2003). A tanker truck accident or a fuel storage tank failure is the most likely source of the largest construction spills. Spills from pipelines, well blowouts[2], uncontrolled releases, or facility accidents would not occur during construction. These latter spills could occur during drilling and operation phases and have the potential to result in larger-volume spills.

Spills could occur from pipelines, production pads (and FFD APFs), airstrips, and roads and bridges. Spills that leave the gravel pads and gravel roadbed could reach one or more of several habitat types including wet and/or dry tundra, tundra ponds and lakes, flowing creeks and rivers, Harrison Bay[3], and potentially the adjacent nearshore Beaufort Sea. Spills could occur anytime in the year and for this impact assessment, we divide the year into four "seasons": (1) summer ice-free, (1) fall freeze-up, (3) winter ice cover, and (4) spring break-up.

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[2] For this EIS, "well blowout" refers to the uncontrolled release of oil/gas/brine and drilling fluids during the well drilling phase. Once a well is drilled and the wellhead and surface safety valve are in place, the loss of produced fluids is termed an "uncontrolled release." For this EIS, it is the loss of fluids (e.g., oil and brine) that are the primary environmental impact concern. The loss of natural gas is a minor environmental issue because it evaporates and disperses quickly, though it may be a safety issue.

[3] For this EIS, Harrison Bay boundary extends east to Oliktok Point, west to Cape Halkett, and north to the line drawn between these two points. The area beyond that is considered the nearshore Beaufort Sea.

Spill impact assessment considers what happens when the probability of a spill has reached 1.0; that is, the spill has occurred. Spill impact assessment is subject to numerous uncertainties and unknowns. As in most of the references consulted for this assessment (including those incorporated by previous reference), the following risk and impact assessment is based on prior analyses for the North Slope, collective empirical experience of spill personnel with North Slope spills, other published and technical reports, experience elsewhere, and the professional judgment of a wide variety of experts (including the authors of this EIS section) experienced with oil, chemical, and seawater spills.

We assume that the risk of oil and seawater spills from the CPAI Development Plan and FFD is likely to be lower than the history of the past 30 years of oil exploration, development, production, and transportation on the North Slope. The combination of more stringent agency regulations, continually improving industry operating practices, and advancements in Best Available Control Technology (BACT) all serve to reduce the risk of an oil spill. The 30-year North Slope history shows that the vast majority of the oil, produced fluids, seawater, and other material spills that have occurred have been very small (fewer than 10 gallons) and very few have been greater than 100,000 gallons (NRC 2003). The history also shows that the probability of these small spills over the life of the project is essentially 1.0; that is, they would occur. However, the probability of a very large spill greater than 1,000,000 gallons is extremely low (less than 0.001+) (BLM and MMS 1998b), and even the probability of a very large spill over 100,000 gallons is low. Most spills have been contained on gravel pads and roadbeds (NRC 2003g). Most of those that have reached the tundra have covered fewer than 5 acres (BLM and MMS 1998b). Upon detection, spills that have occurred were promptly contained and cleaned up as required by state, federal, and borough regulations (NRC 2003g). Impacts that have occurred were judged minor, and natural and/or anthropogenic-assisted restoration, and have generally occurred within a few months to years (NRC 2003).

4.3.2 Background for Oil, Seawater, and Hazardous Material Spills

4.3.2.1 Introduction

This section presents a general discussion of the impact of potential spills. The section is structured as follows:

- First, a brief history of oil, seawater, and other spills on the North Slope is provided as background (Section 4.3.2.2).
- Second, the spill characteristics and assumptions used to develop the scenarios for risk assessment and impact assessment are described (Section 4.3.2.3). These include size, type of material, type or source of the spill, seasons, and location relative to oilfield infrastructure.
- Third, the risk of spills is discussed (Section 4.3.2.4). The risk posed by a potential spill is based upon the likelihood or probability that a spill would occur and the severity of that spill. This section discusses the risk of spills based upon the industry operating record on the North Slope, risk analyses performed for other North Slope projects, and considerations specific to the CPAI Development Plan and FFD.
- Fourth, the behavior and fate of spilled material is assessed (Section 4.3.2.5). Behavior and fate depend upon the material released and the receiving environment. This section identifies the type of materials that could be spilled and discusses their chemical and physical properties that influence their behavior in the natural environment. This section also provides a general description of the receiving environment, the seasons, and associated conditions that would influence spill behavior and fate.
- Fifth, potential exposure to the spilled material and its effects on the environment are evaluated (Section 4.3.2.6). In many cases, exposure of various habitats would depend upon the spill

location. Similarly, effects of exposure would depend upon the habitat and associated plant and animal species exposed.

A more detailed resource-by-resource impact assessment for each of the CPAI Plan alternatives and the FFD is provided in Section 4.3.3.3.

4.3.2.2 History of North Slope Spills

The recent NRC report on "Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope" (NRC 2003) summarizes the history of North Slope oil spills, "Major oil spills have not occurred on the North Slope or adjacent areas as a result of operations [of the oilfields]. … Many small terrestrial spills have occurred in the oilfields, but they have not been frequent or large enough for their effects to have accumulated. They have contaminated gravel, which has been difficult to clean up and has made the gravel unavailable for rehabilitation." Appendices F and G of the same NRC report provide the most recent detailed analysis of risk, size, type, and general impacts of North Slope oil and seawater spills. These analyses are the basis for the conclusion quoted earlier.

A key conclusion of Maxim and Niebo (2001a, 2001b, 2001c)[4] is, although there continues to be oil and seawater spills on the North Slope and the total annual volume of oil spilled fluctuates substantially, there is nevertheless a general decreasing trend over a 30-year oil-field operating history in the total volume of oil spilled. This trend occurs despite better reporting of all sizes of spills, especially the small spills, and despite aging of much of the oilfield infrastructure. Maxin and Niebo attribute this trend to improved technology, better engineering design, greater stress on clean operations, and greater awareness on the part of all the oilfield personnel. Increasingly stringent federal, state, and borough regulatory requirements for reporting spills, as well as for preparation of response plans and training also contribute to the declining long-term trend in total spill incidents. The authors do not analyze the trends in the number or size-frequency of spills, especially the smaller volume ones, partly because of the changes in the way spills have been reported over the 30-years-plus record and partly because the important environmental variable is the volume spilled.

A review of the ADEC spill database from January 1, 1995 to Aug 18, 2003 (provided by Camille Stephens, ADEC through Ken Taylor, ADNR September 2003 and hereafter referenced as ADEC 2003 d) for the North Slope shows 3,673 spill records[5] including oil, seawater (including produced waters and treated seawater), and other hazardous materials, as well as a few "freshwater" spills. The database is probably a fair representation of the type, size, location, and cause of spills that one might expect from North Slope oilfield operations in the near future.

The 3,673 spill records and annual oil production volumes obtained from the ADR website are distributed on a calendar-year basis as shown in Table 4.3.1-1.

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[4] Maxim and Niebo were the primary contributors to the detailed analysis of oil and brine spill risks as presented in the NRC report appendices F and G, as well as that presented in the TAPS EA (TAPS Owners 2001a).

[5] There are duplicate and even as many as six records for the same incident. According to Luick (pers. comm., 2003), this is an artifact of the database structure that occurs when the same incident involves more than one listed substance. The number of replicated incidents is small and does not materially change the discussion provided in this section.

TABLE 4.3.1-1 ADEC 1995–2003 DATABASE SPILL RECORDS AND ADR ANNUAL OIL PRODUCTION VOLUMES

Year	Number of Records	Annual Oil Production (millions of gallons)[c]
1995	226	23,331
1996	438	21,983
1997	470	20,437
1998	442	18,488
1999	381	16,510
2000	396	15,330
2001	505	15,179
2002	615	14,734
2003	282[a]	--[d]
TOTAL	3755[b]	145,992
Average Number of Records	417	

Notes:
[a] The database shows 200 records through mid-August 2003; extrapolating that rate to the end of the year approximates 282 records.
[b] The total number of records is greater than 3,673 actual records in the database because of the extrapolation to the end of 2003.
[c] From the ADR, Tax Division web site (ADR 2003c) and using the calendar year data for Alaska North Slope crude oil.
[d] No data available on calendar year basis until year end.

The average number of records by year for spills over the 9-year period (1995 to 2003) is approximately 417 with a range of 226 in 1995 to 615 in 2002 (ADEC 2003 d). At the current rate, one might expect approximately 282 spills in 2003.

Of the 3,673 spill records, no spill was greater than 1,000,000 gallons. Only one spill was greater than 100,000 gallons; this was a seawater spill of 994,400 gallons on March 1997 from a drill site for unknown causes. There were 22 additional records of spills greater than 10,000 gallons of which two were crude oil (approximately 38,000 and 30,000 gallons), one was diesel (18,000 gallons), eight were drilling muds (composed of three incidents with six records for one incident), six were seawater, and five were other materials (e.g., Halon, reserve pit gravel, natural gas, and freshwater/bentonite). There were 112 records of spills of 1000 to less than 10,000 gallons, 411 records of spills 100 to less than 1000 gallons, 912 records of spills 10 to less than 100 gallons, and 2,215 records of spills less than 10 gallons. Of the latter, 498 records (23 percent) were reported as less than or equal to one gallon.

Since March 1998 when APF-1 began operations, the ADEC database (ADEC 2003 d) shows 54 records of spills associated with APF-1 through August 8, 2003. This averages approximately 12 spills per year. One seawater spill was reported as 4,998 gallons, three spills of aviation gas or hydraulic fluid were 100 to 1,000 gallons, 19 records were for spills of 10 to less than 100 gallons including diesel, hydraulic fluid and ethylene glycol (antifreeze), and 31 records were less than 10 gallons of various materials. Most of these spills were on pads or roads and were associated with routine operations. They were generally the result of human error or equipment failure. According to the CPAI ODPCP (CPAI 2003), there was one spill in March 1999 of drilling mud that did not leave the pad and there were three spills (100, 210, and 252 gallons) of oil or diesel that did reach the tundra.

There have been no blowouts or uncontrolled releases of produced fluids at APF pads since drilling was initiated. There was one release of 24,654 gallons of drilling mud in March 1999 when the formation was being pressurized by drilling fluid that surged to the surface of the ice pad because a pump at the exit pad failed (CPAI 2003).

North Slope-wide, Fairweather (2000) (quoted in Appendix F, NRC 2003), reported five events from 1971 to 2001 that resulted in uncontrolled surface release of liquids or gas from the boring. None of these events resulted in oil spills (Mallary 1998). Over this same period approximately 5,000 wells were drilled or re-drilled, giving a frequency of approximately one event per 1,000 wells drilled or a probability of approximately 0.001, about the same as for other areas (Mallary 1998, S.L. Ross 1998). The conclusion is that blowouts and uncontrolled releases have been rare events and are likely to be even more rare in the future as BACT is applied to future drilling and production activities.

4.3.2.3 Basic Assumptions for Spill Risk and Impact Assessments

The discussion of the risk and impacts of spills requires description of the several basic assumptions and classifications related to the spills themselves and to the environmental variables that might affect the spill impacts. These descriptions are provided with the caveat that they are necessarily simplified and might not represent the entire spectrum of possible values or combinations of values and events that might be realized in actual spills. However, many of these assumptions have been used in previous assessments and all are based on the empirical experience of oil spill experts on the Alaska North Slope and elsewhere.

Spill Size Classification

To describe the risk and impacts of spills in this EIS, we categorize spills into five spill sizes:

- Very small spills – less than 10 gallons (approximately 0.25 barrels[6] or bbl)
- Small spills – 10 to 99.5[7] gallons
- Medium spills – 100 to 999.5 gallons
- Large spills – 1000 to 100,000 gallons
- Very large spills – greater than 100,000 gallons.

This size classification is similar to the unofficial "rule of thumb" used by ADEC when they respond to and evaluate spills of oil and hazardous materials (B. Smythe 2003, pers. comm.). We added the very small spill and very large spill categories to facilitate discussion of the majority of spills (less than 10 gallons) and of the very rare spills (greater than 100,000 gallons); the latter are discussed in more detail in Section 4.3.4.

Types of Materials Spilled

Potentially spilled materials could include the following:

- Produced fluids, composed of crude oil, natural gas, brine, and grit

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[6] One barrel contains 42 gallons. Gallons are used throughout this section.

[7] Any spill of 99.5 – 99.9 gallons is considered a 100 gallon spill; i.e., spill volume is rounded to the nearest gallon.

- Seawater[8], composed of treated seawater from the Kuparuk STP at Oliktok Point and brine separated from the produced fluids
- Arctic diesel
- Jet-A 50 (which is very similar to diesel)
- Methanol
- Antifreeze (including tetraethylene glycol [TEG])
- Drilling fluids
- Unleaded gasoline (in small quantities for a limited number of small motors, especially on boats)
- Mineral oil
- Water soluble chemicals
- Corrosion inhibitor
- Scale inhibitor
- Dra-Flo XL (drag reducing agent)
- Sales Oil[9] (from FFD only)

The risk and impact assessment is based primarily on spills of produced fluids (sometimes referred to as crude oil spills in some of the North Slope literature), refined products (primarily diesel), and seawater. These materials are the most likely to spill in sufficient volume and frequency at locations that could result in impacts to the natural environment. Hence, most of the data on spills on the North Slope (and elsewhere) are on "oil" spills and, to a lesser extent, on seawater spills.

Phase of Oilfield Development

Where appropriate, this EIS considers potential spill impacts associated with the construction, drilling, and production and operation phases of the oilfield development separately. This is relevant because some sources and sizes of spills would not occur in some phases or they would be more likely in one phase than another. For example, during construction, most of the spills would be relatively small, consist of diesel, hydraulic fluid, antifreeze, lubricating oils, and similar materials associated with the vehicles and construction equipment on site or in transit to and from the site. Once construction and drilling are completed, the likelihood of spills and leaks from vehicles and heavy equipment would be reduced because vehicle and equipment activity would be reduced during production and operations relative to construction and drilling, and the volumes of refined products and most chemicals being transported is reduced. In addition, blowouts would not occur during construction and, if they were to occur at all, would occur during the drilling phase. Uncontrolled releases could only occur during production and operation. Spills of produced fluids and seawater would only occur during the production and operation phase.

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[8] In this EIS, "brine" refers to the saline water that is part of the produced fluids (in addition to crude oil, natural gas, and grit) coming from the oilfields. Seawater is the treated seawater from the Kuparuk STP. Because the environmental impacts are similar for brine, treated seawater, or the mixture of the two, "seawater" is used throughout this section of the EIS to refer to any combination of these saline waters.

[9] Sales Oil is the crude oil from the produced fluids with the brine, grit, natural gas and other impurities removed before the crude oil is transported to the Trans Alaska Pipeline and eventually to the Valdez Marine Terminal.

Seasons

The season in which a spill occurs might dramatically influence its behavior, impacts, and the cleanup response actions. This EIS considers spills in four seasons, specifically:

Summer

Summer is confined to the ice-free period when most of the rivers and creeks are flowing, ponds, lakes, and Harrison Bay are open water, tundra is snow-free, and biological use of tundra and water bodies is high. Currents, winds, and passive spreading forces would disperse spills to the water bodies. Spills to tundra would directly affect the vegetation, although the dispersal of the spilled material is likely to be impeded by the vegetation.

Freeze-up

Freeze-up is the period when the water bodies are beginning to ice over but the ice cover might come and go depending upon temperature, wind, currents, and river flow velocities. Snow begins to cover the tundra and most of the migratory birds are leaving the North Slope. Spilled material could be dispersed when it reaches flowing water but stopped when it reaches snow or surface ice. The spilled material could be contained by the snow or ice but dispersed if this ice breaks up and moves before it re-freezes. The spilled material also could flow into ice cracks to the underlying water where it could collect.

Winter

Winter is the long, dark period when water bodies including Harrison Bay and the Colville River are covered with mostly unbroken ice and snow covers the tundra. Dispersal of material spilled to the tundra generally would be contained by the snow cover and seldom reaches the underlying dormant vegetation or tundra ponds and lakes. Similarly, spills to rivers and creeks generally would be contained by the snow and ice covering the water body. Spills under the ice might disperse very slowly as the currents are generally slow to non-existent in the winter.

Break-up

Break-up is the short period in the spring when thawing begins in the higher foothills of the Brooks Range and river flows increase substantially and quickly, often to flood stages. These increased flows cause the river ice cover to break up and flow downriver, eventually to Harrison Bay. The river floodwaters usually flow over the sea ice of Harrison Bay, which hastens the break-up of the sea ice. Snow cover begins to melt off the tundra and many of the migratory species, especially birds, return to the tundra. Spills to water bodies during break-up are likely to be widely dispersed and difficult to contain or cleanup. Spills to the tundra might be widely dispersed if the flooding overtops the river and creek banks, and entrains the spilled material.

Location of Spills

Most spills would occur in close association with the oilfield infrastructure. For convenience, the locations are classified as follows:

- gravel pads for drilling, production and processing facilities
- gravel roads (including culverts)
- gravel airstrips

- temporary ice roads and ice pads
- pipelines (including the VSM and bridges that support the pipelines)

Only in a rare and unusual circumstance (e.g., aircraft crash) would the source of a spill occur any distance from one of these structures. Most spills, except from pipelines, occur and are contained on the ice or gravel pads, roads, and airstrips, and they are promptly cleaned up as required by federal, state, and borough regulations before they reach the tundra or water bodies. Pipeline spills could occur at some distance from the nearest road or pad, especially in Alternative D.

Potential Sources of Spilled Material

The main sources of spilled material from the proposed CPAI Development Plan facilities would include the following:

- Alpine production pads CD-3 through CD-7 would include storage tanks and containers, gas and seawater injection facilities, and produced fluids pumping facilities The size, contents, and secondary containment for the storage tanks and containers at the drilling and production pads (and APF-2 and APF-3 in the FFD) are described in Sections 2.3.3.1 and 2.2.12.3. Because of the secondary containment around the storage tanks and containers, it is very unlikely that catastrophic failure of one or more storage tanks could be a potential source of a spill large enough to leave the pad. However, as a worst-case scenario in the ODPCP (CPAI 2003), such a spill is considered possible if the secondary containment were breached. Processing facilities also store chemicals such as methanol and glycol.
- In-field pipelines for produced fluids, diesel, and seawater connect the various production pads to the process facilities at APF-1. The produced fluids pipeline would contain crude oil, natural gas, and produced water. The seawater pipelines would contain either treated seawater or a blend of treated seawater and brine from the produced fluids. The diesel pipeline would be used to distribute various types of diesel to the CD-3 production pad in Alternative A. The MI pipelines would contain light hydrocarbon fluid that would dissipate as a gas if released; thus, it is not a concern for impact except for the potential for a fire that could subsequently damage an adjacent pipeline and cause a release of another material. The lift gas pipeline would transport natural gas from the central processing facility to the production pads for use as fuel gas and/or to lift produced fluids in the well bore.
- Vehicles including light- and heavy-duty trucks and tank trucks, aircraft (fixed-wing and rotary), watercraft, snow machines, and heavy equipment might spill or leak fuels (diesel, gasoline, jet), oils (motor, transmission, hydraulic), and antifreeze from unintentional releases during refueling and maintenance, leaks and drips during normal operations, or releases related to vehicle or equipment accidents. Impacts from these types of spills generally would be confined to small areas on airstrips, ice pads, and gravel roads or gravel pads where cleanup could be easily accomplished. Spills from snowmobiles might occur on the tundra remote from roads and pads, but the volumes would be small and the snow would generally contain it. Spills from watercraft also would be relatively small.

The main sources of spilled material from the hypothetical FFD facilities include all the sources listed above for the CPAI Development Plan and a potential additional seawater pipeline and sales oil pipeline, if new processing facilities are developed along with associated production pads and pipelines. In the FFD, the extended Sales Oil and treated seawater pipelines would extend from CD-1 to APF-2 and APF-3 if they were built. An FFD sales oil pipeline from NPR-A would not necessarily connect to the existing sales oil line between KRU and APF-1. The connection would depend upon the production rates of the FFD processing facilities and the capacity of the existing Alpine sales oil line at the time. In the complete development of the FFD, the additional FFD pipelines would cross at least five major rivers (i.e., Kalikpik River, Fish-Judy creeks, Ublutuoch River, and the Nigliq Channel). The FFD Sales Oil pipeline would contain at least 10 vertical loops, one on each side of these rivers.

Well blowouts and uncontrolled releases are an additional but low-risk potential source of spilled production fluids (NRC 2003). Blowouts could occur during well drilling and uncontrolled releases could occur during production activities including workover operations. A well blowout could result in a potentially large volume spill of produced fluids (crude oil and brine) over an extended period. Fluids[10] released by a well blowout or uncontrolled release could extend beyond the limits of the gravel production pad anywhere in the Plan Area under the proposed CPAI Development Plan or FFD and could potentially reach nearby ponds, lakes, creeks, and/or rivers with a potential to enter the marine environment in Harrison Bay.

4.3.2.4 Risk of Spills

Risk of a spill is determined based upon the likelihood or probability of occurrence; severity is determined in terms of size, type of material, and source or location. The probability of occurrence is a function of several factors including age of the infrastructure, operating procedures, personnel training and awareness, maintenance, and human error. Risk analyses typically are presented in various scenarios to span the range of likelihood and severity of spills. Likelihood is expressed in terms of frequency; for example, “once in 1,000 years,” “once in one Bbbl of oil produced,” or “once per 10,000 wells drilled.” Severity typically is based on one or more measures such as volume released, cost to clean up and restore, acres of impact, location of spill, and type of material spilled. The environmental impact analysis process requires us to analyze the potential impacts of a range of possible spills including the very low probability, very large volume spills. This section presents a general discussion of risk of spills associated with North Slope oilfield construction, drilling, and production, and includes discussion of the more likely spills, mostly small ones. The very low probability, very large volume spills (VLVS) and their impacts are discussed separately and in more detail in Section 4.4.4.

Risk of Various Sizes and Types of Spills

A review of the several EISs and similar documents referenced earlier in this section indicates that the risk of very small, small, and even medium size spills is relatively high, with the risk of very small and small spills being 1.0 over the life of the CPAI Development Plan and/or the FFD, i.e., they will occur. The risk of large spills is substantially less, i.e., there will be fewer large spills, but there is likely to be at least one and probably more over the life of the projects. Finally, the risk of a very large spill is very low and might approach 0.0 as the size of the potential spill increases. The qualitative assessment of potential risks in provided in Table 4.3.2-1.

The rest of this section provides the background information for the potential risks of various size spills. The risk is based on analyses prepared for other EISs that are incorporated earlier by reference, and by the size and proportion of spills that are recorded in the ADEC database for North Slope spills from 1995 to 2003. The relevant information is summarized in Table 4.3.2-2.

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[10] The natural gas in a blowout or uncontrolled release will vaporize and remain airborne. It will have a minimal impact on the tundra habitat and other resources.

TABLE 4.3.2-1 RELATIVE POTENTIAL RISK FOR SPILLS FROM MAIN SOURCES

	Spill Size				
Source Pipeline	Very Small (<10 gal)	Small (10–99.5 gals)	Medium (100–999.5 gal)	Large (1,000–100,000 gals)	Very Large (>100,000 gals)
Produced Fluids	H	H	M	L	VL
Seawater	H	H	M	L	VL
Diesel	H	M	L	VL	0
Sales Oil (FFD only)	M	M	M	L	VL
Bulk Storage tanks & containers on pads	L	L	L	VL	0
Tank vehicles	H	M	L	VL	0
Vehicle & Equipment Operation and Maintenance	VH	VH	M	VL	0
Other Routine Operations	VH	VH	H	L	VL
Drilling Blowout	VL	VL	VL	VL	VL
Production Uncontrolled Release	VL	VL	VL	VL	VL

Notes:
VL = Very Low Risk of occurrence (approaching 0.0)
L = Low Risk
M = Medium Risk
H =.=High risk
VH = Very High Risk (approaching 1.0)
0= no risk

TABLE 4.3.2-2 TYPE, NUMBER, SIZE AND PERCENTAGE OF SPILLS IN ADEC 1995 TO 2003 NORTH SLOPE DATABASE

Material	No. Records[a]	Size (gal) of Largest Spill	% of All Records [b]	Probability (per Bbbl oil transported in TAPS)[d]
Crude Oil	421	38,000	11.5	0.0027
Diesel	819	10,000	22.3	0.0053
Hydraulic Oil	630	660	17.2	0.0040
Engine Lube	177	650	4.8	0.0011
Transmission Oil	39	75	1.1	0.0003
Waste Oil	14	1,500	0.4	<0.0001
Gasoline	18	100	0.5	<0.0001
Other Refined Products	32	5,700	0.9	0.0002
Seawater	121	994,400	3.3	0.0008
Produced Water	172	92,400	4.7	0.0011
Propylene/Ethylene Glycol	267	5,700	7.3	0.0017
Drilling Muds	206	20,000	5.6	0.0013
Methanol	197	2,520	5.4	0.0013
Others[c]	560	30,000	15.2	0.0036

Notes:
[a] Number of records in the 1995 to 2003 ADEC database (ADEC 2003 d).
[b] Total number of records for each material out of the total of 3,673 spill records in the ADEC 1995–2003 database
[c] Includes Halon, corrosion inhibitors, drag reducing agents, chemicals, acids, water, unknown and “others.”
[d] For the 1995 to 2003 period of ADEC database, approximately 156,000,000,000 gallons of oil were transported. The probability in column 5 is based on dividing the number of records (column 2) by 156,000.

The probability of each type of material spilling, regardless of the volume, might be estimated using the ADEC 1995 to 2003 spill database and the ADR data on oil throughout since 1995. The probabilities are shown in Table 4.3.2.2 and are expressed as probability of a spill per Bbbl of oil transported from Pump Station 1. The probabilities are all small, ranging from less than 0.0001 (less than one in 10,000) to 0.0053 (approximately one in 190).

Crude Oil

For this analysis, the "crude oil" category includes oil in the produced fluids (which also contain brine that would likely be spilled at the same time), as well as the Sales Oil Pipeline (FFD only).

In the Northeast NPR-A IAP/EIS (BLM and MMS, 1998b), and based on data for spills on the North Slope from January 1989 to December 1996, the BLM estimated the average crude oil spill at approximately 160 gallons and the median size at approximately seven gallons. The size range was 1 gallon to 38,850 gallons. Approximately 99 percent of the spills were less than 1,050 gallons and no oil spill was greater than 42,000 gallons. For the Northeast NPR-A IAP/EIS, the BLM assumed the average crude oil spill was 168 gallons (4 bbls). They also assumed that a large spill from a pipeline was 117,600 gallons (2,800 bbls) spilled over a 30-day period.

In the Northwest NPR-A Draft IAP/EIS (BLM and MMS, 1998), and based on data for spills on the North Slope from January 1989 to December 2000, the BLM estimated the average crude oil spill at approximately 113 gallons and the median size at approximately five gallons. The size range was 1 gallon to 38,850 gallons. Approximately 99 percent of the spills were less than 2,520 gallons and again, no spill was greater than 42,000 gallons. For the Northwest NPR-A Draft IAP/EIS, the BLM assumed the average small crude oil spill was 126 gallons. The BLM also assumed that the large crude oil spill was 21,000 gallons from a pipeline spill.

The CRU Satellite Development EED (PAI, 2002a), and the Liberty EIS (BLM and MMS, 2002) report ranges of values for the small and large spills of crude oil that are similar to, or the same as, those in the NPR-A EISs cited above and incorporated by reference.

The ADEC North Slope spill database (ADEC 2003 d), for the period of January 1995 through August 2003, includes 3,673 records. The two largest of the 421 crude oil records were 38,000 and 30,000 gallons. There were 10 other large spills, 67 medium spills, 145 small spills, and 196 very small spills, using the definitions provided in Section 4.4.2.3. Some of the crude oil spills could be associated with produced fluids or produced water making it impractical to determine how much of the spilled material was actually oil.

The largest oil spill reported by CPAI (CPAI, 2003) was 275 gallons at CD-1 Pad.

For the analysis of the CPAI Development Plan and the FFD, we assume that:

- The risk of very small and small spills is 1.0 and that the size of these spills are 5 and 168 gallons, respectively. The very small spill volume is an arbitrary designation of the midpoint in the spill volume range and the small spill volume is the same as that used for the Northeast NPR-A IAP/EIS (BLM and MMS 1998a), which is incorporated by reference. Based on the ADEC database, the proportion of these very small and small oil spills is approximately 9.3 percent[11] of all the spill records since 1995.

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[11] As an example, calculated as (145 + 196/3,673) 100 percent = 9.28 percent

- The risk of medium spills (i.e., 100 to 999.5 gallons) is approximately 1.8 percent based on the ADEC database.
- The size of a large spill is 38,850 gallons, which is the value in the Northeast NPR-A IAP/EIS (BLM and MMS 1998a) that is incorporated by reference. This is very close to the two largest spills reported in the ADEC database since 1995 (see above). The risk of the large spill is 0.05 percent; 2 out of 3,673 records for the entire database.

This might be an overestimate because, in some cases, the spills could have produced fluids of which part of the volume spilled was brine.

Refined Hydrocarbons

For this analysis, the "refined hydrocarbon" category includes diesel, hydraulic oil, engine lube oil, transmission oil, waste oil, gasoline, and other refined products. The number of records, maximum size, and percentages that each of these spill types constitute of all spills on the North Slope since 1995 are shown in Table 4.3.2-2.

The average spill size has been estimated at 29 gallons (BLM and MMS 1998b; BLM and MMS 2003; PAI 2002a) and diesel spills account for most of the spills in frequency and total volume (BLM 2003b) (Table 4.3.2-2). Of the 819 diesel spills listed in the ADEC database (ADEC 2003d), 18 were large greater than (less than 1,000 gallons) with the largest at 10,000 gallons, 69 were medium (100 to 999.5 gallons), 272 were small (10 to 99.5 gallons) and 460 were very small (less than 10 gallons).

Hydraulic oil, engine lube oil, and transmission oil spills, though relatively numerous (846 or 23 percent out of 3,673 records) are generally small (maximum reported size was 660 gallons) and confined to the pads. Gasoline spills are small and infrequent. Waste oil and "Other Refined Products" also are relatively infrequent (46 or 1.3 percent of 3,673 records) and most are very small and small spills, with an occasional medium spill.

Because these spills are small, unpredictable in time and location, mostly occur on gravel pads or roadways, and cannot spread far. The impacts are not anticipated to be cumulative. Therefore, they are evaluated as individual spills of approximately 100 gallons each.

In the Northwest NPR-A Draft IAP/EIS (BLM and MMS 2003), the BLM assumed that a large spill of diesel from an onshore bulk storage tank would be 37,800 gallons. Based on the project description for the CPAI Development Plan and the FFD, and assuming that the entire contents of the storage tank could be spilled onto the environment (that is, the secondary containment fails completely), the maximum spill of diesel could be 4,200 gallons at any production pad and 15,000 gallons for the FFD processing facilities. For the analysis of the CPAI Development Plan and the FFD, the large diesel spill is assumed at 15,000 gallons.

Seawater

There appear to be limited data and/or analyses of the existing data on frequency, location, volume, or causes of seawater spills, whether it is seawater from the STP, brine in the produced fluids, or the blended brine and seawater that is re-injected into the oilfield. The risk of seawater spills from pipelines generally can be addressed by the same approach as produced fluids. Qualitatively, the likelihood of a seawater spill is similar to the likelihood of a produced fluids spill, since the lines are collocated, the materials transported have approximately the same corrosivity, and the other causes of pipeline leaks are human or mechanical in nature.

The ADEC database for spills on the North Slope from 1995 to 2003 (ADEC 2003d) shows 121 seawater and 172 produced water spills (approximately 8.0 percent of all spill records) with the largest spills being 994,400 and 92,400 gallons respectively. Most were medium to small spills.

Other Materials

Other spilled materials in the records of the ADEC database (ADEC 2003d) include drilling muds, methanol, propylene and ethylene glycol (antifreeze), Halon, corrosion inhibitors, drag reducing agents, other chemicals, acids, source water, unknown, and “other.” These account for approximately 1,230 or 33.5 percent of the records. There have been a few large spills of some of these materials (e.g., drilling muds at 18,900 gallons, source water, ethylene glycol at 5,700 gallons, drag reducing agent at 6,000 gallons, and Halon at 11,400 pounds) but most of the spills have been small or very small. Most of these spills were contained on and cleaned up at the pad or road where they occurred.

The risk of a spill of one of the “Other Materials” is relatively high (approximately 33.5 percent of all spills) but the volumes are relatively low and most occur on pads or roads.

4.3.2.5 Behavior and Fate of Spilled Materials

This section describes primarily the properties and behaviors of spilled oil that are important to the evaluation of the potential effects that the spilled oil might have in the various environments in the Plan Area. Much of this section is excerpted from the Northwest NPR-A Draft IAP/EIS, which is incorporated by reference (BLM and MMS 2003). The focus is on spilled oil, broadly defined to include crude oil, produced fluids, and refined products. Because the impacts are likely to be greater and more persistent from oil than from most other spilled materials (except possibly seawater), there are more data and analyses available, and most, though not all, stakeholders are generally more concerned about oil spills than about seawater or other chemical spills.

Seawater might behave generally like oil when it is spilled in large volumes, although seawater usually would be less viscous, especially in the warmer break-up and ice-free seasons, and could therefore spread further than the same amount of oil might. If spilled into freshwater bodies, the seawater would be completely miscible and the salt concentration would be diluted in the freshwater. The amount of dilution depends primarily on the relative volume of the receiving water and the spilled seawater, as well as the dynamics of the receiving water body. For example, a spill into the Nigliq Channel at spring break-up flood stage might be diluted very rapidly, whereas a seawater spill to a small tundra lake on a calm summer day make remain at relatively high salinity for some time.

Other materials such as methanol and ethylene glycol are completely miscible in water though they could be toxic for some period until they disperse through dilution or dissipation to the air. Others, such as acids and some chemicals, are completely soluble in water but could also be toxic until they are substantially diluted.

Factors Affecting the Fate and Behavior of Spilled Oil

The primary and shorter-term processes that affect the fate of spilled oil are spreading, evaporation, dispersion, dissolution, and emulsification (Payne et al. 1987; Boehm 1987; Boehm et al.1987; Lehr 2001). These processes are called weathering. Weathering dominates during the first few days to weeks of a spill. A number of longer-term processes also occur, including photo- and biodegradation, auto-oxidation, and sedimentation. These longer-term processes are more important in the later stages of weathering and usually determine the ultimate fate of the spilled oil.

The chemical and physical composition of oil changes with weathering. Some oils weather rapidly and undergo extensive changes in character, whereas others remain relatively unchanged over long periods of time. As a result of evaporation, the effects of weathering are generally rapid (one to two days) for hydrocarbons with lower molecular weights (for example, gasoline, aviation gas, and diesel). Degradation of the higher-weight fractions (for example, crude oil, transmission and lube oil, hydraulic fluid) is slower and occurs primarily through microbial degradation and chemical oxidation. The weathering or fate of spilled oil depends on the oil properties and on environmental conditions, both of which can change over time.

Spreading

Spreading reduces the bulk quantity of oil present in the vicinity of the spill but increases the spatial area over which adverse effects could occur. Thus, oil in flowing systems (for example, rivers and creeks, Harrison Bay) rather than contained systems (for example, tundra ponds and lakes) would be less concentrated in any given location, but could cause impacts, albeit reduced in intensity, over a larger area. Spreading and thinning of spilled oil also increases the surface area of the slick, enhancing surface-dependent fate processes such as evaporation, bio- and photodegradation, and dissolution.

Evaporation

Evaporation is the primary mechanism for loss of low-molecular-weight constituents and light oil products. As lighter components evaporate, the remaining petroleum hydrocarbons become denser and more viscous. Evaporation tends to reduce oil toxicity but enhance persistence. Hydrocarbons that volatilize into the atmosphere are broken down by sunlight into smaller compounds. This process, referred to as photodegradation, occurs rapidly in air, and the rate of photodegradation decreases as molecular weight increases.

Dispersion

Dispersion of oil increases when water surface turbulence increases. Wind, gravity or tidal currents, or broken ice movement could cause the turbulence. The dispersion of oil into water increases the surface area of oil susceptible to dissolution and degradation processes and thereby limits the potential for physical impacts. However, some of the oil could become dispersed in the water column and/or on the bottom as it adheres to particulate matter suspended in the water column. The presence of particulates including organic matter, silt and clay, and larger sediment particles is likely to be greatest during break-up, flood flows, and wind storms (especially in Harrison Bay).

Dissolution

Dissolution[12] of oil in water is not the primary process controlling the fate of the oil in the environment; i.e., oil generally floats on, rather than dissolves in water. However, to the extent dissolution does occur, it is one of the primary processes affecting the toxic effects of a spill, especially in confined water bodies. Dissolution increases with (1) decreasing hydrocarbon molecular weight, (2) increasing water temperature, (3) decreasing salinity, and (4) increasing concentration of dissolved organic matter. Components of gasoline (for example, benzene, toluene, ethylbenzene, and xylenes) would dissolve more readily than the heavier crude oil or fuel oils under the same environmental conditions.

Emulsification

Emulsification is the incorporation of water into oil and is the opposite of dispersion. Small drops of water become surrounded by oil. External energy from wave or strong current action is needed to

[12] In this case, the definition of "dissolution" is to dissolve into water.

emulsify oil. In general, heavier oils emulsify more rapidly than lighter oils. The oil could remain in a slick, which could contain as much as 70 percent water by weight and could have a viscosity of a hundred to a thousand times greater than the original oil. Water-in-oil emulsions often are referred to as "mousse."

Photodegradation

Photodegradation of oil increases with greater solar intensity. It can be a substantial factor controlling the disappearance of a slick, especially of lighter products and constituents, but it would be less important during cloudy days and could be nonexistent in winter months on the North Slope. Photodegraded petroleum product constituents tend to be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, could thus increase the biological impacts of a spill event.

Biodegradation

Biodegradation of oil by native microorganisms, in the immediate aftermath of a spill, would not tend to be a major process controlling the fate of oil in water bodies previously unexposed to oil. Though oil-degrading microbial populations are ubiquitous at low densities, including on the North Slope, a sufficiently large population must become established before biodegradation can proceed at any appreciable rate.

Overall, the environmental fate of released oil is controlled by many factors, and persistence is difficult to predict with great accuracy. Major factors affecting the environmental fate include the type of product, spill volume, spill rate, temperature of the oil, terrain, receiving environment, time of year, and weather. Crude oil would weather differently than diesel or refined oil in that both diesel and refined oil would evaporate at a much faster rate than crude oil.

The characteristics of the receiving environment, such as type of land, the surface gradient, marine or freshwater, spring ice overflow, summer open water, winter under ice, or winter broken ice, would affect how the spill behaves. In ice-covered waters, many of the same weathering processes are in effect as with open water; however, the ice changes the rates and relative importance of these processes (Payne et al. 1991).

The time of year when a spill occurs has a major effect on the fate of the crude oil. The time of year controls climatic factors such as temperature of the air, water, or soil; depth of snow cover; whether there is ice or open water; and the depth of the active layer. During winter, the air temperature can be so cold as to modify the viscosity of the oil so it would spread less and could even solidify. The lower the ambient temperature, the less crude oil evaporates. Both Prudhoe Bay and Endicott crudes have experimentally followed this pattern (Fingas 1996). Frozen ground would limit the depth of penetration of any spill.

Fate and Behavior of Spills on Tundra

Oil movement over the ground surface follows the topography of the land. In general, oil flows until (1) it reaches a surface water body or a depression, (2) infiltration into the vegetation cover, soil, and snow prevents further movement, or (3) increased viscosity due to low temperatures slows movement. The rate of oil movement and depth of penetration into tundra depend on a variety of factors. If released onto tundra, oil can penetrate the soil because of the effects of gravity and capillary action. The rate of penetration depends on the season, temperature, soil saturation, nature of the soil, and the type of oil. In summer, spills generally penetrate the active layer and then spread laterally on the frozen subsurface, accumulating in local depressions. From there, the oil can penetrate into the permafrost (Collins et al. 1993). Precipitation can increase penetration into and dispersion over thawed soils (Chuvilin et al. 2001).

In winter, the snow cover or frozen soil controls the spreading. Snow cover can act as an absorbent, slowing the spread of oil and preventing the spill from reaching the tundra surface. During winter, oil spreads on the surface of the frozen soil, and penetration of oil into the soil is generally limited. Pore space in the soils that is not filled with ice, can allow spilled oil to move into the frozen soil (Yershov et al. 1997; Chuvilin et al. 2001).

Tundra relief on the coastal plain of the North Slope is low enough to limit the spread of spills. During summer, flat coastal tundra develops a dead-storage capacity averaging 0.5 to 2.3 inches deep (Miller et al. 1980), which can retain 12,600 to 63,000 gallons of oil per acre. Even at high water levels, the tundra vegetation tends to act as a boom, with both vegetation and peat functioning as sorbents that allow water to filter through, trapping the more viscous oil (for example, see Barsdate et al. 1980). On the other hand, even small spills can spread over large areas if the spill event includes aerial, pressured discharge. With the high-velocity, bi-directional winds on the North Slope, oil can be misted substantial distances downwind of a leak (BLM and MMS 2003). For example, in December 1993 an ARCO drill site line failed, and 40 to 160 gallons of crude oil misted over an estimated 100 to 145 acres (Ott 1997).

Seawater spills on tundra generally respond in much the same way as oil spills. The primary difference is that seawater can become more viscous (i.e., freeze) at temperatures just below freezing, depending upon the overall salinity of the seawater. This can prevent the seawater from spreading very far, especially in winter. However, in the summer, seawater can be much less viscous and flow farther through the vegetation than would the same volume of oil. The seawater also is more likely to penetrate farther into the soil and the permafrost to the extent that there are voids in the permafrost. Finally, the salts in seawater do not weather as oil does and these salts would likely persist until they are diluted and/or transported from the area by freshwater flows from precipitation or floods.

Spills into Marine or Fresh Water

Weathering processes generally would be similar in freshwater and coastal marine regimes in the Plan Area. Seasonal ice cover could greatly slow weathering in both regimes.

Oil spreading on the water surface (but not necessarily the transport of oil by moving water) would be restricted in most Plan Area waters. Because of the increased viscosity of oil in cold water, oil spills in Plan Area lakes, rivers, and marine waters would spread less than in temperate fresh or marine waters. The exception to this would be a spill in shallow, marshy, or ponded tundra or flooded lake margins in summer, which could spread similarly to a temperate spill. The exception is possible because these shallower waters are often warmer than other tundra waters (Miller et al. 1980) and warm enough to lower oil-slick viscosity.

An oil spill in broken ice in the Nigliq Channel or Harrison Bay would spread less than on an open lake and would spread between ice floes into any gaps greater than approximately 4 to 6 inches (Free et al. 1982). An oil spill under ice in lakes, rivers, or Harrison Bay would follow the general course described below:

- The oil would rise to the under-ice surface and spread laterally, accumulating in the under-ice cavities (Glaeser and Vance 1971; NORCOR 1975; Martin 1979; Comfort et al. 1983).
- For spills that occur when the ice sheet is still growing, the pooled oil would be encapsulated in the growing ice sheet (NORCOR 1975; Keevil and Ramseier 1975; Buist and Dickens 1983; Comfort et al. 1983).

- In the spring, as the ice begins to deteriorate, the encapsulated oil would rise to the surface through brine channels in the sea ice or water channels in lake ice (NORCOR 1975, Purves 1978, Martin 1979, Kisil 1981, Dickins and Buist 1981, Comfort et al. 1983) or by ablation of the surface layers of ice. If the ice breaks-up before the oil is exposed, then the oil would be transported downcurrent or downwind in the broken ice and could be widely distributed along the creek and riverbanks, in the Colville River Delta and possibly even as far as Harrison Bay.

The presence of currents could affect the spread of oil under the ice if the magnitude of those currents is large enough. A field study near Cape Parry in the Northwest Territories reported currents up to 10 centimeters per second (cm/sec). This current was insufficient to move oil from under the ice sheet after the oil had ceased to spread (NORCOR 1975). Laboratory tests have shown that currents in excess of 0.3 to 0.5 knots are required to move oil collected in under-ice depressions (Cammaert 1980). Current speeds in the nearshore Beaufort Sea, including Harrison Bay, generally are less than 0.2 knots during the winter (Weingartner and Okkonen 2001). The area of contamination for oil under ice could increase if the ice were to move. For example, because the nearshore Beaufort Sea, including Harrison Bay, is in the landfast ice area, the spread of oil from ice movement would not be anticipated until spring break-up; however, once break-up occurs the oil could be moved long distances rapidly.

The weathering processes that act on oil in and along a river or stream are similar in most cases to those for marine spills. The dynamics of a river or stream environment, however, have additional effects on the fate and behavior of spilled oil. Oil entering a river begins to spread in the same manner as in the marine environment, but the spreading motion would be overcome rapidly by the surface current at which point an elongated slick would form. The oil would flow downstream at the speed of the surface current. As the surface current speed increases with channel constriction and decreases with channel widening, the oil movement rate also would increase and decrease as the slick alternately passes through constricted meander bends and wider, straight channel sections. The effect of wind would slow or accelerate the downstream movement if the wind direction parallels that of the channel. With the sinuous character of most North Slope rivers, this could lead to alternate slowing and acceleration as the oil slick moves downstream. A second effect of wind would be to move the oil toward the downwind riverbank, contributing to the stranding of oil. Water near the center of a stream channel generally would flow faster than water near the banks or bottom of the channel where the retarding forces of friction with the channel are greater. This difference in current speed and the resulting shearing forces between water layers is typically the major mixing mechanism that causes a slick to spread as it moves downstream. The resulting spread of the oil along the axis of flow controls the plume shape and size, and the distance over which the oil concentration would remain above a particular level of concern. The leading edge of the slick could move as a relatively sharp front (at the current speed in the middle of the channel), however, mixing would continuously exchange water and oil between the slower, near-bank regions and the faster-flowing, center regions of the river. From a practical point of view, this means that although it would be possible to predict the initial arrival of oil at a point along the river, it would be considerably more difficult to estimate when the threat is past, since the areas of slower currents could continue to supply oil to the main stream channel, even after the leading edge is past (BLM and MMS 2003).

Stream flow is unidirectional in a long, straight channel; however, few natural channels in this region are straight and uniform for more than a few hundred meters. As water flows around a bend in a river, or encounters an eddy, centrifugal force tends to pile water up along the outside edge of the turn. This secondary flow slightly deflects the streamlines in the flow as the river moves around bends. More importantly, secondary flow helps move oil particles across the shear boundaries and greatly increases the spreading, or dispersion, of the slick in the downstream direction. Thus, oils tend to spread more rapidly, decreasing their peak concentrations relative to what would be expected for a straight channel (BLM and MMS 2003). Shear-dominated flows cause another effect that characterizes river spills. Shear in currents along the banks and river bottom are typically the major source of turbulence in rivers, in contrast to surface-wave activity in oceans. Mixing and dispersion caused by the interaction of the shear and the turbulence can move substantial amounts of oil below the surface (particularly if it is relatively dense, such as a heavy fuel or crude oil, or if it is finely distributed as droplets). The shear-dominated river regimes tend to produce spill distributions having higher subsurface oil concentrations than would be expected in marine spills (BLM and MMS 2003). This turbulence increases with increased velocity of flow and bed roughness. In faster flowing conditions, the geographic spread and the affected area could be greater than under slower flow conditions, although local concentrations of oil could be greater for slower streams.

The rate of movement of the leading edge of oil spilled into a river could be virtually the same as the maximum surface current in the river. Near-surface current velocities in the range of one to 2 knots have been measured in the Ublutuoch River, which could result in oil moving downriver approximately 30 to 60 miles per day (PAI 2002a, PAI 2002d, CPAI 2003p). These values provide an estimate for the speed at which the leading edge of a surface oil slick could travel downstream.

For any oil that enters a river, irrespective of flow velocities or water levels, some of the oil would end up on the riverbanks or in flood flows, even on the tundra, and in normally isolated tundra ponds. The most common riverbank substrate material in the Plan Area is sand, and the most common bank forms are sand point bars or channel margin bars and sand- or peat-eroding cut banks. It is not practical to predict or estimate how much oil per unit area would be stranded on a riverbank or reach as this depends on the following factors:

- Physical character of the oil, which would change as the spilled oil weathers
- Physical character of the riverbank material, such as sand, grass, peat etc., which would vary considerably even over short distances
- Speed at which the water would flow at the water-sediment interface
- Size of any wind-generated waves on the river surface that would spread the oil over a band above the water level
- Changes in the water level and flow volume through the time that oil would pass through a reach; these changes would depend upon both season and recent/ongoing storm events

Direction, persistence, and magnitude of winds occurring during and after the oil spill event; strong persistent winds could strand oil against lee banks and/or create surface currents that could be stronger than the instream, near-surface velocities would otherwise be

- Stable vegetated banks where the oil could coat branches, leaves, and grass
- Ponds or channels where the oil is left above the level of the river by falling water levels
- Areas of quiet water or eddies at the inside of river bends on a meandering channel
- Other pools or backwaters where velocities are slower

The NPR-A Oil Spill Experiment

The empirical experience of North Slope personnel responding to an oil spill is not often documented in the technical or peer-reviewed scientific literature. However, an experiment initiated on July 16, 1970 began with an experimental spill of approximately 210 gallons of Prudhoe Bay crude in 0.07-acre tundra Pond E in the NPR-A near Barrow (Miller et al. 1978; Barsdate et al. 1980; Hobbie 1982). The general behavior of this experimental spill bolsters the empirical experience about what to expect for a small spill to a pond or lake in the Plan Area during the summer or for a winter spill that melts out during thaw.

In this experimental spill, the oil spread over the water surface within a few hours to a 0.06-inch thickness. Within 24 hours, the slick thickened, as lighter hydrocarbons evaporated, and shrank into a 10- to 16-foot band on the downwind side of the pond. For approximately a month, the oil moved back and forth across the pond, shifting sides with changes in wind direction. Gradually, the oil worked part way into the pond's vegetated margins. By the end of summer, all of the oil was trapped along the pond margins either on the water's surface or on the bottom. No oil left the pond during the next spring runoff, despite substantial water throughflow. Half of the oil was estimated to have evaporated or degraded within a year, but the rest of the oil remained with little change for at least five years.

The results of this experiment are generally consistent with the empirical experience and observations (mostly undocumented) of resource scientists, resource managers, oil spill response personnel, and others who have responded to and assessed impacts of oil spills on the North Slope over the past 30-plus years.

4.3.3 Summary of Impacts to Resources from Very Small to Large Spills

4.3.3.1 Overview

This section focuses on the potential impacts to each of the resource categories resulting from very small spills (less than 10 gallons and mostly less than one gallon) to large spills (1,000 to 100,000 gallons) (see Section 4.3.2.3). Very large spills (greater than 100,000 gallons) are considered in more detail in Section 4.3.4.

The impact assessment is based on the past 30 years of North Slope experience. The vast majority of spills have been very small or small, contained within the boundaries of the secondary containment, or at least on the gravel pads and roadways, cleaned up expeditiously, and resulted in impacts to the natural resources of the North Slope that are limited in area, duration, and size. However, large spills have occurred or could occur, albeit with low probability, and the impacts of those are included here.

This section summarizes impacts by resource category for Alternative A – CPAI Development Plan. We draw heavily upon and incorporate by reference the impact assessments from the Northwest NPR-A Draft IAP/EIS (BLM and MMS 2003), as well as information in other recent North Slope EISs (BLM and MMS 2002; BLM and MMS 1998b; TAPS Owners 2001a). Substantial differences in Alternatives B through E are then described. To reduce redundancy, there is no repeat of each of the resource-specific impact assessments where they are essentially the same in Alternatives B through D as those in Alternative A.

This section also evaluates the potential impacts of FFD on each resource category in Alternative A. For many of the resources (for example, paleontological, soils, air, economy, visual, and recreational), the impacts would be essentially the same as those for the CPAI Development Plan and, to reduce redundancy, the appropriate descriptions are referenced. For others (for example, fish, spectacled eiders, marine mammals, subsistence use of caribou) where the location of production pads and/or processing facilities result in potential spills affecting resources that the CPAI Development Plan might not, an assessment of potential impacts of the FFD is provided.

4.3.3.2 Spill Scenarios

A range of spill scenarios are provided to facilitate the impact assessment.

Very Small and Small Spills

The most common scenarios are the very small spill and small spill of material, usually diesel, hydraulic fluid, transmission oil, and antifreeze, on gravel pads, roads, and airstrips, or on ice roads and pads. Rarely do these spilled materials reach the tundra or water bodies and when they do, they are usually limited in the area they affect. Some of these small spills are from seawater, oil, or produced fluids lines, and they could occur on the tundra or into water bodies remote from the roads and pads.

Medium and Large Spills

A similar scenario exists for medium-to-large spills except they are much less common and they do occasionally reach the tundra or water bodies adjacent to the roads, pads, and airstrips. Pipeline spills are likely to reach tundra and/or adjacent water bodies, especially if they are large and occur in the ice-free seasons. These spills are more likely to be of seawater, oil, or produced fluids, although medium to large spills of antifreeze, diesel, and drilling muds are not uncommon.

Large Pipeline Spills

Spill scenarios could result in impacts to creeks or rivers, as well as to the tundra. The main features of these scenarios are provided in Table 4.3.3-1. These scenarios were selected as reasonable worst-case incidents in terms of the largest volume that might be spilled to the water body or tundra, and of the diversity and sensitivity of environmental resources that might be impacted.

The first four scenarios in Table 4.3.3-1 are guillotine ruptures of the pipelines crossing a major creek or river. The actual volumes spilled could vary depending upon location and activation methods and times for valves or vertical loops, pressure in the line, actual location of the break, and other factors; however, the type and magnitude of potential impacts is likely to be similar over the potential range of spill volumes.

The tundra spill scenario is a proxy for substantial spill to the tundra of produced fluids, seawater, and, in the FFD, Sales Oil. The actual length of line that drains after rupture could vary substantially, usually being shorter than the estimated 7.8 miles between CD-7 and CD-6. Also, to the extent the pipelines follow the topographic contours and there are low spots in the pipelines (or vertical loops or valves), the amount of oil that spills could be much smaller. However, until the final alignments are determined and the pipelines constructed, the largest and most likely potential spill volumes cannot be estimated accurately.

TABLE 4.3.3-1 POTENTIAL PIPELINE SPILL VOLUMES

		Produced 3-Phase Fluids		Seawater[e]		Diesel		Sales Oil (FFD only)	
Pipeline Segments	Length (ft)	Size (in)[g]	Vol (gal)[a]	Size (in)	Vol (gal)	Size (in)	Vol (gal)	Size (in)	Vol (gal)
Nigliq Channel	2500[b]	24	11,750	14	19,992	–	–	14	23,100
Ublutuoch River	2500[f]	24	11,750	14	19,992	–	–		
CD1-CD3	34,054	18	86,688	10	127,470[c]	2	5,558		
CD22-CD6 (Fish Creek in FFD only)	55,864	24	141,666	14	446,732				
CD7-CD6 (Tundra crossing)[d]	41,184	24	193,571	14	329,340	–	–	14	329,340

Notes:

[a] Assumes that the produced fluids are approximately 20 percent liquid, consisting of oil and brine in some currently unspecified proportion that could be deposited on the surface.
[b] Length of segment that would drain
[c] Based on CPAI response to ENTRIX request for information (Shifflet 2003)
[d] Assumes no valves between pads and the entire segment could drain. Topographic relief of final pipeline route could result in substantially smaller spill volumes.
[e] Static volume assuming entire length of line drains and valves at the ends of the segment stops flow immediately.
[f] Based on the assumption that all major river/creek crossings would have valves or vertical loops approximately 2,500 feet apart on either side of the river.
[g] Pipeline size is inches in diameter.

Proximity to Major Streams and Rivers

Though not a scenario *per se*, the proximity of pads and processing facilities at which medium to very large spills of produced fluids, oil, and seawater, as well as diesel and other materials in bulk storage tanks and containers could occur and the materials could reach water bodies. This is a consideration in the impact assessment. In general, if the spilled material flows to the tundra, the material would not disperse very far. However, if a medium- to-large (or very large) spill reaches a flowing creek or river, the material could be dispersed for substantial distances downstream. In flood flows, the material also could be distributed over the flooded tundra, and into tundra ponds and lakes. As shown in Table 4.3.3-2, most of the pads and hypothetical processing facilities are greater than 0.5 miles from the nearest major river or stream. Whether a spill would reach these rivers or streams would depend upon several variables including the type and volume of material spilled, the topographic relief and slope, air temperature, presence of snow and/or vegetation, and response time and actions.

TABLE 4.3.3-2 PROXIMITY OF POTENTIAL PRODUCTION PADS AND PROCESSING FACILITIESTO NEAREST MAJOR RIVERS AND STREAMS IN CPAI DEVELOPMENT PLANAND FFD SCENARIOS

Facility	Nearest Major Stream	Approx. Distance (miles)
CD-3	Tamayagiaq Channel	<1.0
CD-4	Nigliq Channel	<0.5
CD-5	Nigliq Channel	2
CD-6	Fish Creek	2
CD-7	Judy Creek	3
CD-8	Fish Creek	<0.5
CD-9	Judy Creek	2
CD-10	Fish Creek	<0.5
CD-11	Colville River	1.5
CD-12	Sakoonang Channel	1
CD-13	Ublutuoch River	2
CD-14	Tamayayak Channel	<1.0
CD-15	Nigliq Channel	<1.0
CD-16	Colville River	3
CD-17	Ublutuoch River	2
CD-18	Colville River	1.5
CD-19	Kupigruak Channel	<0.5
CD-20	Elaktoveach Channel	<1
CD-21	Colville River	<0.5
CD-22	Tingmeatchsiovik	<0.5
CD-23	Judy Creek	1
CD-24	Judy Creek	1.5
CD-25	Fish Creek	3
CD-26	Judy Creek	2
CD-27	Kalikpik River	<0.5
CD-28	Kogru River	4
CD-29	Kogru River	<0.5
APF-2	Judy Creek	<1.0
APF-3	Kalikpik River	2

4.3.3.3 Resource Specific Impact Assessment

Soils

Spills that are not confined to ice or gravel pads and roads could affect the soils, especially where there is little to no vegetation or snow cover to provide a barrier and “sorbent” for the spilled material. Crude oil in the produced fluids and Sales Oil (FFD only), lubricating oil, and similar heavy oils would be less likely to reach the surface soil layers than would refined oil (for example, diesel), which could infiltrate through the vegetation. Seawater is likely to reach the soil especially in the warmer snow-free seasons because its low viscosity would allow it to penetrate the vegetation and even thin snow layers. The depth of penetration of oil into the soil would depend on the porosity of the soil and the extent to which it is frozen or saturated with liquid water. The area affected would be limited to that area immediately adjacent to and covered by the spill.

Spills could affect soils indirectly by affecting the vegetation, which in turn could die and expose the soil to thermokarsting, wind erosion, etc., even if the soil itself were not directly affected by the spilled material.

Spill cleanup is more likely to affect the soils than the presence of the spilled material itself unless the cleanup is well controlled and heavy traffic and digging are minimized (especially for summer spills). Spill cleanup mitigates impacts on soils only if cleanup methods and operations are very carefully controlled and minimize surface disturbance.

Spilled seawater would be likely to infiltrate to and into the surface soil layers, even if there is vegetation or snow cover. Depending on the porosity of the soil and the extent to which the pore spaces are filled with ice, the seawater could penetrate to or below the tundra vegetation root zone. In locations such as the outer regions of the Nigliq Channel and Colville River Delta, as well as the estuarine region of Fish Creek, where the vegetation includes halophytic (salt-tolerant) plants, the impacts of seawater spills could be of smaller magnitude and duration than in most of the rest of the tundra where the plants are non-halophytes. The soils affected by seawater spills could take several years to return to normal, depending on the amount of flushing from precipitation and flooding.

This impact assessment also applies to the FFD for the Plan Area. Seawater spills could have a lesser impact on the soils supporting halophytic plants in the estuarine reaches of the Kogru River and Kalikpik River because (1) the halophytic plants are salt tolerant, and (2) all but a large to very large seawater spill are likely to be substantially diluted with the Kalikpik River freshwater flow by the time the spilled seawater reaches the estuary located several miles downstream from the hypothetical pipeline crossing.

Paleontological Resources

Most spills are confined to a pad or roadway or to an area adjacent to them. The primary exceptions are spills from pipelines to tundra, remote from the roads and pads. In the construction stage, most spills would occur on an ice pad or ice road during winter conditions, where snow and ice would limit impacts to paleontological resources and cleanup is less invasive than in a summertime terrestrial spill. In any case, paleontological resources usually are so deeply buried that they would not be affected by either a spill or subsequent spill cleanup. The effects of spills and spill cleanup associated with drilling and production would be similar to those associated with construction activities except that they could occur during the snow-free months. Although cleanup from these spills might be more invasive because of the non-frozen surface environment, there is little chance that subsurface paleontological resources would be affected. If present, surface paleontological remains could be affected in the same manner as surface cultural material. However, because the occurrence of surface paleontological remains is rare, and where known, would be avoided by plan facilities, the probability of any impact is remote.

This impact assessment also applies to the FFD for the Plan Area.

Water Resources

In the unlikely event that spilled material flows to or is deposited on the water bodies near the pads and/or leaks from a pipeline, it could affect the water resource value of that water body. The primary resource use of water bodies, other than as habitat for wildlife and fish, is to support the oilfield activities. A key use is water from the Permitted Lakes (see Figure 2.4.1.1-7). In the CPAI Development Plan, there is a potential for a medium to large spill from pipelines or from a vehicle or equipment on roads to reach these lakes between CD-7 and CD-6, and near CD-3 in Alternatives A, B, and C. In Alternative D (the roadless alternative), the likely potential source would be only from pipelines.

If the spilled material is oil, cleanup actions could adversely affect water resources until the petroleum residue weathers or could be flushed from streams. This process could take a few weeks in a fast-flowing stream to a few years in lakes and ponds.

Spills of chemicals and saline waters would be rapidly diluted and have little impact in a large lake or river. In small lakes, tundra ponds, and shallow water tracks, the impacts could be greater, with waters remaining toxic to sensitive species for up to a few years. These spills could be pumped out of the water body, if confined, or neutralized, and then diluted with uncontaminated freshwater.

This impact assessment also applies to the FFD for the Plan Area. In the FFD, there are additional Permitted Lakes near CD-23 and APF-2, near the road between CD-9 and CD-17, and near the pipeline and road between CD-5 and Nuiqsut that could also be affected.

Surface Water Quality (Fresh Water)

Spills could affect freshwater quality if the spilled material reaches water bodies either directly or from flowing over the tundra. However, the vast majority of all spills are confined to a pad, road, or airstrip, to an adjacent area, or to the area under a pipeline. Most spills are very small to medium in volume (i.e., fewer than 1,000 gallons). In addition, spill response could remove almost all of an oil, chemical, or drilling mud spill from frozen tundra or ice-covered water bodies prior to snowmelt for two-thirds of the year. During one-third of the year (late May through late September) any spills could reach and affect wet tundra and tundra ponds and lakes, as well as creeks and rivers before spill response is initiated or completed.

If the spilled material, especially petroleum hydrocarbons and other organics, reach the freshwater bodies, there could be an impact to water quality in reduced dissolved oxygen concentrations and increased toxicity to aquatic organisms.

Dissolved-oxygen concentrations in tundra waters could be affected by spilled oil in summer. The NPR-A experiment (Section 4.3.2. 4) provides an illustration of the potential impacts. In summary, 210 gallons of Prudhoe Bay crude were spilled into a 0.07-acre tundra pond. Dissolved-oxygen concentrations a week after the spill were reduced by approximately 4 milligrams per liter (mg/l) below levels in a control pond, and some measurements within inches of the surface, just under the slick were less than 5 mg/l (state standard for protection of wildlife). At the 4-inch water depth (average pond depth, [Miller et al. 1980]), outside the slick, oxygen concentration was within the expected normal range of 10.8 mg/l versus 11.4 mg/l in the control pond. The oxygen deficit under the slick (and also in the shallower waters of the control pond) was attributable to decreased oxygen influx from the air because of the relative impermeability of the oil slick to oxygen and to the relatively high rate of natural sediment respiration in coastal tundra ponds. The oxygen deficit was not attributable to oil-enhanced respiration of oil-biodegrading microorganisms in the pond.

In winter, even under ice, an oxygen deficit would not be expected to result from a small spill in most waters because low biological abundance and activity means that sediment and water column respiration rates are low to negligible. In addition, sediment respiration has even less relative effect in the thicker water column of lakes deep enough not to freeze solid in winter. Such lakes, even those that hold fish, tend to be supersaturated with dissolved oxygen in winter, to levels above the state water-quality standard of 110 percent saturation (BLM and MMS 1998). An exception might be if a spill were to occur underneath thick ice cover in very restricted waters holding a concentrated population of overwintering fish that already has depleted oxygen levels. These low oxygen concentrations could occur in the deeper pools of the Colville River, Nigliq Channel, and several of the other rivers and creeks in the Plan Area.

During open water periods, there would be no detectable impacts on dissolved oxygen levels due to the spilled materials in the Colville River Delta, Nigliq Channel, Ublutuoch River, and, for the FFD in Fish-Judy creeks, and Kogru River. The relatively river high volume (relative to the volume of oil) and the high rate of water flow would dilute the oil before there were any effects on dissolved oxygen concentrations.

The primary effect of a very small to large oil spill on tundra water quality would be from direct toxicity to aquatic organisms. Long-term toxicity (up to seven years) can result from a small spill, as shown in the NPR-A experimental pond spill. In a real oil spill, response likely would recover the bulk of spilled oil, but sufficient oil could remain trapped in the sediments and/or aquatic vegetation to promote long-term, low-level toxicity on a local basis. In larger lakes and creeks or rivers, long-term toxicity would be less likely to occur because the oil would be diluted in the larger water volumes and/or dispersed with the sediment over large areas by currents and wind/wave action. Spills into the larger rivers and creeks (e.g., Colville River Delta, Nigliq Channel, Ublutuoch River, and, for the FFD in Fish-Judy creeks, and Kogru River), especially during open water periods, might have toxicity impacts limited to the first few reservoir pools downcurrent of where the spill entered the river because of the large and rapid dilution of the oil relative to the flow volumes. In the smaller flowing creeks, the lower relative volume and rate of water flow, especially compared to a medium- to large-spill volume, could have direct toxicity impacts in the water column and sediments. Some toxicity might persist in these creeks for a few weeks to years, until toxic compounds were washed out of the oil trapped in the sediment or the oiled sediment was buried under cleaner sediment.

An oil spill reaching the larger tundra lakes (e.g., Oil Lake, Nanuk Lake; see Figure 2.4.1.1-7) also would result in a minimal effect on water quality. Dissolved oxygen levels would not be affected. Direct toxicity would be minimal because of the much greater dilution volume in these lakes than in the small ponds and lakes, and because of the relatively unrestricted movement of slick and underlying water. The spreading of the spill over the lake surface could be considered an effect on water quality. This effect would exist for a few weeks, until either the slick was cleaned up, or the oil stranded on the shoreline.

A seawater spill to any of the freshwater bodies would greatly exceed state freshwater quality standards (State of Alaska, ADEC 1997), which prohibit total dissolved solids or salinity from exceeding 1,500 mg/L (1.5 percent) salinity. The treated seawater from Kuparuk Seawater Treatment Plant is approximately 3.3 percent (33 ppt) much of the year and the brine in the produced fluids is likely to be approximately 2 percent (CPAI 2003q). In a year with high rainfall, some of the salt would be diluted and flushed from the tundra ponds and lakes in summer. Some of the seawater could settle into the deepest reaches of the contaminated waters. The freeze/thaw cycle in the Arctic and the depth of any lake reached by the spill would play a controlling role in the fate of the remaining contaminating salts from a spill. (Hobbie 1984, Prentki et al. 1980, Miller et al. 1980, O'Brien et al. 1995). Salinity above state standards could persist for several years, especially in deeper lakes and ponds.

There are likely to be fewer spills that would affect freshwater bodies in Alternative D than in Alternatives A through C because there would be much less vehicle and heavy equipment traffic in the ice-free season when the freshwater bodies are most vulnerable. There would be more winter traffic and thus a greater chance of bulk container spills in Alternative D, but the spills are likely to be cleaned up quickly.

This impact assessment also applies to the FFD for the Plan Area.

Marine and Estuarine Water Quality

Marine

Very small to medium spills (i.e., up to 1,000 gallons) and even most large spills (i.e., up to 100,000 gallons) of oil or other hazardous materials are unlikely to reach marine waters of Harrison Bay or the nearshore Beaufort Sea in measurable amounts. Even if these spills reach the flowing waters of the creeks and rivers, the volume of the spilled material would be diluted before it is discharged to the marine waters where it would be diluted rapidly to very low concentrations approaching ambient conditions. There are no proposed facilities or pipelines on the marine coastal zone and, with exception of CD-29, CD-12, CD-20, and CD-21 in the FFD, the sources of spilled material are far enough from marine waters that, by the time spilled material reaches the marine waters, the spilled material would have no impact.

If a medium to large spill enters a river resulting from an undetected slow leak, the oil could be transported over the landfast ice in the marine environment during break-up before it could be cleaned up. The transport of the oil along with ice and freshwater would occur during the break-up floods. The flood flow volumes would dilute the oil and disperse it over a large area of the landfast sea ice where it would be further diluted as it mixes with the marine water and flood waters. The dilution factor is likely to be great enough that the oil would be essentially undetectable in the marine waters.

Any spill of seawater that is eventually transported to the marine environment would have no impact on the marine water quality of organisms. The seawater is near to ambient salinity so that even if it could be discharged directly to the marine waters (there are no sources proposed in the CPAI Development Plan or the FFD that are likely to result in this), the spilled seawater would rapidly be diluted to ambient salinity.

Estuarine

Most spills are small and would not leave the pads, roads, airstrips, or other facilities, so they would not affect estuarine water quality or resources. Spills (primarily medium to large) from pipelines directly into rivers and creeks flowing to the Nigliq Channel, Colville River Delta, and/or Harrison Bay or lower Kogru River, could affect estuarine water quality at the mouths of these rivers and could measurably degrade estuarine water quality and shorelines of the Plan Area. Spilled oil would persist on some types of shoreline for many years, and possibly for more than a decade. (www.oilspill.state.ak.us/facts/lingeringoil.html).

If a medium to large oil spill were to occur during the open water or broken-ice seasons from the pipeline between CD-1 and CD-3, especially where the pipeline crosses the channels in the Colville River Delta, or from the CD-3 pad, the oil could reach the estuarine waters of the Colville River Delta and lower Harrison Bay. This oil could be dispersed over and dissolved in the water column, and could be incorporated into the sediments (BLM and MMS 2002). The oil could measurably degrade estuarine water quality and contaminate shorelines, in spite of proposed spill responses. The Liberty EIS (MMS 200eb) concluded that hydrocarbons dispersed in the water column from a medium to large (greater than or equal to 21,000 gallon) oil spill could exceed the 1.5-ppm acute toxicity criterion during the first day in the immediate vicinity of the spill (BLM and MMS 2002). Further, the hydrocarbon concentration could exceed the 0.015-ppm chronic criterion for up to 30 days in an area that ranges up to 70 square miles, which would include the size of most of the estuarine habitats in the Plan Area.

This impact assessment also applies to the FFD for the Plan Area. In the FFD, additional estuarine habitats that might be affected include the mouths of Fish and Judy creeks, Kalikpik and Kogru rivers, and the northeastern Colville River Delta near CD-11, CD-14, CD-19, CD-20, and CD-21.

Air Quality

Based upon modeling work by Hanna and Drivas (1993), the volatile organic compounds (VOC) from crude oil spills likely would evaporate almost completely within a few hours after the spill occurred. Concentrations of VOCs, such as benzene, ethylbenzene, xylene, and toluene, peak within the first several hours after the spill starts and are reduced by two orders of magnitude after approximately 12 hours. The heavier compounds take longer to evaporate and might not peak until approximately 24 hours after spill occurrence. Total ambient VOC concentrations are often measurable soon after and in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day. In the event of an oil spill on land in the NPR-A, the air quality effects would be less severe than on water because some of the oil could be absorbed by vegetation or into the ground, but some effects might last longer before the VOC compounds completely dissipated.

Diesel fuel oil could be spilled either while being transported or from accidents involving vehicles or equipment. A diesel spill would evaporate faster than a crude oil spill. Ambient hydrocarbon concentrations would be higher than with a crude oil spill, but would also persist for a shorter time. Also, since any such spill would probably be smaller than potential crude oil spills, any air quality effects from a diesel spill likely would be even lower than for other spills.

There would be no air quality impacts associated with seawater spills.

The air quality impacts of oil spills would be localized, short term, and have little impact on the biological or physical resources of the Plan Area in either the CPAI Development Plan or the FFD.

Vegetation

Most spills occur on ice or gravel pads, roads, and airstrips, and the spilled material does not leave the facility. Consequently, their effects would not reach, and would have no impact on the vegetation. However, some of the medium to large spills could reach the adjacent tundra vegetation by (1) directly flowing from the facility, (2) depositing from aerial dispersal of fluids from a pressurized pipeline leak, or (3) spilling from a pipeline over the tundra.

Approximately 60 percent of the year, there is sufficient snow cover to allow spill cleanup efforts to occur before spilled materials reach vegetation. Thus, there would not be an impact to vegetation from these spilled materials. However, there might be an impact from the cleanup operations if they are not implemented carefully and with regard for minimal disturbance of the surface soils and vegetation.

Most oil spills would cover less than an acre and potentially up to several acres if the spill were a windblown mist. Overall, past spills on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown a good potential for recovery with wetter areas recovering more quickly (Jorgenson and Martin 1997; McKendrick 2000b). Oil spills on wet tundra kill the moss layers and aboveground parts of vascular plants and sometimes kill all macroflora at the site (McKendrick and Mitchell 1978). Damage to oil-sensitive mosses could persist for several years, if the site is not rehabilitated (McKendrick and Mitchell 1978). The length of time a spill persists depends upon soil moisture and the concentration of the product spilled. McKendrick (2000b) reported that complete vegetation recovery occurred within 20 years on a wet sedge meadow without any clean up. A dry habitat exposed to the same application supported less than 5 percent vegetative cover after 24 years. For the most part, tundra oil spills would be very local (less than one acre) in their effects and would not be expected to contaminate or alter the quality of habitat. However, some local contamination of tundra vegetation is expected to occur near production wells and processing facilities. Spills that occur within or near streams and lakes could affect foraging habitat along these water bodies.

A spill of seawater has the potential to affect vegetation. The size of the area affected would depend on the terrain and land cover at the spill site and would be proportional to the amount of seawater spilled. If such a spill were to occur within a community of halophytic plant species, there could be little effect. Otherwise, depending on the specific situation under which the spill occurred, the result could vary from little impact to total plant death in the area affected, with eventual replacement of the vegetation community by halophytic species. According to McKendrick (1999b, 2000b), brine (and other seawater) spills kill plants on contact and increase soil salinity to the point that many species cannot survive. Unlike oil, salts are not biodegradable, and natural recovery occurs only after salts have leached from the soil. A spill would have adverse effects on salt-intolerant vegetation near the seawater pipeline, but the amount of tundra habitat affected would be small, no more than a few acres. Thus, potential saltwater spills are not likely to affect forage availability for caribou, muskoxen, moose, or other terrestrial mammals in the Plan Area.

The potential impacts to vegetation could be less in Alternative D (roadless) than for Alternatives A through C because there would be less risk of oil spills from vehicle and heavy equipment accidents during the ice/snow-free season. The increase in vehicle and equipment, as well as bulk fuel transport in winter in Alternative D, could result in more spills on ice roads and pads, but the spilled material would be contained by and cleaned up from the snow and ice before it could contact the vegetation.

This impact assessment also applies to the FFD for the Plan Area.

Fish (Freshwater and Anadromous/Amphidromous)

Spills could affect freshwater and anadromous/amphidromous fish while they are in freshwater (hereafter called freshwater fish in this section), if the spilled material reaches fish habitats either directly or from flowing over the tundra. However, the vast majority of all spills are confined to a pad, road, or airstrip, to an adjacent area, or to the tundra area under a pipeline. Most spills are very small to medium in volume (i.e., less than 1,000 gallons). Finally, spill response would remove almost all of an oil, chemical, or drilling mud spill from frozen tundra or ice-covered water bodies prior to snowmelt for two-thirds of the year. During one-third of the year (late May through late September) any spills could reach and affect tundra ponds and lakes, as well as creek's and river's waters, before spill response is initiated or completed.

The effects of oil spills on freshwater fish have been discussed in previous Beaufort Sea EISs (e.g., BLM and MMS 2002; USACE 1999), which are incorporated here by reference and summarized. Oil spills have been observed to have a range of effects on North Slope fish. (For more detailed discussions, see Starr, Kuwada, and Trasky 1981; Hamilton, Starr, and Trasky 1979; and Malins 1977.) The specific effect depends on the concentration of petroleum present, the length of exposure, and the stage of fish development involved (eggs, larva, and juveniles are most sensitive). If lethal concentrations are encountered (or sub-lethal concentrations over a long enough period), fish mortality might occur. However, mortality caused by a petroleum-related spill is seldom observed outside the laboratory environment. Most acute-toxicity values (96-hour lethal concentration for 50 percent of test organisms [LC50]) for fish are generally from 1 to 10 ppm of the toxic hydrocarbons. Concentrations observed under the oil slick of former oil spills at sea have been less than the acute values for fish and plankton. For example, extensive sampling following the *Exxon Valdez* oil spill (approximately 11,000,000 gallons in size) revealed that hydrocarbon levels were well below those known to be toxic or to cause sub-lethal effects in fish and plankton (Neff 1991). The low concentration of hydrocarbons in the water column following even a large oil spill appears to be the primary reason for the lack of lethal effects on fish and plankton. The concentration in flowing rivers and creeks of the Plan Area also would be relatively low, even for medium to large oil spills.

However, if an oil spill of sufficient size were to occur in a small body of water containing fish with restricted water exchange (e.g., tundra ponds, small slow-flowing creeks), lethal and sub-lethal effects could occur for the fish and food resources in that water body. Toxic concentrations of oil in a confined area would have greater lethal impacts on larval fish versus adults. McKim (1977) reviewed results from 56 toxicity tests and found that, in most instances, larval and juvenile stages were more sensitive than adults or eggs. Increased mortality of larval fish is expected because they are relatively immobile and are often found at the water's surface where contact with oil is most likely. Adult fish could be able to avoid contact with oiled waters during a spill in the open water season but survival would be expected to decrease if oil were to reach an isolated pool of ice-covered water.

An example of the impacts to fish food resources is provided by Barsdate et al. (1980), who studied the limnology of an arctic pond near Barrow with no outlet, after an experimental oil spill. They found that half of the oil was lost during the first year. The remaining oil was trapped along the edge of the pond; most of it sank to the bottom by the end of summer. Researchers found no change in pH, alkalinity, or nutrient concentrations. Photosynthesis was briefly reduced and then returned to normal levels after several months. *Carex aquatilis*, a vascular plant, was affected after the first year because of emerging leaves encountering oil. Certain aquatic insects and invertebrates that lived in these plant beds were reduced in numbers, presumably from entrapment in the oil on plant stems. Some of the insects were still absent six years after the spill. There were no fish in this pond, therefore, the impact of the loss of a prey base to the fish could not be measured. Reducing food resources in a closed lake or pond, as described above, would decrease fitness and potentially reduce reproduction until prey species recovered.

Another potential impact could occur if oil that spilled before or during the spring floods was dispersed into some of the tundra lakes that have continuous or ephemeral connection to the rivers and large creeks (see Section 3.3.2.2 for discussion of perched, tapped and drainage lakes). These lakes are normally not connected to the river/creek system except during the spring and maybe fall high-water periods. Fish are transported to these lakes and become “landlocked” until the next high-water event. If the oil concentrations in the water column reach toxic levels, these fish could suffer mortalities or injury.

Although lethal effects of oil on fish have been established in laboratory studies (Rice et al. 1979; Moles et al. 1979), large kills following oil spills are not well documented. This is likely because toxic concentrations are seldom reached. In instances where oil does reach the water, sub-lethal effects are more likely to occur, including changes in growth, feeding, fecundity, survival rates, and temporary displacement. Other possibilities include interference with movements to feeding, overwintering, or spawning areas, localized reduction in food resources, and consumption of contaminated prey.

Most oil spills are not expected to have a measurable effect on arctic fish populations in the Plan Area over the life of the CPAI Development Plan or the FFD. Oil spills occurring in a small body of water containing fish with restricted water exchange might be expected to kill a small number of individual fish, but are expected to have no measurable effect on arctic fish populations.

The effects of seawater spills on freshwater fish populations would depend on the specific location, size, and timing of the spill. No effect would be expected during the winter period when the surface is already covered by ice. During the spring and summer, large quantities of seawater entering a fish-bearing freshwater environment would have from no effect on freshwater fish to lethal effects, depending on the specific water body involved, the size of the seawater spill into that water body, and the rate of freshwater exchange within that water body. Migratory fish are less likely to be affected by seawater spills because of higher tolerance to seawater and the probability that most would have already left the freshwater environment by spring in their migration to sea. In large freshwater bodies, seawater spills are expected to have from no effect to sub-lethal effects on freshwater fish because the seawater would be rapidly diluted to ambient salinity. In small water bodies with restricted water exchange, lethal effects could result from a medium to large seawater spill. Because of the small size of most of the seawater spills anticipated, and the low diversity and abundance of freshwater fish in most of the Plan Area, seawater spills are not expected to have a measurable effect on arctic fish populations in the Plan Area over the production life of the field.

This impact assessment also applies to the FFD for the Plan Area.

Marine Fish

In the CPAI Development Plan, even the large spills are unlikely to reach the marine waters of Harrison Bay at concentrations that would affect marine fish or their prey (see Section 4.3.3). A large spill from CD-3, or the pipelines between it and CD-1, could affect the estuarine fish in the Colville River Delta but probably would be diluted by the time the spill reached the much larger volume of marine water in Harrison Bay.

In the FFD, a large spill from CD-21, CD-20, or CD-19 could have the same limited impact to marine fish as a spill from CD-3, while a large spill from CD-29 could have a limited impact to the marine fish in the adjacent nearshore Beaufort Sea. The impacts are likely to be low-level chronic toxicity effects that would disappear in a few hours to days with additional dilution and weathering of the toxic materials.

Birds

Most spills are very small to medium volume and are contained on the ice or gravel pads, roads, and airstrips. If the spill does leave the gravel or ice structures, it is usually confined to small areas of the tundra vegetation and small ponds adjacent to the structure. Most pipeline spills are also contained on the tundra or tundra ponds, especially during the two thirds of the year when there is snow and ice over the tundra and water bodies. Some small to medium spills from pipelines or from vehicle accidents on bridges and culverts could result in spilled material entering flowing water bodies.

There would be no impact of the spills on or near the roads, pads, or airstrips to populations of birds, although there could be a few individual shorebirds, waterfowl, and very few passerine birds that would be exposed to the spilled material, especially oil. These individuals are likely to die from hypothermia or from toxic effects of ingesting the spilled material. There could be some impact to a few individual birds, especially waterfowl and shorebirds using the small tundra ponds and creeks affected by the small to medium spills. Again, there would not be a population-level impact.

A large spill onto “dry” tundra could cause the mortality of small numbers of shorebirds and passerines from direct contact, especially with oil. If the spilled material were to enter local or inter-connected wetlands, small numbers of loons and waterfowl, plus additional shorebirds, could be exposed. Numbers of individuals oiled would depend primarily upon wind conditions, and numbers and location of birds following entry of the spill into the water. If the spill were to enter a creek or river, ranging from the many small creeks in the Plan Area to the Nigliq Channel and Colville River Delta, a variety of waterfowl and shorebird species could be present, particularly where the river empties into the estuarine environment. Such losses are likely to represent negligible impacts at both the local and regional population level.

If gyrfalcons, peregrine falcons, or rough-legged hawks were breeding in the spill vicinity, they could become secondarily oiled by preying on oiled birds. Mortality of breeding falcons likely would represent a minor loss for the local population, but (as with rough-legged hawks) is not likely to affect the regional population.

If a large spill were to move into the Colville River Delta, mouth of the Nigliq Channel, or the estuarine habitats of the other major rivers in the Plan Area, several waterfowl species that breed, stage, or stop there during migration would be at risk. A spill entering a river in spring could contaminate overflow areas or open water where spring migrants of several waterfowl species concentrate before occupying nesting areas.

It is unlikely that even a large spill would reach the marine environment with a substantial concentration of floating oil. If it did, it could contact loons and flocks of brant, long-tailed duck, and eiders staging before or stopping during migration in protected coastal habitats, as well as black guillemots year-round or Ross' gulls in fall. Physiological effects on individual birds would be the same as described in the Northeast NPR-A IAP/EIS (BLM and MMS 1998). Lethal effects are expected to result from moderate to heavy oiling of any birds contacted. Light to moderate exposure could reduce future reproductive success because of pathological effects that interfere with the reproductive process caused by oil ingested by adults during preening or feeding.

Some brood-rearing, molting, or staging loons, brant, long-tailed ducks, or other waterfowl could contact oil in coastal and estuarine habitats. Mortality of molting long-tailed ducks from a spill entering protected areas could be substantial, but the population effect would be difficult to determine because numbers of that species are stable, declining, or increasing in various areas (Conant et al. 1997; Larned et al. 2001). Flocks of staging eiders could contact oil in nearshore or offshore areas. In addition, several thousand shorebirds could encounter oil in shoreline habitats (e.g., river deltas), and the rapid turnover of migrants during the migration period suggests many more could be exposed. A spill that enters open water off river deltas in spring could contact migrant loons and eiders.

A pipeline spill of salt water used in the waterflood enhancement stage of production would kill salt-intolerant tundra vegetation near the pipeline. The amount of tundra habitat affected is expected to be no more than a few acres. Such a small area of degraded habitat is not likely to result in loss of productivity by displaced breeders and the loss will not be detectable at the population level.

Marine Mammals

Any spills to the tundra that do not reach a flowing river or creek would not affect marine mammals.

Most spills are very small to medium in volume and are contained on the ice or gravel pads, roads, and airstrips. Most pipeline spills also are contained on the tundra, especially during the two-thirds of the year when there is snow and ice over the tundra and water bodies. There would be no impact of these spills to marine mammals.

Large spills that directly or indirectly enter flowing water of the rivers or creeks that discharge to Harrison Bay, the Colville River Delta (including the lower Nigliq Channel), and Kogru River mouth could have limited impacts on some of the marine mammals.

There should not be impacts to migrating bowhead whales whose migration route typically is well offshore of Harrison Bay and the immediately adjacent nearshore Beaufort Sea, where low concentrations of oil from a large spill might occur in open water season. Any spill reaching this marine environment would disperse to undetectable levels before it reaches migration routes and offshore habitats of the bowhead.

Some seals could be exposed to oil if a spill were to reach the marine environment of Harrison Bay or the areas they occupy in the Colville River Delta, lower Nigliq Channel, Kogru River, and the adjacent nearshore Beaufort Sea during the open water season. Such an event could result in the oiling of those seals directly exposed. It is possible, though unlikely, that a small number of these exposed seals could die, but the population would be likely to replace this loss within one year.

A large spill would not be likely to affect many bearded seals, walruses, beluga or gray whales because these species tend to occur offshore of Harrison Bay. Such a spill would be expected to disperse before it reached the migration routes and offshore habitats of these species. Such a spill would not be likely to have any food chain effects on marine mammals.

Polar bears would be most vulnerable to an oil spill were the spill to reach the coastal habitats of Harrison Bay. The number of bears likely to be contaminated or to be indirectly affected by a local contamination of seals probably would be small. Even in a severe situation where a concentration of perhaps 10 bears (such as at a whale-carcass site) were to be contaminated by the spill and all 10 bears were to die (a highly unlikely worst-case situation), this one-time loss would not be expected to affect the regional polar bear population.

In the CPAI Development Plan, a large spill from CD-3 or the pipeline between CD-3 and CD-1 where it crosses river channel,s or from the Nigliq Channel crossing are the most likely to have any impact on marine mammals, primarily polar bears foraging in the coastal areas and on seals in the Nigliq Channel. All other potential sources are far enough from the marine environment that spills are not likely to reach the marine mammals. There is a slightly reduced risk of large spills occurring in the ice-free season in Alternative D, compared to Alternatives A through C, because of the lack of vehicles and heavy equipment that might spill a container or tank of material or that could cause a rupture of a pipeline over a bridge, such as the Nigliq Channel or Ublutuoch River.

In the FFD, the same impact assessment is generally applicable. However, large spills from additional pads (CD-29, CD-12, CD-14, CD-19 to CD-21) plus the pipelines connecting them to flowing waters also could have similar impacts to marine mammals as described for CD-3.

Terrestrial Mammals

Most spills would be very small to medium volume and would remain on the ice or gravel pads, roads, and airstrips where they would be expeditiously cleaned. Some of the spilled material, especially from the medium spills, might reach the tundra adjacent to the gravel or ice structures. In addition, small spills from pipelines could reach the tundra anywhere along the pipeline and affect the tundra. These spills, especially oil, would have a very limited impact on the terrestrial mammals found in the Plan Area. The extent of impacts would depend upon the type and amount of materials spilled; the location of the spill; the type of habitat impacted; the mammals' distribution, abundance, and behavior at the time of the spill; and the effectiveness of the response. The proportion of habitat impacted would be very small relative to the size of the habitat utilized by most of the mammals. In addition, most of the mammals would not be present or would be limited in abundance and distribution in the Plan Area during the winter months; they would not be exposed to winter spills. The potential impacts to terrestrial mammals of these small to medium spills would be lower for Alternative D than for Alternatives A through C because the risk of spills to the habitat during the early summer through fall period is lower with the reduction of vehicle and equipment traffic.

A large spill that reaches the tundra adjacent to the gravel or ice pads, roads, or airstrips, or pipeline corridors could affect the terrestrial mammals directly or indirectly through impacts to their habitat and/or prey.

Caribou and other terrestrial mammals such as moose and muskoxen could become oiled by direct contact with oiled vegetation or soil, or by ingesting contaminated vegetation. Adult caribou, moose, and muskoxen that become oiled are not likely to suffer from a loss of thermal insulation during the summer, although toxic hydrocarbons could be absorbed through the skin or inhaled. However, the oiling of young calves could reduce thermal insulation, leading to their death (BLM and MMS 1998). Oiled caribou, moose, and muskoxen hair would be shed during the summer before the winter fur is grown. If caribou were oiled in the winter after shedding their summer coats, oiling would not be expected to affect thermal insulation, because the outer guard hairs of caribou are hollow. No documented caribou deaths have been attributed to the spills associated with TAPS. Toxicity studies of crude-oil ingestion in cattle (Rowe et. al. 1973) indicate that anorexia (measurable weight loss) and aspiration pneumonia leading to death are possible adverse effects. Caribou, moose, and muskoxen that become oiled by contact with a spill in contaminated lakes, ponds, rivers, or coastal waters could die from toxic hydrocarbon inhalation and absorption through the skin.

A large spill would likely affect tundra vegetation, the principal food of the larger mammals. Caribou, moose, and muskoxen probably would not ingest oiled vegetation, because they tend to be selective grazers and are particular about the plants they consume (Kuropat and Bryant 1980). For most spills, control and cleanup operations (ground traffic, air traffic, and personnel) at the spill site would frighten caribou, moose, and muskoxen away from the spill and reduce the possibility of these animals grazing on the oiled vegetation. In most cases, onshore oil spills are not expected to affect caribou, moose, and muskoxen through ingestion of oiled vegetation. However, the spilled material could affect the vegetation and reduce its availability as food for several years (see Section 4.3.3), though this impact would be limited in area and not affect the overall abundance of food for the grazing mammals.

For large spills that are not immediately or successfully cleaned up, the potential for contamination would persist for a longer time and there would be a greater likelihood of animals exposed to the weathered oil. Cleanup success could vary depending upon the environment. Over time, any remaining oil would gradually degrade. Although oiling of animals would likely not remain a threat after clean-up efforts, some toxic products could remain for some time. Depending upon the spill environment, part of the oil could persist up to five years (BLM and MMS 1998).

Grizzly bears depend on coastal streams, beaches, mudflats, and river mouths during the summer and fall for catching fish and finding carrion. If an oil spill were to contaminate beaches and tidal flats along the Harrison Bay coast or the Colville River Delta, or the shore of other water bodies in the Plan Area, some grizzly bears would likely ingest contaminated food, such as oiled birds, seals, or other carrion (BLM and MMS 1998). Such ingestion could result in the loss of a few bears. Brown bears on the Shelikof Strait coast of Katmai National Park (an area contacted by the *Exxon Valdez* oil spill) were observed with oil on their fur and were consuming oiled carcasses (Lewis and Sellers 1991). A study of the exposure of Katmai National Park brown bears to the *Exxon Valdez* oil spill through analysis of fecal samples indicated that some bears had consumed oil or were exposed to oil; one young bear that died had high concentrations of aromatic hydrocarbons in its bile and might have died from oil ingestion (Lewis and Sellers 1991). Anecdotal accounts of polar bears deliberately ingesting hydraulic and motor oil, and foreign objects from human garbage sites, suggest that both bear species are vulnerable to ingesting oil directly, especially from oiled carrion and other contaminated food sources (Derocher and Stirling 1991). Skin damage and temporary loss of hair can result from oiling of bears, with adverse effects on thermal insulation (Derocher and Stirling 1991).

Small mammals and furbearers could be affected by spills due to oiling or ingestion of contaminated forage or prey items. These impacts would be localized around the spill area and would not have population level impacts.

A seawater spill could kill plants on contact and increase soil salinity to the point that many species could not survive McKendrick (2000b). Unlike oil, salts are not biodegradable, and natural recovery occurs only after salts have leached from the soil. A spill would have adverse effects on salt-intolerant vegetation near the seawater spill, but the amount of tundra habitat affected would be small, usually no more than a few acres. Thus, potential saltwater spills are not likely to affect forage availability for caribou, muskoxen, moose, or other terrestrial mammals in the Plan Area.

The impact assessment is also applicable to the FFD. In the FFD, several of the pads, roads, and pipelines, and thus, potential for large spills, are closer to foraging habitats of grizzly bears and caribou than are the five-satellite facilities of the CPAI Development Plan.

Physiological effects of oil on individual birds would be the same as described in the Northeast NPR-A IAP/EIS (BLM and MMS 1998). Lethal effects are expected to result from moderate to heavy oiling of any birds contacted. Oiled individuals could lose the water repellency and insulative capacity of their feathers and subsequently die from hypothermia. Light to moderate exposure could reduce future reproductive success as a result of pathological effects on liver or endocrine systems (Holmes 1985) that interfere with the reproductive process and are caused by oil ingested by adults during preening or feeding. Stress from ingested oil can be an additive to ordinary environmental stresses such as low temperatures and metabolic costs of migration. Oiled females could transfer oil to their eggs, which at this stage could cause mortality, reduced hatching success, or possibly cause deformities in young. Flocks of staging eiders could contact oil in nearshore areas. Oil could adversely affect food resources, causing indirect, sub-lethal effects that decrease survival, future reproduction, and growth of the affected individuals. Because the spectacled eider population is small and declining, even relatively low mortality could represent a detectable impact.

The impacts of FFD would be similar except that there are several additional pads (CD-11, CD-12, CD-14, CD-19, CD-20, and CD-21) and pipelines in the Colville River Delta that represent potential sources of spills that could affect the eiders and their habitat.

Economy

The vast majority of spills would be very small to medium size in volume, contained on the ice or gravel structures, or be limited to the tundra adjacent to the ice and gravel structures. They would not affect the local economy including the Helmericks commercial fishery on the Colville River Delta.

A large spill of oil, seawater, or chemicals that enters the Colville River from CD-3 or, in the FFD, from CD-11, CD-14, CD-19, CD-20, CD-21 or pipelines joining these pads, could potentially affect the commercial fish populations (e.g., arctic cisco, least cisco and humpback whitefish) and/or the Helmericks fishing gear (see Section 3.3.2). The nets, boats, personal gear, and other gear used in the fishery could become oiled if the oil reaches the fishing area. This could close the fishery, resulting in the loss of jobs and income for the company. In addition, depending upon the publicity the spill receives, the customer demand for potentially “tainted” fish could drop, resulting in a reduction or loss of demand for the fish and thus a reduction of loss of income and jobs.

No employment would be generated from cleanup of very small to medium spills (up to 1,000 gallons) on pads, roads, airstrips, or pipeline corridors. Even large spills of up to 100,000 gallons might not generate many additional jobs depending upon where the spill occurs. Onsite workers doing other operations and other response personnel from the North Slope, as well as other locations in Alaska, would clean up most small to medium spills. A large spill that enters the flowing water, especially where the oil strands along a substantial stretch of shoreline or river bank, could require the temporary employment of additional labor to clean up the oil.

Socio-Cultural Characteristics

Effects on the socio-cultural systems of local communities could come from interference with subsistence-harvest patterns from large oil spills and oil-spill cleanup, and stress due to fears of a potential spill and the disruptions it would cause. Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed for at least an entire season if there are concerns over the tainting of fish and other subsistence resources or potential displacement of subsistence resources and hunters. If a large spill contacted and extensively oiled coastal habitats, the presence of hundreds of humans, boats, and aircraft would displace subsistence species and alter or reduce access to these species by subsistence hunters. The overall effects from these sources are not expected to displace ongoing socio-cultural systems.

Oil-spill employment (response and cleanup) could disrupt subsistence-harvest activities for at least an entire season and disrupt some socio-cultural systems, but most likely, it would not displace these systems. The employment increase could have sudden and abnormally high effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup is unlikely to add population to the communities, because administrators and workers would live in separate enclaves. Cleanup employment of local Inupiat also could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs. Oil spills producing disruption of this magnitude are not expected from Northwest NPR-A activities.

Cultural Resources

Most spills are confined to a pad or roadway or to an area adjacent to them. The primary exceptions are spills from pipelines to tundra remote from the roads and pads. In the construction stage, most spills would occur on an ice pad or ice road during winter conditions, where snow and ice would limit impacts to cultural resources and cleanup would be less invasive than in a summertime terrestrial spill. Further, the type and location of cultural resources usually are clearly identified before construction begins so that they would not be affected by most spills or by subsequent spill cleanup. The effects of spills and spill cleanup associated with drilling and production would be similar to those associated with construction activities except that they could occur during the snow-free months. Although cleanup from these spills could be more invasive because of the non-frozen surface environment, there is little chance that cultural resources would be affected by either the spill or cleanup. Because the occurrence of most of the surface and subsurface cultural resources near the facilities are documented, the risk of impact is low.

This impact assessment also applies to the FFD for the Plan Area.

Subsistence Harvest and Uses

Impacts on subsistence-harvest patterns would result from impacts to subsistence resources. The effects of spills on terrestrial mammals, birds, freshwater fish, marine fish, bowhead whales, beluga whales, and other marine mammals (ringed, spotted, and bearded seals; walruses; polar bears; and gray whales) are analyzed earlier .

The vast majority of spills are very small to medium in size, are confined to the ice or gravel structures or immediately adjacent habitat or to the pipeline corridor, and are confined to relatively small areas even when they do affect the tundra or most tundra ponds, lakes, or small creeks. The impacted areas constitute very small proportions of the North Slope habitat of the subsistence species. These and any associated cleanup activities for spills in the CPAI Development Plan or the FFD are not likely to affect subsistence resources or subsistence harvests.

Large spills, particularly those in remote sections of the pipelines or in the larger rivers and creeks, could affect a limited proportion of the habitat for subsistence species such as caribou or waterfowl, or a small proportion of the subsistence resource population itself. These impacts are likely to be limited to the immediate area of the spill and could have a duration of a year or two after the spill. Most of the subsistence resources would move to adjacent unaffected areas and the subsistence users are likely to follow the resources.

A large spill could result in a major response and cleanup effort, especially for a spill that is in habitat remote from the ice or gravel structures. The response could include the presence of hundreds of humans, boats, and aircraft that would displace subsistence species and alter or reduce access to these species by subsistence hunters. This impact would last as long as the major response activity continues, probably no longer than two seasons and generally less than one.

Land Uses and Coastal Zone Management

The vast majority of all spills are confined to a pad, road, or airstrip, to an adjacent area, or to the area under a pipeline. Only those spills that occurred on the tundra under a pipeline might affect land uses or Coastal Zone Management policies and regulations. A spill occurring at a bridge, culvert, or pipeline over water could be dispersed some distance from the spill site, especially if the spill is a medium- to large-volume one, and could affect land uses or Coastal Zone Management policies and regulations.

Most small spills are quickly contained or cleaned up. The impacts of such spills are expected to be minor, especially given the required measures addressing prevention and response described in Section 2.0. No conflicts with any of the land uses or statewide standards or district enforceable Coastal Zone Management policies are anticipated.

A large spill, especially if it reaches a water body such as the Nigliq Channel or Ublutuoch River, could influence local subsistence resources, habitats, and land and water quality in the Plan Area. If a spill occurs during the winter months, cleanup efforts would be conducted during the winter months and would be less likely to affect the resources or uses of the coastal zone. However, even if a large spill were to occur during the summer months, it is not anticipated that any species would become unavailable or unharvestable because of such a spill. While localized availability and harvestablility could be affected, it is expected that subsistence activities would continue outside the localized spill area. Habitats also would be influenced locally if a spill were to occur during summer months or break-up. Water quality in the area of the spill could be compromised but the effect would be short term.

This impact assessment also applies to the FFD for the Plan Area.

Recreation Resources

Most spills are very small to small and few are medium to large. Nearly all these spills would be confined to pads, roads, airstrips, or in the immediate vicinity of them and the pipelines. Therefore, impacts on scenic quality, solitude, naturalness, or primitive/unconfined recreation resulting from spills likely would be confined to the same area.

A large spill, most likely from a pipeline or from a tank truck accident that reaches a creek or river (e.g., Ublutuoch River) including the Nigliq Channel in the break-up to initial freeze-up season could move rapidly downstream. The spilled material, especially oil, might be visible and thus could have a short-term (and possibly long-term) impact on recreation values. Fishing, boating, camping, scenic values, and other recreation pursuits could be affected as a result of an oil spill in a riverine environment that is used by recreationists. The obvious short-term effects would be the oil residues in areas of use. The long-term effects would possibly be the reduction or loss of fishing and diminished scenic value of the area, as oil residue could take a long time to weather and would not be detectable.

A spill of seawater and other miscible materials could have less short-term impact on recreational uses because it could be less visible. However, it could affect the fish, birds, and, over a longer period, the vegetation, which could diminish the recreational value and use of these resources.

This impact assessment also applies to the FFD for the Plan Area.

4.3.4 Very Large Volume Spills

4.3.4.1 Introduction

This section evaluates the risk of a VLVS (greater than 100,000 gallons) (see Section 4.3.2 for spill sizes) and the potential impacts to the environment for both the CPAI Development Plan and the FFD.

A review of the ADEC North Slope spill database for 1995 to 2003 (ADEC 2003 d) shows one VLVS of 994,400 gallons of seawater from a pipeline for unknown causes. One other spill occurred that approaches the VLVS criterion of greater than 100,000 gallons; that was a 92,400-gallon produced water spill resulting from corrosion at APF-1 in April 2001. There are no reported Very Large volume oil spills since January 1995; the largest was a 38,000-gallon crude oil spill.

A further review of the 1971 to 1994 ADEC database[13] for spills on the North Slope shows approximately 6,900 spills, most of which occurred in the oilfields[14], and shows 4 spills estimated to be greater than 100,000 gallons. All occurred at gravel pads between 1983 and 1991. They include 1,050,000, 420,000, and 147,000 gallons of drilling mud, and 357,000 gallons of produced water. There were no reported VLVSs of seawater, produced fluids, or oil in the North Slope oilfield before 1995.

4.3.4.2 VLVS Scenarios

The VLVS scenario has been analyzed for crude-oil spills in several North Slope environmental evaluations, which are incorporated by reference (BLM and MMS 2003; BLM and MMS 2002; TAPS Owners 2001a; PAI 2002a; CPAI 2003f). The definition of a VLVS varies among these documents, depending on the situation being analyzed and the potential source of the spill. The volume ranges from approximately 117,600 to 126,000 gallons (MMS 2002; PAI 2002a) to 5,040,000 gallons (BLM 2003b), based on various risk assessments.

The CPAI Alpine ODPCP (CPAI 2003f) for the existing Alpine field wells presents a VLVS scenario of 4,725,000 gallons for a well blowout. This value is based on known production rates of the wells; it does not include the appropriate ADEC-approved credits taken, account for evaporation and volatilization of the light ends (e.g., benzene, toluene), or consider that as much as 80 percent of the material from a blowout could be non-oil (i.e., brine, natural gas, grit). This VLVS scenario also assumes approximately 43,134 gallons could reach a major river (e.g., Nigliq Channel) either by flowing over the tundra or by airborne transport in strong winds. As indicated in Table 4.3.3-2, pads are generally greater than or equal to 0.5 miles from rivers and creeks, so most of the fluids from a blowout would be deposited on tundra and associated ponds or lakes.

For the proposed CPAI Development Plan and the FFD, the potential well production characteristics and rates are not known (Shifflett 2003) so the ADEC blowout default values of 231,000 gallons per day for 30 days could be used to provide a total of 6,930,000 gallons of produced fluids that potentially could be spilled. Some of this would evaporate and some (perhaps the majority) would consist of natural gas, which would volatilize.

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[13] According to Luick (pers. comm. 2003), the pre-1995 database was compiled in R-Base and the input data did not always provide information in a complete and/or consistent manner for every incident. However, the database provided to ENTRIX by the ADEC is sufficient to provide a general picture of the pre-1995 North Slope spill history for this scenario development and impact analysis.

[14] Spills at Barrow and other North Slope areas (but not oilfield locations) are included. However, they do not constitute many spills (the exact number was not determined) and do not materially change the following discussion. The one exception is for VLVS. Besides the four described in this paragraph, there were five other VLVS at North Slope villages or other locations.

Another possible VLVS scenario is the rupture of the proposed pipelines for produced fluids, seawater, and/or diesel, and for the FFD, the Sales Oil Pipeline crossing the Nigliq Channel or other major rivers and creeks (Table 4.3.3-1). If only one of the co-located pipelines were severed completely between valves or vertical loops, up to approximately 195,000, 450,000, and 5,600 gallons of produced fluids, seawater, or diesel, respectively, could be discharged from the pipeline. For the FFD, up to 330,000 gallons of Sales Oil Pipeline could potentially be spilled to the tundra and 23,100 gallons of Sales Oil to the Nigliq Channel if a new pipeline were required to transport oil from APF-2 and/or APF-3 to APF-1, and if the pipeline were located on the bridge. If all the co-located pipelines were completely ruptured (e.g., because of a truck or heavy equipment crash, or loss of a bridge in a major flood) in the CPAI Development Plan, total spill volumes potentially could amount to approximately 32,000 gallons at the Nigliq Channel and Ublutuoch River crossings, and approximately 220,000 gallons in the Colville River Delta between CD-1 and CD-3. A complete rupture of the lines between CD-6 and CD-7 could potentially result in a spill of approximately 523,000 gallons on the tundra and/or tundra ponds and lakes between the pads. This tundra spill is intended to represent spills between any of the production pads in the CPAI Development Plan and between production pads and the hypothetical processing facilities (APF-2 and APF-3) in the FFD, though the volume spilled would likely be smaller in most instances.

This EIS considers spills from greater than 100,000 gallons to the hypothetical maximums postulated for the CPAI ODPCP (for example, 4,725,000 gallons) to be VLVSs in terms of the potential impacts. In addition, for purposes of this analysis, a VLVS is a spill that would affect a substantial area of tundra and possibly surface water beyond gravel pads, roads or airstrips and that could require substantial resources from the North Slope for response, control, and cleanup.

4.3.4.3 Risk of Very Large Volume Spills

There have been five VLVSs reported for the North Slope oilfield since 1977 in the ADEC databases and the total oil production has been approximately 1.6×10^{12} gallons in that time (www.tax.state.ak.us/ programs/oil/production/index.asp). This amounts to approximately one VLVS for every 300 trillion gallons of oil, and none of these VLVSs consisted of oil or produced fluids. Another indicator is that approximately 2,968,000 gallons of material (none that are oil or produced water) were spilled only in VLVS or approximately one gallon for every 2,000,000 gallons of oil produced from the North Slope. Thus, the risk of a VLVS of oil (or oil in produced fluids) in the Plan Area approaches zero. This risk is still extremely low for all hazardous materials combined.

Based on the recent history of reported North Slope spills and proposed oil production in the CPAI Development Plan, the most likely potential VLVSs would be composed of produced fluids or seawater. The occurrence of VLVS of drilling muds from reserve pits is much less likely now, than it was pre-1995, because of the changes in drilling operations and procedures for handling drilling muds. The largest hypothetical spills would be produced fluids from a well blowout. The actual largest spills in the ADEC 1995-2003 database are of seawater and produced water.

Therefore, the following VLVS impact assessment is based primarily on potential spills of produced fluids and/or seawater.

4.3.4.4 Behavior and Fate of a Very Large Volume Spill

A VLVS would most likely result from a major pipeline break, well blowout, or uncontrolled release. In the latter two cases, some or much of the spilled material could be contained on the pad or on the tundra in the immediate vicinity. However, in all three cases, there is a high likelihood that the oil and/or seawater would affect the tundra, possibly relatively remote from the road or pads in pipeline spills. Depending upon proximity and season, the oil and/or seawater could also reach wet tundra, tundra ponds and lakes, creeks, larger rivers, estuaries, Harrison Bay, and the nearshore Beaufort Sea.

The processes that affect the fate and behavior of the spilled material are described in Sections 4.3.2.3 and 4.3.2.4, as well as in several previous North Slope EISs, which are incorporated by reference. The primary difference between the discussion about behavior and fate of very small to large spills and VLVSs, is the larger scale of the VLVSs, i.e., generally a larger area would be affected, the duration of the impact would be greater, the magnitude of the impacts would be greater, the time required for weathering would be longer, and the response/cleanup effort could be much greater.

In summary, the behavior and fate of a VLVS from the CPAI Development Plan or the FFD would be influenced by:

- Type and volume of material spilled
- Duration of the release (e.g., essentially instantaneous in a pipeline rupture compared to an extended period for a well blowout)
- Topography of the tundra or water bodies
- Season (including temperature, wind, and precipitation)
- Water velocity and flood stage if spill reaches flowing waters
- Response actions
- Vegetation, snow and ice cover

Winter Season

During the two-thirds of the year when the tundra typically is covered with snow, the water bodies covered with ice, air temperatures are well below freezing, and there is little, if any, water flow in rivers, a VLVS generally would not disperse far from the source. Oil would cool rapidly to a point where the viscosity is high, and flow would be limited. The snow would act as a sorbent and retain much of the oil. VOCs will evaporate more slowly than in warmer periods so the potential toxicity of the oil to vegetation, fish and wildlife would last longer; however, there are generally fewer biological resources to be exposed to the oil in winter. Seawater will begin to freeze[15] especially when temperatures are well below freezing. Both the oil and seawater could be removed from the tundra or water surfaces before they become incorporated into the soil, vegetation, or water. Also, the response actions to contain and clean up the spilled material would be less environmentally damaging if they are implemented to minimize surface disturbance or removal of vegetation and soil.

Break-up

During the few days to weeks that constitute spring break-up, snow melts off the tundra and the snowmelt, as well as rain ponds in depressions in the tundra or runs off to the creeks and rivers. The river water levels rise to flood stage and "break up" the ice in the rivers. The ice and floodwaters are transported downriver, eventually to Harrison Bay where the freshwater floods over the landfast sea ice. The floodwaters also could overtop the riverbanks and temporarily flood the tundra, tundra ponds, and lakes.

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[15] Seawater with a salinity of 3.3 percent salt begins to freeze at approximately 28°F and, as indicated by the presence of landfast sea ice in Harrison Bay and the nearshore Beaufort Sea, seawater can freeze rapidly to substantial thickness in a few days to weeks.

During break-up, a VLVS of oil to the dry tundra could be limited in its dispersal because of the sorbent effect of the vegetation. However, the oil could still cover several acres to tens of acres of tundra, and possibly more if it is aerially dispersed in a blowout. Oil spilled on wet tundra could be dispersed over a larger area as the wind blows it across the water surface and/or the sheet flow takes it toward the creeks, rivers, or tundra ponds and lakes. Oil spilled to tundra lakes and ponds would disperse over the water surface but eventually would collect on the downwind shores where vegetation would trap it. Oil spilled to flowing waters, especially the larger creeks and rivers (e.g., Nigliq Channel, Colville River Delta, Ublutuoch River, Fish Creek and Judy creeks, Kogru River and Kalikpik rivers), would rapidly disperse in the flood waters and broken ice and be transported downstream toward Harrison Bay and the nearshore Beaufort Sea. The fate of this oil would depend largely upon the location of the spill and the volume and velocity of flood flows.

A VLVS of seawater would undergo much the same behavior and fate. However, the key difference for spills that reach flowing waters and large volume tundra lakes is that seawater would be rapidly diluted to ambient salinity of freshwater and therefore lessen its impact to the natural habitats.

Cleanup of oil spills during break-up is more challenging than in the winter. The CPAI ODPCP provides details of the necessary response actions, training programs, required equipment, etc.

Summer

In summer, a VLVS to the tundra would be limited in dispersal because the soil is relatively dry and the vegetation is at peak growth, thereby increasing the sorbent effect it has on oil. In addition, the VOCs would evaporate more quickly than in winter because of the higher air temperatures. Both oil and seawater could infiltrate farther into the soil to fill the interstices that were filled with ice in the winter. The warmer air temperatures would result in lower viscosity of oil and seawater would remain liquid. In both cases, this would increase the dispersal over tundra despite the sorbent effect of the vegetation. Spills to flowing water would be transported downstream but the velocity of transport and distance could be less than during break-up. More of the oil would be trapped in the vegetation and sediments of the riverbanks. The rate of dilution of seawater would not be as great as during break-up and the seawater could cause higher salinities for longer in the freshwater systems.

Freeze-up

During the freeze-up period, a VLVS of oil to the tundra would be similar to one in winter except there could be less snow and ice cover, and the snow could come and go for a few weeks. The air temperatures would not be as consistently cold so the viscosity of the oil and the evaporation of VOCs would vary with air temperature. Oil spilled to tundra ponds and lakes could become incorporated into the vegetation and soil, as well as the ice cover. As the ice freezes, the oil could become trapped unless it is removed during cleanup, an action that would be influenced by the thickness and strength of the ice. Oil spilled to flowing water could also become incorporated into or under the ice, not to be released until the following break-up and summer periods.

Seawater spills could become slush or solid ice, depending upon the temperature. This could enhance the removal where it is the appropriate response strategy.

4.3.4.5 Effects of Very Large Volume Spills

Overview

A VLVS is most likely to result from a major pipeline break, a well blowout, or uncontrolled release from a drilling or production pad. In the latter two cases, some (and possibly much) of the spilled material could be contained on the pad or on the adjacent tundra. However, in all three cases, there is a high likelihood that the oil and/or seawater would affect several to hundreds of acres of tundra, and in the case of pipeline spills, possibly relatively remote from the road or pads. The oil and/or seawater could also reach wet tundra, tundra ponds and lakes, creeks, larger rivers, estuaries including the Colville River Delta, Harrison Bay, and the nearshore Beaufort Sea, with the amount depending largely upon proximity of the spill source to the water bodies, season, and volume of the spill. In sum, a VLVS is more likely to affect a greater area and diversity of natural habitats and resources than are very small to large spills described in Section 4.4.3.

The range of potential impacts for very small to large spills are summarized in Section 4.3.3.3, as well as in several previous North Slope EISs, which are incorporated by reference. The primary difference between the previous discussion about potential impacts of very small to large spills and VLVSs is the larger scale of the VLVSs, i.e., generally a larger area is affected, duration of the impact is greater, magnitude of the impacts are greater, the time required for weathering is longer, and the response and cleanup effort could be much greater.

Therefore, we incorporate by reference the impact assessments from Section 4.3.3.3, into the following impact assessment of VLVSs in the CPAI Development Plan and FFD. The resource and issue categories in Section 4.3.3.3 are consolidated into physical, biological, and social/cultural/economic environments. These sections summarize the major differences in the impacts, mostly in magnitude and in areal extent, particularly into Harrison Bay and the nearshore Beaufort Sea.

Physical Environment

The impact to soils would cover more area than small to large spills and could result in a thicker, continuous layer of oil. This dark layer could result in increased thermokarsting underneath and potential incorporation of oil into the soil voids.

The impact to paleontological resources would be similar to that for small to large spills. They are typically subsurface and the oil or seawater would not penetrate far into the soil.

Freshwater water quality and water resources are likely to experience greater impacts because the amount of oil or seawater relative to the volume of potentially influenced freshwater bodies would be greater, especially in tundra ponds, lakes, and wetlands where there is low to no flow. Therefore, the potential concentration of toxic materials or salts could exceed toxicity thresholds for aquatic plants, fish, and macroinvertebrates. In flowing waters, the relatively greater proportion of oil or seawater could result in more oil reaching the sediments and shoreline vegetation further downstream than for small to large spills.

The greatest difference in impacts to the physical environment is likely to be in the estuarine and marine water quality, and to be largely limited to oil spills. Because the volume of oil in a VLVS is large, more of it is likely to reach the estuarine and marine environments of Harrison Bay and nearshore Beaufort Sea than in smaller spills, even if the spill were to occur well upstream on a major river or creek (e.g., at the Ublutuoch River crossing near CD-6 or in the FFD at CD-24 near Judy Creek or CD-15 near Nuiqsut). For VLVSs that occur near the Colville River Delta, Harrison Bay, or Beaufort Sea (e.g., for CD-3, Nigliq Channel crossing; for FFD, CD-14, CD-19, CD-20, CD-21, and CD-29), the oil is likely to quickly reach the estuarine and marine environments in relatively large amounts and relatively unweathered.

4.3.4.6 Biological Environment

A VLVS of oil and/or seawater could affect several to tens or potentially hundreds (in a blowout) of acres of vegetation. The major difference from small to large spills is the greater areal extent of oiling or seawater inundation. A VLVS from FFD pads CD-20, CD-12, CD-14, CD-19, CD-20, and CD-21, as well as from the pipeline joining them, could affect more halophytic vegetation than would the CPAI Development Plan, which has only CD-3 on the Colville River Delta.

Freshwater fish populations are likely to be affected in the tundra ponds and lakes, as well as creeks and river channels exposed to the oil and/or seawater. As discussed for freshwater quality (Section 4.3.3.3), toxic concentrations could exceed toxicity thresholds especially in smaller water bodies. Also, if the oil is discharged under ice or is entrained under the ice through cracks in it, especially in the Colville River or Nigliq Channel, it could collect in the deep pools where it has the potential to (1) depress dissolved oxygen levels as a result of the biodegradation of the oil, even at low microbial density and activity levels, and (2) exceed acute and chronic toxicity levels. Similarly, a VLVS of seawater, which is substantially denser than freshwater and would sink, could collect in these pools in winter if the seawater found cracks in the ice. The high salinity could cause osmotic stress in the fish and cause mortalities. There is no escape in winter for the fish from these reservoirs.

Unlike the impact assessment for small to large spills, a VLVS of oil could reach the marine environments of Harrison Bay and, especially in the FFD, nearshore Beaufort Sea (e.g., near CD-29) in concentrations and volumes great enough to contact the nearshore marine fish and benthic community. The impact is likely to be localized because the spilled oil would be diluted rapidly in the large volume of marine water and the toxic components would evaporate rapidly. Also, marine fish do not usually suffer many mortalities as a result of oil spills unless they are trapped in bays or similar areas. The benthic organisms could be exposed and some could die from the toxic effects of oil in the water or in the sediments. Again, the spatial extent is likely to be localized around the river discharge area.

A VLVS of oil is likely to affect substantially more shorebirds, passerines, gyrfalcons, hawks, and other terrestrial birds than would a small to large spill. The areal extent and thus, potential for direct or indirect exposure increases with the VLVS. The number of individuals exposed and affected would not likely have an impact on the regional population size. Waterfowl, loons, geese, gulls, endangered spectacled eiders, and other birds that spend much to most of their time on the water resting, feeding, or molting, or nesting immediately adjacent to the water, could be impacted in large numbers, depending upon the distribution of oil, behavior of the birds, and their density. If large volumes of surface oil reach the estuarine portions of the rivers, the Colville River Delta, mouth of Nigliq Channel or Harrison Bay during the summer season, large numbers of birds would likely be oiled and ultimately die. The risk is greater in the FFD because there are more pads and pipelines in the Colville River Delta and coastal habitats that are key nesting, resting, feeding, and molting/staging areas for these migratory birds.

Marine mammals in the Colville River Delta, lower Nigliq Channel, Harrison Bay and possibly the nearshore Beaufort sea have a greater risk of exposure to oil in VLVSs than in small to large ones for the same reasons birds do. Even in a VLVS (unless it approaches millions of gallons) from the CPAI Development Plan or the FFD is unlikely to affect bowhead whales or other marine mammals outside Harrison Bay.

Terrestrial mammals could be affected over several acres to tens or hundreds of acres in a VLVS, (especially of oil). They would tend to avoid oiled areas and thus lose a measurable though small proportion of available forage habitat. The risk of direct contact with oil and thus potential injury or death increases over that of small to large spills. Most of the larger mammals could avoid the oiled area. The loss of vegetation from oil and/or seawater spills is measurable, but would not constitute a substantial portion of the available forage.

4.3.4.7 Social/Cultural/Economic Environment

The economy, socio-cultural, and cultural aspects of the North Slope could be affected by a VLVS. A VLVS spill of oil that enters the Colville River from CD-3 or for the FFD, from CD-11, CD-14, CD-19, CD-20, CD-21, or pipelines joining these pads, would likely affect the commercial fish populations and/or the Helmericks fishing gear for at least one fishing season and maybe longer if it directly impacted the fishery areas (see Section 3.3.2.4 for discussion of the commercial fishery). This could close the fishery resulting in the loss of jobs and income for the company.

VLVSs could generate many additional jobs depending upon where the spill occurs. Onsite workers doing other operations and other response personnel from the North Slope, as well as other locations in Alaska, would conduct the initial responses. A VLVS oil spill that enters the flowing water, especially where the oil strands along a substantial stretch of shoreline or riverbank, could require the temporary employment of additional labor to clean up the oil. Some of this labor would come from the North Slope population while much of it would come from outside contractors, spill response organizations, and other sources identified in the CPAI ODPCP.

Effects on the socio-cultural systems of local communities could come from interference with subsistence-harvest patterns from both the physical impacts of VLVS of oil and oil-spill cleanup, and stress due to fears of a potential spill and the disruptions it would cause. Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed for at least an entire season and possibly longer if there are concerns over the tainting of fish and other subsistence resources or potential displacement of subsistence resources and hunters. If a VLVS contacted and extensively oiled coastal habitats, the presence of hundreds of humans, boats, and aircraft would displace subsistence species and alter or reduce access to these species by subsistence hunters. The overall effects from these sources are not expected to displace ongoing socio-cultural systems but these systems could be disrupted for several years.

Oil-spill employment (response and cleanup) could disrupt subsistence-harvest activities for at least an entire season and disrupt some socio-cultural systems, however, it would probably not displace these systems. The sudden employment increase could have sudden and abnormally high effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup of a VLVS is unlikely to add population to the communities, because administrators and workers would live in separate enclaves. Cleanup employment of local Inupiat also could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs.

A VLVS (especially of oil) could affect certain types of cultural resources if they are near water bodies and above the ground surface (e.g., hunting camps). The type and location of cultural resources usually are clearly identified before construction of a facility so that the cultural resources would not be affected by most spills or by subsequent spill cleanup. Although cleanup from these spills might be more invasive because of the non-frozen surface environment, there is little chance that either the spill or cleanup would affect cultural resources. Because the occurrences of most of the surface and subsurface cultural resources near the facilities are documented, the risk of impact is low.

VLVSs of oil could affect a limited proportion of the habitat for subsistence species such as caribou or waterfowl, particularly those in remote sections of the pipelines or in the larger rivers and creeks. These impacts are likely to be limited to the immediate area of the spill and could have a duration of a year or two after the spill. Most of the subsistence resources would move to adjacent unaffected areas and the subsistence users would likely follow the resources. A VLVS would result in a major response and cleanup effort, especially for a spill that is in habitat remote from the ice or gravel structures. The response could include the presence of hundreds of humans, boats, and aircraft that would displace subsistence species and alter or reduce access to these species by subsistence hunters. This impact would last as long as the major response activity continues, probably no longer than two seasons, and generally less than one.

A VLVS that reaches a creek or river (including the Nigliq Channel) in the break-up to initial freeze-up season could move rapidly downstream. The spilled material (especially oil) could be visible and thus could have a short-term (and possibly long-term) impact on recreation values. Fishing, boating, camping, scenic values, and other recreation pursuits could be impacted as a result of an oil spill in a riverine environment that is used by recreationists. The obvious short-term effects would be the oil residues in areas of use. The long-term effects would possibly be the reduction or loss of fishing, and diminished scenic value of the area, as oil residue could take a long time to weather to the point it is not detectable. A VLVS of seawater is likely to have less short-term impact on recreational uses because it is less visible. However, it could affect the fish, birds, and over a longer period, the vegetation which could result in the recreational value and use of these resources.

A VLVS spill requiring a large contingent of cleanup personnel and equipment cleanup on the tundra, especially on a creek or river, or a large tundra lake, could have a temporary impact on the viewshed.

4.3.5 Mitigation Measures

Most of the “mitigation measures” focus on prevention of spills or the rapid and efficient containment and cleanup of those spills that do occur. Most of these measures are incorporated into the design and operation/maintenance procedures for the oilfield and are described in Section 2.0. They include a detailed ODPCP that would be prepared by CPAI for the project facilities as they are constructed and put into production.

Additional mitigation measures to reduce the risk of a spill, reduce the volume potentially spilled, or to decrease response time include:

- Install vertical loops in the produced fluids pipelines, or automatic shutdown isolation valves in the seawater and diesel pipelines on each side of the major creek or river crossings. These crossings include Nigliq Channel (except in Alternative D), Ublutuoch River, and Tamayayak Channel in the CPAI Development Plan. For the FFD, additional crossings could include Fish-Judy creeks, Kalikpik River, and the Colville River (if an additional Sales Oil line is required). These valves should be capable of automatic shutdown, and closure from a remote location (e.g., APF-1), as well as manual closure. The goal is to minimize the amount of spilled material that might enter these rivers and creeks in the event of a leak, and especially in the event of a complete pipeline rupture.
- In Alternatives A through C, regular and frequent visual inspection of the pipelines on the bridge crossing the Nigliq Channel during break-up floods, especially in the larger flood events (e.g., greater than or equal to a 50-year flood level). The inspection would identify any potential problems with the integrity of the bridge because of ice jams, erosion and scour, etc., as well as determine if there are additional risks of pipeline failure and a need to reduce or stop flows until integrity is assured. These inspections would be more frequent than the routine inspections of the pipeline system already included in Section 2.0.

An additional recommendation is to require that CPAI and other potential operators in the FFD scenario conduct a long-term basic monitoring program for each spill that reaches the wet or dry tundra and/or water bodies including tundra ponds, tundra lakes, creeks, rivers and estuaries. The primary goal would be to determine (1) the type, magnitude, and duration of impacts from the spilled material, as well as the cleanup actions, and (2) the recovery process of the impacted habitats and measurably affected resources. The purpose for this information would be to provide a more quantitative basis than exists at present for evaluating impacts of future potential and actual spills on the North Slope, and to evaluate the benefits and costs of natural and anthropogenic restoration processes.