Appendix K

Information, Models, and the Assumptions Used to Analyze the Effects of Oil Spills

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APPENDIX K

INFORMATION, MODELS, AND ASSUMPTIONS USED TO ANALYZE THE EFFECTS OF OIL SPILLS

This Supplement to the Amended IAP/EIS analyzes oil spills, and their potential impacts to environmental, economic, and sociocultural resources and resource areas, which could result from onshore oil exploration and development in the Northeast National Petroleum Reserve – Alaska (NPR-A). Predicting an oil spill is an exercise in probability. There is uncertainty associated with the location, number, and size of oil spills, the chemistry of the oil, and the environmental conditions at the time of a spill. Although some of the uncertainty reflects incomplete or imperfect data, there is also a considerable amount of uncertainty involved in predicting events 15 to 25 years into the future. However, the chance of an oil spill occurring can be estimated using historical data.

Assumptions about oil spills are used to analyze the effects of oil spills. These assumptions pertain to the type of oil, the source of an oil spill, the general location and size of a spill, the chemistry of the oil, how the oil will weather, how long the oil will remain, and where the oil will go. Project-specific information, statistical analysis, and professional judgment support the assumptions. Based on these assumptions, a scenario is created to reflect a spill, and the effects of such a spill are analyzed. These steps constitute a "what if a spill occurs" analysis.

This oil spill analysis considers the entire production life of the planning area, and assumes that commercial quantities of hydrocarbons are present in the planning area and that these hydrocarbons will be developed and produced at the estimated resource levels presented in the Supplemental IAP/EIS. Uncertainties exist, such as 1) the actual resource levels, 2) the actual size of a crude or refined oil spill, 3) the approximate location of oil assumed to be produced, and 4) whether production would occur at all. If no hydrocarbons exist, there is no chance of a crude oil spill occurring in the planning area.

K.1 Oil Spill Size Categories

This Supplement analyzes what is likely to happen in the future, using assumptions about the likely size, duration, and type of a spill to analyze the effects. To estimate these parameters, oil spills are divided into two types: crude oil and refined oil spills. Crude oil spills are divided into three size categories: small, large, and very large. Within each of these categories, generalized and specific assumptions are made. Refined spills fall into the small spill size category.

Small spills are defined as those less than 500 barrels (bbl; 1 bbl = 42 gallons); large spills are greater than or equal to 500 bbl or 1,000 bbl (depending upon the data source); and very large spills are greater than or equal to 120,000 bbl. Table K-1 shows the assumed source of a spill(s), type of oil, size of spill(s) in bbl, and the receiving environment that is assumed in the analysis of the effects of oil spills in this Supplement. The effects of spill(s) are analyzed in Chapter 4 (Environmental Consequences). The following sections discuss the oil spill analysis, and the assumptions used for analysis, for each of these three size categories.

K.1.1 Probability of a Large Crude Oil Spill

Large spills are defined as greater than or equal to 500 bbl for the Alaska North Slope and Trans-Alaska Pipeline System (TAPS), and greater than or equal to 1,000 bbl for the TAPS tankers. Historical information about previous large spills on the Alaska North Slope, from TAPS, and from TAPS tankers was used to estimate the hypothetical size of large spills and the rate at which such large spills would be expected to occur in the future.

Table K-1. Oil Spill Scenario Assumptions for the Alternatives

Source of Spill	Type of Oil	Size of Spill (bbl)	Assumed Number of Spills Under Each Alternative				Receiving Environment
			A	B	C	D	
Small Spills (< 500 bbl) Onshore and Offshore							
Operational spills from all sources	Crude	3	561	596	721	659	Ice, tundra, snow, gravel pad, and water
	Refined	0.7	1,276	1,474	1,782	1,628	
Large Spills (≥ 500 bbl) Onshore or Offshore							
Pipeline	Crude	4,800	2	3	3	3	Ice, tundra, snow, gravel pad, and water
Platform/gravel pad	Crude	900					
Storage tank/gravel pad	Diesel	900					
Very Large Spills (≥ 120,000 bbl)							
Well blowout	Crude	120,000	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Ice, tundra, snow, gravel pad, and water

K.1.1.1 Historical Large Crude Oil Spill Sizes

Assumptions for large spills from production in the planning area are based on the historic spill sizes from onshore Alaska North Slope oil industry spills from 1985 to 2000, TAPS spills from 1977 to 2001, and TAPS tanker spills from 1977 to 1999. Additional consideration is given to the large spill that occurred in March 2006 known as the GC-2 Oil Transit Line Release.

Historical Crude Oil Spills Greater Than or Equal to 500 Barrels on the North Slope

The Alaska North Slope oil spill analysis includes onshore oil and gas exploration and development spills from the Point Thompson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, and offshore Duck Island Unit (Endicott). Alaska North Slope data include spills from onshore pipelines and offshore and onshore production and gathering facilities. The following information does not include spills on the Alaska North Slope from the TAPS, which were evaluated separately.

For the Alaska North Slope, all available information on historic spills greater than or equal to 100 bbl during the period 1968 through 2000 was obtained from industry and regulatory agencies and collated (Anderson and LaBelle 2000, Hart Crowser, Inc. 2000). Information on the 2006 GC-2 Oil Transit Line Release came from Situation Reports posted on the Alaska Department of Environmental Conservation website. The USDOI MMS and Hart Crowser, Inc.

collected data for crude oil spills for the U.S. Beaufort Sea, the NPR-A, and Onshore Alaska North Slope east of the NPR-A from the following sources:

- British Petroleum (BP) Exploration (Alaska), Inc., electronic database files of oil spills in the Prudhoe Bay Unit Western Operating Area (1989 through 1996), Duck Island (Endicott) Unit (1989 through 1996), and Milne Point (1994 through 1996).
- BP Exploration (Alaska), Inc., electronic spreadsheet containing all industry and contractor oil spills from January 1997 to May 2001.
- Atlantic Richfield Company (ARCO) electronic spreadsheet files of oil spills for the Prudhoe Bay Unit Eastern Operating Area (1977 through 1996), Kuparuk River Unit (1977 through 1985 and 1986 through 1996), and Kuparuk River Unit exploration (1986 through 1996).
- Alyeska printed summary report of oil spills greater than 1,000 bbl along the TAPS from 1977 through 1989.
- Joint Pipeline Office electronic database of oil spills along the TAPS (1970 through 1994).
- Bureau of Land Management (BLM) printed reports of oil spills along the TAPS during 1981 and 1982.
- Alaska Department of Environmental Conservation (ADEC) electronic text and spreadsheet files of oil spills from the agency's current oil and hazardous substances spill database (July 1995 through February 1997) and an earlier oil and hazardous substances spill database (1971 through July 1995).
- Alaska Department of Environmental Conservation electronic spreadsheet containing all oil spills in their current oil and hazardous substance spill database to December 2000.
- An unattributed printed summary of oil spills over 100 gallons on the Alaska North Slope and along the TAPS from 1970 through 1981.
- An electronic spreadsheet summary of Alaskan and Canadian oil spills of 100 bbl or greater, from 1978 through 2000, as reported by the Oil Spill Intelligence Report.
- An MMS report that no oil spills of 100 bbl or larger have occurred in the Alaska Outer Continental Shelf Beaufort or Chukchi sea(s) study area.
- Alyeska electronic spreadsheet file containing all oil spills of 100 bbl or larger from the company's oil-spill database to September 1999.

A review of the reliability and completeness of the data for spills greater than or equal to 500 bbl (Hart Crowser, Inc. 2000) indicates that the available information was most reliable for 1985 through 2000, based on written documentation or lack of documentation and spills before that period. The MMS determined that spills greater than or equal to 100 bbl were documented and included in the database since 1985. In 1985, the ADEC began tracking spills in an electronic format. Although Hart Crowser, Inc. (2000) states that the database is complete for the years since production began, the BLM prefers to use 1985 as the starting point of reliability. Any uncertainty in documenting spills before that time is a concern because it is typical for spills to occur more frequently during field and pipeline startup.

Six crude oil spills greater than or equal to 500 bbl associated with onshore or offshore Alaska North Slope oil production occurred from 1985 to 2000. No spills greater than or equal to 1,000 bbl were documented during this time period. Of the six spills, one (i.e., a leak in either a 20- or 24-inch flow line from the wells in Kuparuk to the Central Processing Facility) is classified as a pipeline spill. The other five spills are classified as facility spills. The 2006 spill was from a 34

inch crude oil transit pipeline with an estimated volume of 201,000 gallons, +/- 33%, or 4800 bbls +/- 33%.

From 1985 to 2000, the median facility spill greater than or equal to 500 bbl on the Alaska North Slope was 663 bbl, and the mean (or average) was 680 bbl. The one pipeline spill had a volume of 510 bbl. For spill analysis, the largest recorded facility spill is used. The largest facility spill on record is 925 bbl. This oil spill analysis uses a pipeline spill of 4800 bbl. Rounded to the nearest 100 (to reflect the uncertainty associated with spill estimates), the hypothetical spill sizes become 900 bbl for the facility spill and 4800 bbl for the pipeline spill.

Historical Crude Oil Spills Greater Than or Equal to 500 Barrels From the Trans-Alaska Pipeline

The TAPS oil-spill analysis includes the pipeline and the pump stations, but excludes the Valdez marine terminal. Eight crude oil spills greater than or equal to 500 bbl associated with TAPS occurred from 1977 through 2001. Most large crude oil spills were associated with the start-up of the pipeline. No large spills greater than or equal to 1,000 bbl occurred from 1981 to 2000. On October 4, 2001, a bullet punctured the 48-inch TAPS mainline; approximately 6,800 bbl of crude oil were released from this intentional sabotage. Using the highest reported spill-quantity values, the mean (average) recorded crude oil spill greater than or equal to 500 bbl from 1977 to 2001 is 5,462 bbl, and the median is 4,381 bbl. Using the Alyeska Pipeline Service Company reported values, the mean and median spill sizes are 4,089 and 1,650, respectively. For spill analysis, the highest reported spill quantity mean is used and rounded to the nearest 100. Therefore, the mean hypothetical TAPS spill size is 5,500 bbl (median 4,400 bbl) for this oil spill analysis.

Historical Crude Oil Spills Greater Than or Equal to 1,000 Barrels from Tankers

Eleven crude oil spills greater than or equal to 1,000 bbl associated with the TAPS tankers have occurred from 1977 to 1999. The mean size for all TAPS tanker spills is 27,000 bbl and the median is 5,000 bbl. For in-port spills, the mean and median are 5,600 bbl and 5,300 bbl, respectively. For at-sea spills, the mean and median are 40,600 bbl and 4,900 bbl, respectively. The TAPS tanker spills are smaller than worldwide tanker spills and slightly smaller than tanker spills in U.S. waters (Anderson and Labelle 2000).

Historical Crude Oil Spills from Blowouts on the Alaska North Slope

The record for Alaska North Slope blowouts is not validated, but is presented as the best available information. There are two written reports regarding blowouts on the Alaska North Slope: Mallory (1998) and Fairweather (2000). Fairweather (2000) found 10 blowouts—six that Mallory had identified for the period 1974 to 1998 and four that occurred before 1974. Of the 10 blowouts, nine were gas and one was oil. The 1950 oil blowout was unspectacular and could not have been avoided, as there were no casings or blowout preventors available (Fairweather 2000). Drilling practices from 1950 would not be relevant today. A third study confirmed that no crude oil spills greater than or equal to 100 bbl from blowouts occurred from 1985 through 1999 (Hart Crowser, Inc. 2000). A recent report titled Blowout Frequency Assessment of Northstar (Scandpower AS 2001) uses statistical blowout frequencies modified to reflect specific field conditions and operative systems at Northstar. This report concludes that the blowout frequency for drilling in the oil-bearing zone at Northstar is 1.5×10^{-5} per well drilled. In comparison, the average statistical blowout frequency for a development well in the North Sea and U.S. Gulf of Mexico is 7.4×10^{-5} per well. This same report estimates that the statistical

frequency of a blowout spill with a size greater than 130,000 bbl is 9.4 x 10^{-5} per well drilled for Northstar.

However unlikely a blowout may be, it is an important concern to the public; therefore, the effects of a 120,000 bbl (15 day) spill are analyzed in **section 4.10** (Low Probability, Very Large Oil Spill).

K.1.1.2 Historical Large Crude Oil Spill Rates

Oil spill rates are the number of spills that occur over some exposure variable. The exposure variable can be bbl of oil produced or pipeline miles per year. Oil spill rates are estimated for the Alaska North Slope, the TAPS, and the TAPS tankers using historical spill data.

Alaska North Slope Spill Rate 1985-2000 Based on Volume

Only one Alaska North Slope facility or pipeline spill greater than or equal to 1,000 bbl from Alaska North Slope production has occurred since 1985. No documentation for crude oil spills greater than or equal to 100 bbl occurring prior to 1985 was found, but spill records dated prior to 1985 have not been validated as complete because of missing or incomplete documentation.

As noted above, five facility spills and one pipeline spill are documented from 1985 to 2000 and a large pipeline spill occurred in 2006. Total Alaska North Slope production was estimated to be 9.36 billion barrels (Bbbl) of crude oil and condensate (Alyeska Pipeline Service Company 2001, McMaines 2001). Anderson and LaBelle (2000) calculated Alaska North Slope spill rates from 1985 to 1998, hence they are slightly different from the spill rates calculated, using the 1985 to 2000 information, for this Supplement. The spill rate of 0.53 large spills per Bbbl handled was calculated for Alaska North Slope facility spills, using the entire record of five spills from 1985 to 2000. BLM and MMS use the 1985 to 2000 time period because spills greater than 100 bbl have been documented since 1985. In addition, the ADEC began an electronic database of oil spills in 1985. BLM and MMS consider the database most reliable from 1985 forward. The Alaska North Slope pipeline spill rate of 0.11 large spills per Bbbl handled was based on the record of one pipeline spill from 1985 to 2000. Including the spill in 2006, without considering the increased production that occurred in that additional time period, gives a very conservative figure of 0.22 spills per Bbl handled. The combined large crude oil spill rate for facilities and pipelines is 0.75 spills per Bbbl handled.

Trans-Alaska Pipeline Spill Rate 1977-2001 and 1985-2001 Based on Volume and Pipeline-Mile-Year

Flow in the TAPS began on June 20, 1977, with throughput of 112 million barrels (MMbbl) by the end of 1977. Throughput increased to almost 400 MMbbl in 1978, peaked at 744 MMbbl in 1988, and was 370 MMbbl in 2001. The estimated total volume transported through the TAPS during the period 1977 through 2001 is 13.62 Bbbl. The TAPS is 800 miles long.

1977-2001

There have been 12 crude oil spills greater than or equal to 100 bbl attributed to TAPS operation, four of which were less than 500 bbl. Eight spills were greater than or equal to 500 bbl, of which six were greater than or equal to 1,000 bbl. The last spill greater than or equal to 1,000 bbl occurred in 2001. The spill rate for spills greater than or equal to 500 bbl of 0.59 spills per Bbbl transported for TAPS was calculated based on the record of six accidental and two

sabotage spills over 13.62 Bbbl of production. The spill rate of 0.000425 large spills per pipeline-mile-year for TAPS was calculated based on the record of six accidental and two sabotage spills over 18,835 pipeline-mile-years during the period 1977 through 2001.

1985-2001

For purposes of this oil spill analysis, approximately the same time period (1985-2001) and the same class size (greater than or equal to 500 bbl) as the Alaska North Slope data in **section K.1.1.1, *Historical Large Crude Oil Spills***, are used. The spill rate of 0.21 large spills per Bbbl transported for TAPS was calculated based on two spills over 9.7 Bbbl of oil transported. The TAPS spill rate is 0.00015 large spills per pipeline-mile-year. The rate was also calculated based on two spills over 13,605 pipeline-mile-years from 1985 to 2001.

Trans-Alaska Pipeline Tanker Spill Rate 1977-1999 Based on Volume

Eleven tanker spills occurred in association with the transportation of Alaska North Slope crude: the Exxon Valdez spill and 10 other spills less than or equal to 15,000 bbl (Anderson and LaBelle 2000). No large spills have occurred since 1991. The spill rate of 0.87 spills per Bbbl transported was calculated based on the record of 11 accidental spills over 12.6 Bbbl of production (Anderson and LaBelle 2000).

K.1.1.3 Estimated Mean Number and Probability of One or More Large Crude Oil Spills for the Northeast National Petroleum Reserve – Alaska

The mean number of large crude oil spills, estimated over the production life of the planning area for Alternative A, Alternative B, Alternative C, and Alternative D are shown in Table K-2. The mean number of spills is derived from the projected resource volumes and the historic spill rate. The estimated total spill volume in Table K-2 is the total volume for all of the spills estimated for the given alternative. For instance, if two spills of 4800 bbl each were likely to occur, then the estimated total spill volume would be 9600 bbl.

Table K-2. Large Crude Oil Spills Estimated Over the Production Life of the Northeast National Petroleum Reserve – Alaska

Alternative	Resources (Bbbl)	Spill Rate (Spills/Bbbl)	Assumed Spill Size (bbl)	Estimated Mean Number of Spills[1]	Estimated Total Spill Volume[2] (bbl)
Crude Oil					
A	2.9	0.75	4,800	2.175	10,440
B	3.35	0.75	4,800	2.513	12,062
C	4.05	0.75	4,800	3.038	14,582
D	3.7	0.75	4,800	2.775	13,320

[1] The estimated mean number of oil spills is based on the estimated resource volume multiplied by the spill rate.
[2] The estimated total spill volume is the total volume for all of the estimated spills for the given alternative and price of oil.

The projected mean number of spills (listed in Table K-1) is used to estimate the chance of one or more large spills occurring.

K.1.2 Probability of a Small Crude Oil Spill - Less Than 500 Barrels

A total small spill rate of approximately 618 spills per Bbbl handled, calculated from the Alaska North Slope record of small spills, is used here. This spill rate consists of 178 small crude oil spills per Bbl and 440 small refined product spills per Bbbl. Since the companies and regulators that now operate onshore will likely participate onshore in the Northeast NPR-A, it seems reasonable to assume that the spill rate in the Northeast NPR-A will be similar to the rate on the Alaska North Slope.

Historical oil spill information and simple statistical methods are used to derive the following information about small crude and refined oil spills that occur on the Alaska North Slope:

- estimates of how often a spill occurs for every Bbbl of oil produced (oil-spill rates);
- estimates of the mean number of oil spills; and
- estimates of the mean and median size of oil spills from facilities, pipelines, and flow lines combined.

This information is used to estimate the number, size, and distribution of operational small spills that may occur in the planning area.

The historical information consists of crude and refined oil spills reported to the ADEC and the Joint Pipeline Office by the oil industry. Crude and refined oil spill rates and patterns from Alaska North Slope oil and gas exploration and development activities are determined for spills greater than or equal to one gallon and less than 500 bbl. Refined oil includes aviation fuel, diesel fuel, engine lubricants, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. The Alaska North Slope oil spill analysis includes onshore and offshore oil and gas exploration and development spills from the Point Thompson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, and Duck Island Unit.

Oil spill information is provided to the ADEC by private industry in accordance with State of Alaska Regulations, 18 AAC § 75. The ADEC figures are based on initial spill reports and may not contain updated information. Because of increased scrutiny after the Exxon Valdez oil spill, information in the ADEC database is most reliable for 1989 and later. Even though the integrity of the database cannot be validated thoroughly, the information in the database is still valuable because it is the only available data on small spills. For this oil spill analysis, ADEC records were spot checked against spill records from ARCO Alaska and BP. All spills greater than or equal to one gallon and less than 500 bbl occurring in the 1989 through 2000 time period were included in the oil spill analysis. A simple analysis of operational small oil spills was performed, and spill rates were estimated without regard to differentiating operation processes. The ADEC database structure does not facilitate quantitative analysis of Alaska North Slope oil spill rates separately for platforms, pipelines, or flow lines without further documentation and validation.

K.1.2.1 Historical Small Crude Oil Spill Rates and Patterns on the North Slope

Because this analysis of crude oil spills was performed collectively for all Alaska North Slope facilities, pipelines, and flow lines, the pattern that emerged was one of numerous small spills. Of the crude oil spills that occurred between 1989 and 2000, the ADEC database indicates that:

- 18% were less than or equal to 1 gallon;
- 54% were less than or equal to 5 gallons; and
- 99% were less than 25 bbl.

The small spill sizes in the database range from less than 1 gallon to 425 bbl. The mean crude oil spill size on the Alaska North Slope is 2.7 bbl, and the median spill size is 5 gallons. For purposes of the oil spill analysis in this Supplement, a mean crude oil-spill size of 3 bbl is assumed for small spills.

The database indicates that the causes of small crude oil spills on the Alaska North Slope, in decreasing order of frequency, are:

- leaks
- faulty valves/gauges
- vent discharges
- faulty connections
- ruptured lines
- seal failures
- human error
- explosions

Approximately 30% of the spills in the database do not include information on the causes.

The estimated small crude oil spill rate for the Alaska North Slope is 178 spills per Bbbl produced. The mean number, size, and total volume of small spills for each of the alternatives are shown in Table K-3. For this oil spill analysis, the mean number of small spills is used as the assumed number of spills.

Table K-3. Small Crude Oil Spills Estimated Over the Production Life of the Northeast National Petroleum Reserve – Alaska

Alternative	Resources (Bbbl)	Spill Rate (Spills/Bbbl)	Assumed Spill Size (bbl)	Estimated Mean Number of Spills[1]	Estimated Total Spill Volume (bbl)
Crude Oil					
A	2.9	178	3	516	1,548
B	3.35	178	3	596	1,782
C	4.05	178	3	721	2,163
D	3.7	178	3	659	1,977

[1] The estimated mean number of oil spills is based on the estimated resource volume multiplied by the spill rate and is rounded to the nearest whole number.

K.1.2.2 Historical Small Refined Oil Spill Rates and Types of Spills on the North Slope

Typical refined products spilled are aviation fuel, diesel fuel, engine lube, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. On the Alaska North Slope, diesel spills represent 61% of refined oil spills by frequency and 75% by volume. Engine lube oil spills are 10% by frequency and 3% by volume. Hydraulic oil spills are 26% by frequency and 10% by volume. All other categories of spills are less than 1% by frequency and volume. Refined oil

spills occur in conjunction with oil exploration and production, and correlate to the volume of Alaska North Slope crude oil produced. As production of crude oil has declined, so has the number of refined oil spills. However, this apparent relationship could be coincidental, as emphasis on pollution prevention has also increased in the last several years. From 1989 to 2000, the spill rate for refined oil was 440 spills per Bbbl produced.

The mean number of refined oil spills during the lifetime of the alternatives is shown in Table K-8.

Table K-4. Small Refined Oil Spills <500 bbl Estimated Over the Production Life of the Northeast National Petroleum Reserve – Alaska

Alternative	Resources (Bbbl)	Spill Rate (Spills/Bbbl)	Assumed Spill Size (bbl)[1]	Estimated Mean Number of Spills[2]	Estimated Total Spill Volume (bbl)
A	2.9	440	0.7	1,276	893
B	3.35	440	0.7	1,474	1,032
C	4.05	440	0.7	1,782	1,247
D	3.7	440	0.7	1,628	1,140

[1] The mean spill size for refined spills on the Alaska North Slope from 1989 through 2000; equivalent to 29 gallons.
[2] The fractional estimated mean spill number and volume are rounded to the nearest whole number.

K.1.3 Probability of a Very Large Oil Spill - Greater Than or Equal to 120,000 Barrels

Size assumptions for very large spills for planning area facilities and pipelines are based on response planning standards and discharge estimates for the Alpine oil field (ARCO Alaska 1999, Phillips 2001). Blowouts are unlikely events. While blowouts are often equated with catastrophic spills, very few blowout events have resulted in spilled oil, and the volumes that are spilled are often small.

K.2 Oil Weathering and Spreading

Information about oil weathering and the aerial extent of an oil spill were estimated from oil weathering models and historical information.

K.2.1 Modeling Simulations of Oil Weathering

To judge the effect of an oil spill, the following volumes must be estimated:

- the amount of oil that evaporates;
- the amount of oil that disperses; and
- the amount of oil that remains after a certain time period.

Alpine field crude oil was used as the analog of oil types in the planning area. Weathering estimates of Alpine field crude oil and Arctic diesel (over a 30-day period) were derived by the SINTEF Oil Weathering Model (OWM), Version 2.0 (Reed et al. 2000).

Individual weathering results for Alpine field crude oil spills from the SINTEF OWM model are shown in Table K-5 and Table K-6. The SINTEF OWM changes both oil properties (density, viscosity, pour point, flash point, and water content) and physical properties (spreading,

evaporation, oil-in-water dispersion, and water uptake) of the oil. The OWM performs a 30-day time horizon on the model weathering calculations, but with a warning that the model is not verified against experimental field data for more than 4 to 5 days. The SINTEF OWM has been tested extensively with results from three full-scale field trials of experimental oil spills (Daling and Strom 1999).

The SINTEF OWM does not incorporate the effects of:

- currents
- beaching
- containment
- photo-oxidation
- microbiological degradation
- adsorption to particles
- encapsulation by ice

The spill sizes chosen for oil weathering were 500 and 900 bbl for the Alpine field-type crude oil spill, and 900 bbl for a diesel spill. Two general scenarios were simulated—one in which oil spills into open water, and another in which oil freezes into the ice and melts into 50% ice cover. It was assumed that open water occurs July through September, and that a winter spill melts out in July. For open water, the weathering of the 500- and 900-bbl spills was modeled as instantaneous spills. For the meltout spill scenario, the entire spill volume was modeled as an instantaneous spill. Although different amounts of oil could melt out at different times, the MMS assumed a conservative approach–all oil was released at the same time. Results are reported for the end of 1, 3, 10, and 30 days. The assumed fate and behavior of Alpine field crude oil and diesel oil, information that was used in the analysis of the effects of oil on environmental and social resources, are summarized in Table K-5 and Table K-6.

Table K-5. Fate and Behavior of a Hypothetical 500 bbl Oil Spill from Lagoon Pipelines.[1]

Features	Summer Spill[2]				Meltout Spill[3]			
Time after spill in days	1.0	3.0	10.0	30.0	1.0	3.0	10.0	30.0
Oil remaining (percent)	75.4	68.0	44.0	38.0	77.0	71.9	64.3	57.6
Oil dispersed (percent)	0.6	2.0	8.0	22.0	0.0	0.1	0.7	2.4
Oil evaporated (percent)	24.0	30.0	36.0	40.0	23.0	28.0	35.0	40.0
Thickness (mm)	3.1	1.9	1.1	1.0	4.6	2.7	1.5	1.0
Discontinuous area (mi^2)[4]	0.6	3.1	15.5	63.9	0.6	4.3	10.5	83.0
Estimated coastline oiled (mi)[5]	10.5				9.9			

[1] Calculated with the SINTEF Oil Weathering Model Version 2.0 (Reed et al. 2000), assuming an Alpine field crude type.
[2] Summer (July through September) and assumes: 12-knot wind speed, 33 degrees Fahrenheit, and 1.3-feet (0.4-meter) wave height.
[3] Spill is assumed to occur in May into first-year ice, pools 0.8 inches (2 cm) thick on ice surface for 2 days at 32 degrees Fahrenheit before meltout into 50% ice cover, 11-knot wind speed, and 0.3 feet (0.1 meter) wave heights.
[4] Calculated from Equation 6 of Table 2 in Ford (1985), and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Ice dispersion occurs for about 30 days before meltout.
[5] Calculated from Equation 17 of Table 4 in Ford (1985), and is the result of stepwise multiple regression for length of historical coastline affected.

The structure of the ADEC Alaska North Slope spill database does not facilitate a quantitative analysis of pipeline spill rates for small spills. The ADEC database specifically identifies five pipeline leaks among 975 spill records. The volumes of these pipeline leaks are 0.7, 5, 18, 125,

and 510 bbl. Additionally, any spills occurring or moving off pads would have some potential to enter a river or water body. For the purposes of this oil spill analysis, the percent of crude oil spills occurring on a pad versus off the pad and onto the surrounding environment was estimated. Approximately 65 to 80% of all crude oil spills would occur on a pad and have little or no effect on the environment. Approximately 20 to 35% could occur in or reach the surrounding environment.

Table K-6. Fate and Behavior of a Hypothetical 900 bbl Oil Spill From a Lagoon Facility.[1]

Features	Summer Spill [2]				Meltout Spill [3]			
Time after spill in days	1	3	10	30	1	3	10	30
Oil remaining (percent)	75.5	68.4	57.9	40	76.9	71.8	64	56.5
Oil dispersed (percent)	0.5	1.6	6.1	20	0.1	0.2	1	3.5
Oil evaporated (percent)	24	30	36	40	23	28	35	40
Thickness (millimeters)	4.1	2.5	1.5	1	6.1	3.9	1.9	1.2
Discontinuous area (square miles)[4]	0.6	4.3	21.1	86.8	1.2	5.6	26.7	112.2
Estimated coastline oiled (miles)[5]	13.6				13.0			

[1] Calculated with the SINTEF Oil Weathering Model Version 2.0 (Reed et al. 2000), assuming an Alpine field crude type.
[2] Summer (July through September) assumes: 12-knot wind speed, 33 degrees Fahrenheit, and 1.3-feet (0.4-meter) wave height.
[3] Spill is assumed to occur in May into first-year ice, pools 0.8 inches (2 cm) thick on ice surface for 2 days at 32 degrees Fahrenheit before meltout into 50% ice cover, 11-knot wind speed, and 0.3 feet (0.1 meter) wave heights.
[4] Calculated from Equation 6 of Table 2 in Ford (1985), and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Ice dispersion occurs for about 30 days before meltout.
[5] Calculated from Equation 17 of Table 4 in Ford (1985), and is the result of stepwise multiple regression for length of historical coastline affected.

K.2.2 Observations of Historic North Slope Spill Patterns

The development scenarios for alternatives A, B, C, and D include an onshore pipeline. Of greatest concern would be the possible contamination of the Colville River, because a pipeline could cross or underlie the Colville River and some of its tributaries, and Teshekpuk Lake.

Those spills reaching the surrounding environment generally remain restricted to a limited area of the tundra unless they reach a river, stream, or other water body. The ADEC records are not accurate enough to provide statistical spill size areas. The following are comments based on information from the ADEC database and Behr-Andres et al. (2001). Off-pad spills that occur in or reach the environment generally cover a small area (less than or equal to 500 ft^2). Larger areas of contamination occur when wind blows a fine oil mist over a large area. The largest area ever covered was the result of a pipeline spill on December 30, 1993, at drill site 5, well 23, which misted a fine oil spray of 4 bbl over a tundra area of 100 to 145 acres (Mueller 1997). Crude oil from a failed flowline spilled onto a gravel pad, reserve pit, and impoundment. High winds resulted in the crude oil being misted over the snow-covered tundra in an area approximately 330 feet wide and 1,300 feet long (Behr-Andres et al. 2001). Of the off-pad spills that occur, many contact snow or ice, which is cleaned up before the oil reaches the tundra. Smaller spills are likely to be contained within the snow layer, depending on snow depth and density. Larger spills are more likely to reach the ground surface. The ADEC database documents that a spill at Point McIntyre covered approximately 23 acres of snow-covered tundra with 142 bbl of crude oil. Because this area was snow covered, there was little impact to

the surrounding environment. If this spill had occurred during the summer, the impacts would have been very different.

K.3 Cumulative Analysis of Oil Spills

This section discusses how the oil spills for Effects of the Cumulative Case (**section 4.7**) were estimated.

K.3.1 Preparing the Cumulative Analysis

The TAPS pipeline, onshore Alaska North Slope, TAPS tankers, and the Alaska Outer Continental Shelf have varying spill rates and spill-size categories. For a summary of the spill rates and spill size categories that were assumed for analysis of oil spills in the cumulative case, see Table K-7. One noteworthy fact is that most oil originating from either onshore or offshore on the North Slope of Alaska flows through the TAPS pipeline and into TAPS tankers.

Table K-7. Oil Spill Rates and Spill-size Categories Used to Estimate Large Crude Oil Spills for the Cumulative Analysis

Location	Beaufort OCS		Alaska North Slope 1985-2001		TAPS Pipeline 1985-2001		TAPS Tanker 1977-1999	
	Spill Rate (Spills/Bbbl)	Size Category (bbl)	Spill Rate (Spills/Bbbl)	Size Category (bbl)	Spill Rate (Spills/Bbbl)	Size Category (bbl)	Spill Rate (Spills/Bbbl)	Size Category (bbl)
Offshore	0.23	≥1,000	-	-	0.21	≥500	0.88	≥1,000
Onshore	-	-	0.64	≥500	0.21	≥500	0.88	≥1,000

Sources: Anderson and LaBelle (2000), Bercha Group, Inc. (2002), and USDOI MMS (2002).

Estimates of past, present, and reasonably foreseeable production are used for the quantitative analysis of oil spills. Past, present, and reasonably foreseeable production contributes 14.4 Bbbl in reserves and resources, with the planning area contributing an additional 1.5 Bbbl (the mean resource value for the planning area), for a total of 15.9 Bbbl.

K.3.2 Estimating Possible Future Spills from All Sources

The estimated mean number and volume of spills for the cumulative case are shown in Table K-8. The likely number of additional oil spills in the Beaufort Sea, onshore, along the TAPS pipeline, or tanker route due to projects in the planning area is two. Thus, for purposes of analysis of the cumulative case, it is assumed that the planning area would contribute a total of two additional oil spills offshore in the Beaufort Sea, onshore, or along the TAPS pipeline or tanker route.

The Beaufort Sea pipeline and platform spill size range used in the analysis is 1,500 to 4,600 bbl. The onshore spill size range used is 500 to 900 bbl. For the cumulative case, a TAPS pipeline spill of 4,400 bbl is estimated. The average spill sizes from TAPS tankers and the distribution of the number of spills used for this analysis is as described in the Northwest National Petroleum Reserve – Alaska IAP/EIS (USDOI BLM and MMS 2003).

It is estimated that one spill greater than or equal to 1,000 bbl would occur as a result of activities in the Beaufort Sea over the lifetime of planning area projects. This estimate is based on production from past, present, and reasonably foreseeable development. Possible offshore

sources in these categories (past, present, and reasonably foreseeable development) include Endicott, Northstar, Kalubik, Gwydyr Bay, Flaxman Island, Liberty, Kuvlum, and Hammerhead. This estimate also includes potential production from undiscovered resources on Federal leased tracts in the Beaufort Sea.

It is estimated that eight spills greater than or equal to 500 bbl would occur onshore before entering the TAPS pipeline. One of these spills is likely to be related to planning area projects.

It is estimated that three spills greater than or equal to 500 bbl would occur along the TAPS pipeline, although it is unlikely that the additional throughput given planning area projects would increase the number of spills.

Fourteen spills greater than or equal to 1,000 bbl are expected to occur as a result of projects along the TAPS tanker route, one would be expected to be due to the additional volume from planning area projects. Of these:

- nine spills with a mean size of 4,000 bbl—four in port and two at sea—would be expected to occur;
- four spills with a mean size of 13,000 bbl would be expected to occur at sea; and
- one spill with a size ranging from 200,000 to 260,000 bbl (for purposes of analysis 250,000 bbl) would be expected to occur at sea.

Previous studies show that the chance of one or more spills both occurring and contacting land along the U.S. coast adjacent to the TAPS tanker route is less than or equal to 3% (LaBelle et al. 1996).

Table K-8. Cumulative Oil-Spill-Occurrence Estimates ≥500 bbl and ≥1,000 bbl over Assumed 15-20 Year Production Life of the Northeast National Petroleum Reserve – Alaska

Spill Location and Timeframe	Crude-Oil Spills					
	Reserves and Resources (Bbbl)	Spill Rate (Spills/ Bbbl)	Size Category	Assumed Size (bbl)	Most Likely Number	Estimated Mean Number of Spills
Offshore						
Past, present, and reasonably foreseeable	2.80	0.23	≥1,000 bbl	NA	1	0.64
Planning Area	NA	0.23	≥1,000 bbl	NA	NA	NA
Total	**2.80**	**0.23**	**≥1,000 bbl**	NA	**1**	**0.64**
Onshore						
Past, present, and reasonably foreseeable	11.6	0.64	≥500 bbl	500–900	7	7.42
Planning Area	1.5	0.64	≥500 bbl	500–900	1	0.96
Total	**13.1**	**0.64**	**≥500 bbl**	**500–900**	**8**	**8.38**
TAPS (Pipeline)						
Past, present, and reasonably foreseeable	14.4	0.21	≥500 bbl	4,400	3	3.02
Planning Area	1.5	0.21	≥500 bbl	4,400	0	0.32
Total	**15.9**	**0.21**	**≥500 bbl**	**4,400**	**3**	**3.34**
TAPS (Tanker)						
Past, present, and reasonably foreseeable	14.4	0.88	≥1,000 bbl	varies	13	12.67
Planning Area	1.5	0.88	≥1,000 bbl	varies	1	1.32
Total	**15.9**	**0.88**	**≥1,000 bbl**	**varies**	**14**	**13.99**

Note: The ADEC database has no significant crude oil spills on the North Slope resulting from well blowouts and no facility or onshore pipeline spills greater than 1,000 barrels for the years 1985-2000.
NA = Data not available or not applicable.
Source: USDOI MMS (2002).

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