Appendix A
Trans Alaska Pipeline System Throughput Analysis

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Assumptions for future Trans Alaska Pipeline System (TAPS) throughput are needed for estimating environmental, economic, and social impacts (incremental and cumulative) of the proposed action. In turn, TAPS throughput depends on assumptions regarding the decline curves applicable to existing fields and the discovery of and production from new fields. Reasonable forecasts can be made for certain mature fields, but reserve additions, future discoveries, and production from new fields are speculative. Actual production depends on exploration and development decisions yet to be made and which will reflect crude oil prices, available technology, field economics, transportation costs, and regulatory actions in the future. Many of these factors, such as future oil prices or lease availability and access decisions, are extremely difficult to forecast.

For example, in the environmental evaluation document for the Alpine Development Project (USACE, 1997), 25 key steps necessary for project development are identified and have probabilistic outcomes. Despite extensive use of sophisticated mathematical models, estimates of economically recoverable resources for the National Petroleum Reserve-Alaska (NPR-A) (BLM and MMS, 1998) made by the Bureau of Land Management (BLM) ranged by more than a factor of four from approximately 500 million to 2,200 million barrels (bbl). New stratigraphic play concepts for the Jurassic system may lead to the discovery of fields overlooked by past exploration efforts, and advancements in technology have lowered the field-size threshold for commercial development. Government decisions to open new areas for exploration and production cannot be predicted with any certainty and are subject to political considerations. For this reason, a "bottom-up" field-by-field forecast is not likely to furnish a useful methodology and is certain to raise extraneous issues.

Since peaking at over 2 million bbl/day in 1988, North Slope oil production has declined at an average annual rate of 4.4 percent. While regularly produced projection forecasts of the Alaska Department of Revenue (ADOR) and the Alaska Department of Natural Resources (ADNR) have consistently proven to be reliable over the near term, they have proven to be conservative over the long term (USDOE, 1994). The reason for this is that the forecasts are based only on known producing fields and those under development. Figure A-1 shows successive annual ADNR throughput projections for the North Slope for the years beyond 1997. Successive projections have generally resulted in upward revisions of expected production in a given year, as well as postponement of the year at which production is expected to fall below a certain benchmark. For example, between 1985 and 1999, the projected production for 2010 has increased from 36 million to 256 million bbl/year — an increase from 0.1 to 0.702 million bbl/day. Also, between 1985 and 1999, the time when production is projected to first fall below 400,000 bbl/day has been extended from 2003 to 2017.

Recognizing that the ADOR and ADNR projections have historically been conservative and have required adjustment as time passes, this analysis adopts as its baseline throughput assumption the most recent U.S. Department of Energy projection (EIA, 1999e). The USDOE projection published in the *Annual Energy Outlook 2000* (which includes Cook Inlet production that is negligible in proportion) forecasts Alaska oil production to decline at a rate of 4.1 percent per year from 1997 through 2020. The reference-case (most-probable) production rates are as follows: 2010, 0.78 million bbl/day; 2015, 0.61 million bbl/day; and 2020, 0.49 million bbl/day (Table A-1).

The projection uses specific assumptions about oil price, the resource base, and technology to develop estimates of profitable investment in three onshore and three offshore regions in Alaska. The world oil price in 1998 dollars/bbl is assumed to rise to $21.00 in 2010 and $22.04 in 2020. The resource base assumptions are taken from the U.S. Geological Survey (USGS) and the Mineral Management Service (MMS) of the U.S. Department of the Interior, with supplemental adjustments to the USGS nonconventional resources by Advanced Resources International, an independent consulting firm. Technological improvements affecting recovery and cost are projected which increase drilling success rates and reduce the effective cost of sup-

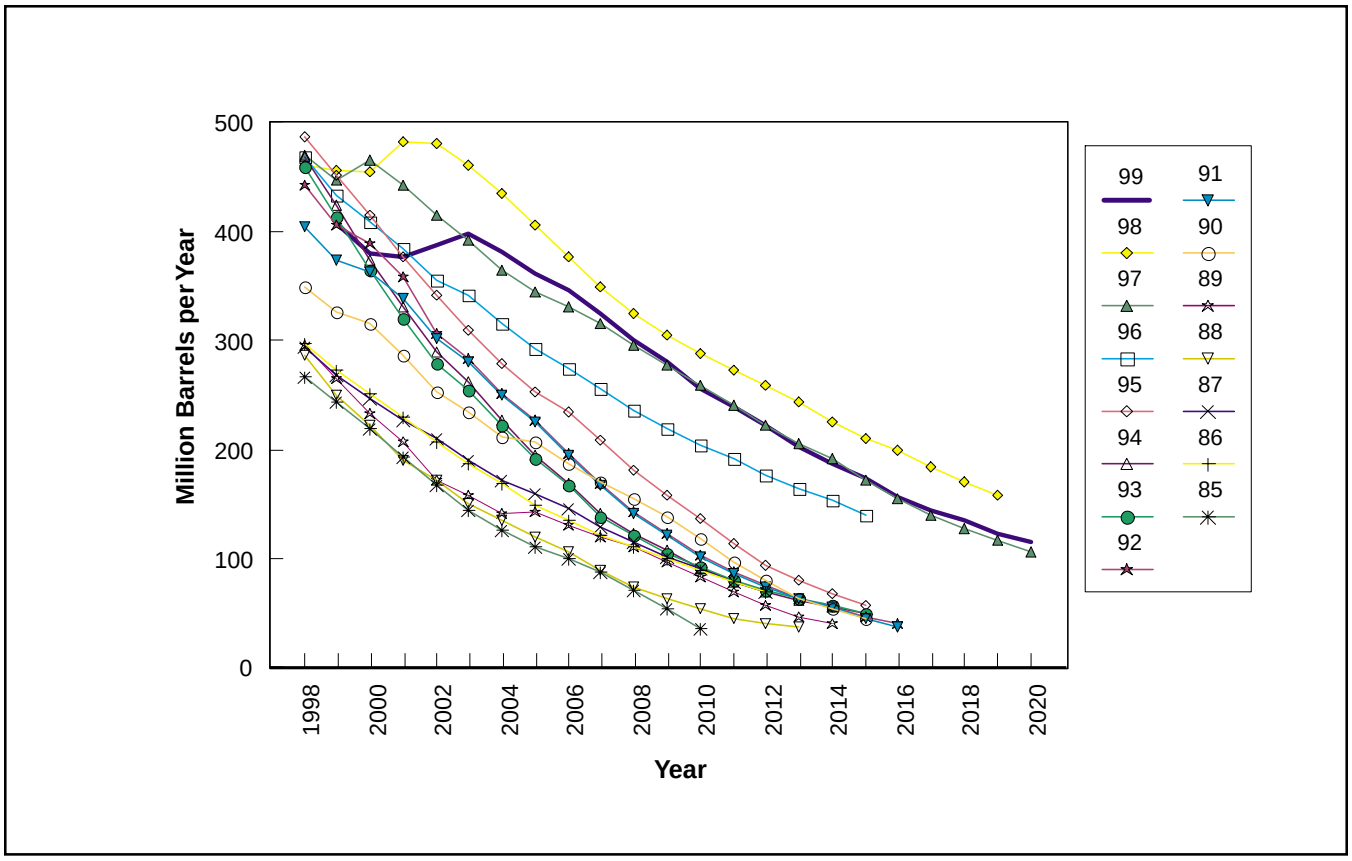

Figure A-1. *Alaska North Slope oil production projections by the Alaska Department of Natural Resources.*

Table A-1. *Baseline throughput assumption and constant decline model compared.*

Year	Baseline (million bbl/day)	Constant Decline Rate (million bbl/day)
2000	1.19	1.19
2002	1.10	1.10
2004	1.02	1.02
2006	0.93	0.93
2008	0.85	0.85
2010	0.78	0.78
2012	0.71	0.71
2014	0.64	0.64
2016	0.59	0.59
2018	0.54	0.54
2020	0.49	0.49
2022	0.49	0.45
2024	0.49	0.42
2026	0.49	0.38
2028	0.49	0.35
2030	0.49	0.33
2032	0.49	0.30

Source: USDOE (1998) and author's estimate.

ply over time. The USDOE forecast includes a provision for new fields, but assumes that current restrictions on leasing and drilling in Alaska, in particular the Arctic National Wildlife Refuge, will continue to be enforced for the duration of the forecast period.

Several alternative projections demonstrate the sensitivity of the USDOE projection of Alaska oil production to various assumptions regarding economic growth, world oil price, and the pace of technological progress. Based on USDOE's projected production in 2020 (Table A-2), there is little downside sensitivity to lower economic growth or world oil price. The projection is more sensitive to the rate of technological progress. USDOE created the technical progress cases by adjusting reference-case parameters which control the rates of change of finding rates, drilling, lease equipment and operating costs, and growth in the undiscovered economic resource base. The rates in the sensitivity cases were varied from their statistically estimated values by one standard deviation.

The baseline TAPS throughput assumption of 0.49 million bbl/day (from 2020) is higher than the spring 1999 ADOR projection (0.38 million bbl/day). However, it is significantly smaller than the "high-case production scenario,"

Table A-2. *Alaska oil production in 2020: Sensitivity results (million bbl/day.)*

Case	Production (million bbl/day)
Reference case	0.49
Low economic growth	0.49
High economic growth	0.50
Low world oil price	0.45
High world oil price	0.59
Slow technological progress	0.37
Rapid technological progress	0.66

Source: USDOE (1998).

which posits an additional 0.98 million bbl/day "technically recoverable" if prices were high enough (ADOR, 1999). At presently projected crude-oil prices, ADOR estimates that an additional 0.23 million bbl/day might be available. Thus, including additional fields, the ADOR estimate totals 0.61 million bbl/day, which is generally consistent with the baseline throughput assumption.

The USDOE projections have been stable in recent years. The *Annual Energy Outlook 1998* projected the Alaska production decline rate at 4.3 percent per year from 1996 to 2020. The 1997 Outlook projected the decline rate from 1995 to 2015 to be 4.2 percent.

In the baseline throughput case, it is assumed that throughput remains constant at 0.49 million bbl/day from 2020 until 2034 — the end of the 30-year TAPS ROW renewal period. This assumption is not a projection, but a recognition that a number of production scenarios are possible. For example, throughput profiles based on limited use of gas-to-liquids conversion for the Prudhoe Bay and Pt. Thomson gas fields are very nearly flat (INEEL, 1996). For comparison, production was also calculated (Table A-1) if the decline rate of 4.1 percent were to continue until 2034. In that case, production would be 0.28 million bbl/day in 2034. Figure A-2 shows the baseline throughput assumption. Over the 30 years from 2004 until 2034, total Alaska North Slope production is equal to approximately 7.02 billion bbl. For quantitative perspective, cumulative TAPS throughput from 1977 through 1998 was approximately 12.5 billion bbl (APSC, 1999).

For estimating the environmental impacts of renewal of the TAPS ROW, the most important consideration is that the production level be sufficient for continued operation of the pipeline. The environmental impacts are less sensitive to the particular level of pipeline throughput. Recent studies projecting when the TAPS pipeline might shut down have variously estimated that the minimum technically feasible sustainable TAPS throughput without modifications is in the range of 0.2 to 0.6 million bbl/day (INEEL, 1991, 1993, 1996; GAO, 1993). Below 0.6 million bbl/day, "mechanical revisions" may be required to operate with a throughput below that level. And operation at less than 0.3 million bbl/day "would require additional mechanical

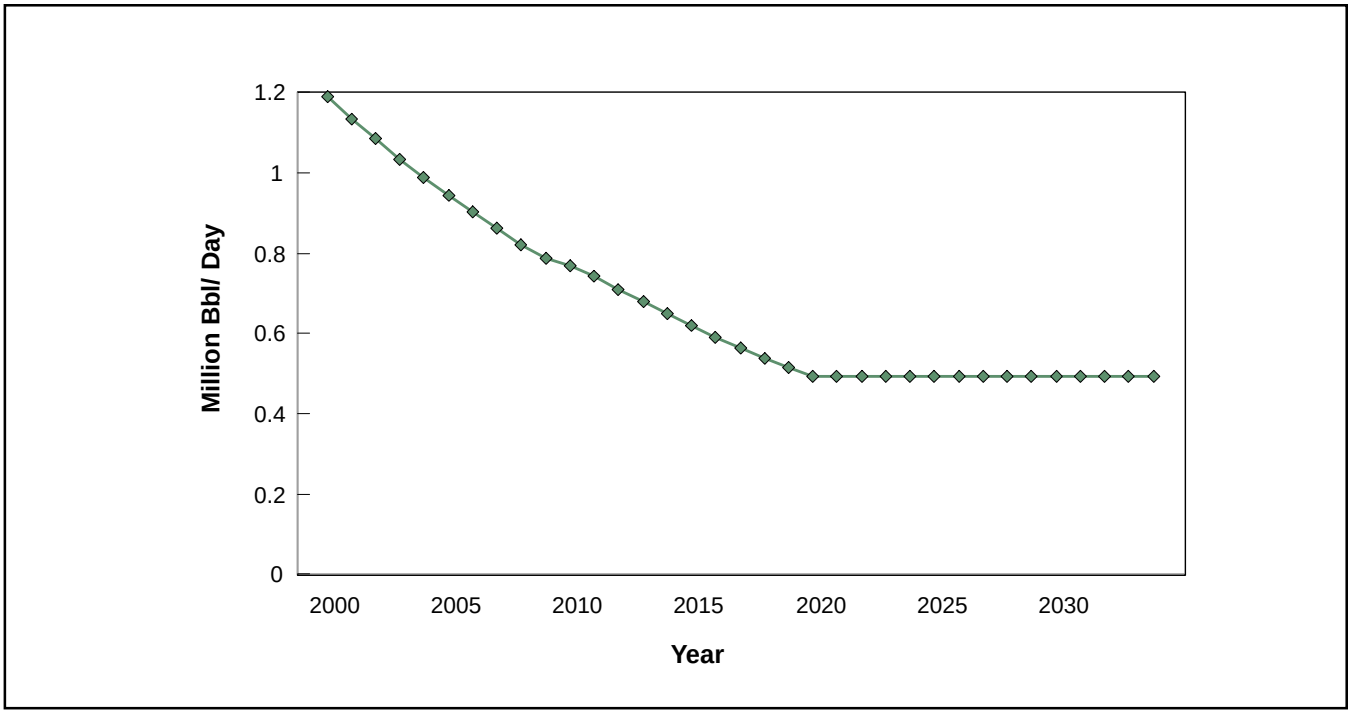

Figure A-2. *Baseline throughput assumption used in this analysis.*

modifications and would result in a greater decrease in the oil temperature in route to Valdez which would cause an increase in the oil viscosity and more wax problems. The increased formation of wax is the more critical and costly of these factors" (INEEL, 1991).

However, the minimum economically feasible throughput is less than this because it is likely that modifications will be made to permit operation at a lower throughput in order to avoid leaving economically recoverable oil stranded on the North Slope. The minimum economically feasible throughput level will be attained when the cost of continued operation, including the cost of modifications to handle reduced throughput, rises to a level that eliminates the profits from additional production on the North Slope. The studies mentioned above recognized the existence of this lower minimum economically feasible throughput but have not attempted to calculate that minimum. Such an analysis would require knowledge of the cost of pipeline operations, the characteristics of the liquid transported, and the cost of design modifications required as throughput declined — as well as other variables. The U.S. General Accounting Office (GAO) study suggested that "companies may be willing to incur the expensive changes required to continue operating TAPS at reduced levels if warranted by the overall profitability of the companies' Alaska operations" (GAO, 1993). The 1996 USDOE study (INEEL, 1996) notes that "it is a common belief by many parties in Alaska that . . . the lower limit will be reduced to 0.1 million bbl/day or less," although there are no known studies to confirm this.

References - Appendix A

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