Cook Inlet Risk Assessment: Benefit-Cost Analysis of the Trans-Foreland Pipeline as an Oil Spill Risk Reduction Option

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Prepared by

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Abbreviations

BCA	Benefit-cost analysis
BCR	Benefit-cost ratio
CIRA	Cook Inlet Risk Assessment
DRT	Drift River Terminal
EIA	U.S. Energy Information Administration
EPA BOSCEM	Environmental Protection Agency Basic Oil Spill Cost Estimation Model
KPL	Kenai Pipeline Company
LSFO	Low Sulfur Fuel Oil
MGO	Marine gas oil
NPV	Net Present Value
O&M	Operating and maintenance
RRO	Risk Reduction Option

1 Introduction and Key Findings

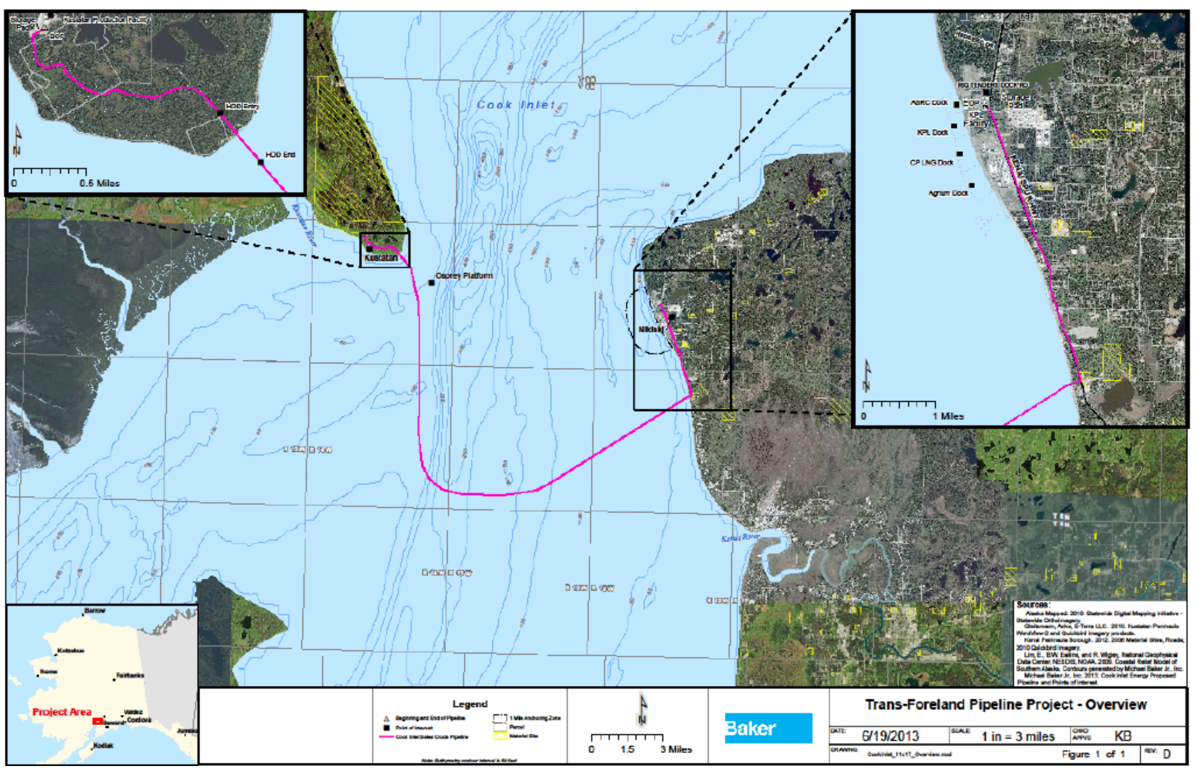
Northern Economics, Inc. conducted a benefit-cost analysis (BCA) in support of the evaluation of the proposed Trans-Foreland Pipeline, an 8-inch diameter pipeline that would transport crude oil from the existing Kustatan Production Facility on the west side of Cook Inlet to the Kenai Pipeline Company (KPL) Tank Farm on the east side of the inlet (Michael Baker, Jr., Inc. 2013). This report documents the data and methodologies that informed this analysis, as well as its major findings.

1.1 Project Background

The proposed pipeline is one of several risk reduction options (RROs) being considered as part of the Cook Inlet Risk Assessment (CIRA). Launched in 2011 by the Cook Inlet Regional Citizens Advisory Council, Alaska Department of Environment Conservation, and U.S. Coast Guard, the goal of the risk assessment is to examine the extent to which marine vessels transiting through or near the Cook Inlet region present risks for oil spills and to identify whether and by what means those risks can be mitigated (Cook Inlet Risk Assessment 2014).

The proposed pipeline would have a project life of 30 years and a capacity of 62,600 barrels per day (Loy 2013). The total cost of construction for the pipeline is $55 million, and annual operating and maintenance (O&M) costs would be $5.2 million (Tesoro 2014). Figure 1 is a map displaying the proposed pipeline route.

Figure 1. Map of Proposed Trans-Foreland Pipeline



Source: Michael Baker, Jr., Inc. 2013.

Cook Inlet Energy filed the initial application to the Alaska Department of Natural Resources in November 2012 for a right-of-way for the Trans-Foreland Pipeline. Tesoro, which operates a refinery at Nikiski, assumed control of the project in fall 2013. The new pipeline would allow Cook Inlet producers to bypass the current Drift River infrastructure on the west side of the inlet.

Project proponents cite three primary benefits (Loy 2013):

1. Elimination of tanker transport of crude across the sometimes icy and turbulent Cook Inlet;
2. Provision of an alternative to the Drift River Terminal (DRT), which was knocked out of service in 2009 as a result of flooding following eruptions of the nearby Redoubt volcano; and
3. Potentially lower oil transportation costs.

This analysis considers the following impact categories in estimating the benefits and costs associated with the proposed pipeline relative to the existing (without pipeline) scenario, given projected oil spill volumes for each: value of spilled oil; oil spill cleanup costs; environmental damages; socioeconomic damages; human injuries and fatalities; and vessel damages. This analysis also considers O&M costs under the without and with project scenarios to the extent that data were available.

1.2 Findings

This analysis concludes that the Trans-Foreland Pipeline presents two major benefits to the Cook Inlet region:

1. The nearly complete mitigation of the risks of oil spills resulting from the transport of crude from the west side to the east side of the inlet; and
2. The avoidance of costs from a large tanker vessel oil spill that would greatly outweigh the costs of construction and operation of the pipeline.

Table 1 underscores the first benefit, comparing small, moderate, large, and worst case spill volumes for crude tanker impact spills and subsea pipeline spills, as modeled by The Glosten Associates (Glosten). For each of the four spill size categories, the estimated pipeline spill volumes represent at least a 99 percent reduction from the associated crude tanker spill volumes.

Table 1. Spill Volumes from a Double Hulled Crude Tanker Impact Incident and Subsea Pipeline Spill

	Small[1] (25^{th} percentile (gallons)	Moderate (50^{th} percentile) (gallons)	Large (95^{th} percentile) (gallons)	Worst Case Discharge (gallons)
Crude tanker impact	500	20,000	15,000,000	28,500,000
Subsea pipeline	<1	5	571	232,227
Reduction (%)	>99	>99	>99	99

Source: Glosten 2013.

If only moderate size tanker vessel spills were to occur over the 30-year design life of the project, and either at or below the rate estimated by Glosten, the alternative yields a very low benefit-cost ratio (BCR). However, the occurrence of even a single large spill clearly justifies the cost of the pipeline from

[1] The spill volume percentile for each spill size category indicates the percentage of spills estimated to be smaller than that percentile. For example, for the 25^{th} percentile, 75 percent of spills for a particular incident type are estimated to be larger than the spill volume in that percentile column.

a benefit-cost standpoint. Thus, the second major benefit of the pipeline is more nuanced than the first, but no less important to the evaluation of the pipeline's merits in addressing the goals of CIRA. Comparison of the four spill scenarios identified in Table 2 is repeated throughout this report and constitutes the entirety of the sensitivity analysis whose results are included herein. As exhibited in Table 2 and developed later in this report, the alternate inclusion of a large or worst case spill is the pivotal factor in determining whether the estimated BCR is far greater than or less than 1. Regardless, the BCRs for spill scenarios 2, 3, and 4 clearly indicate that the pipeline would prove a far more cost-effective alternative to the accrual of the catastrophic costs of a large vessel tanker oil spill.

Table 2. Benefit-Cost Ratio of the Alternative under Four Spill Scenarios

	Scenario 1 Median Spills Only	Scenario 2 Single Large Spill Only	Scenario 3 Single Large Spill and Median Spills	Scenario 4 Worst Case Spill Only
BCR	0.05	5.8	5.9	18.1

Source: Glosten 2013; Jensen 2014; Etkin 2004; Northern Economics estimates.

1.3 Key Assumptions and Limitations

Except where otherwise noted, "baseline" refers to the "without pipeline" scenario and "alternative" refers to the "with pipeline" scenario.

This analysis assumes completion of pipeline construction in 2014 and the total cessation of tanker traffic between DRT and Nikiski beginning in 2015 and continuing through the life of the project. The assumed life of the pipeline is 30 years, although similar pipelines have been in operation for much longer periods of time.

This analysis excludes the annual O&M cost for DRT. This avoided cost represents a benefit of the pipeline and would elevate the BCR. This analysis also ignores the risk of a potential catastrophic failure of DRT tanks, considered a possibility given the facility's proximity to the recently active Mount Redoubt volcano (Petri 2009). This analysis further assumes that DRT would have to be decommissioned at some point, regardless of whether construction of the pipeline occurs, and that this cost does not vary between the base (without pipeline) and alternative (with pipeline) scenarios. This analysis does not consider the cost of decommissioning or removal of the pipeline at the end of its life.

In addition to low sulfur fuel oil (LSFO), the tankers that transport crude from DRT to Nikiski burn require some volume of marine gas oil (MGO) for the operation of the vessel generators (Jensen 2014). While an estimate for the amount of MGO burned annually was not available, the avoidance of its use represents a benefit of the alternative and would increase the BCR.

Other benefit-cost impact categories excluded from this analysis include vessel damage and human injuries and fatalities. Vessel damage is likely to take place with collisions, allisions, and groundings. Neither actual vessel damage costs from previous tanker incidents nor academic literature informing the development of a damage cost estimate could be found. A review of National Oceanic and Atmospheric Administration summaries of Cook Inlet oil spills from tanker vessels over the time period 1987–present revealed no record of injuries or fatalities involved in the transport of crude from DRT to Nikiski. However, the grounding of the M/V Alaska Constructor in the Upper Cook Inlet in November 1988 resulted in the deaths of three crewmen. At the time of grounding, the vessel was en route from Anchorage to Trading Bay to deliver fuel to an earth-moving operation. This analysis does not attempt to quantify the risk of human injuries or fatalities based on this incident, but acknowledges that the removal of vessel traffic involved in the transport of crude and requiring the use of other fuels also eliminates some of this risk.

All costs are in 2013 dollars. Where cost estimates are from years prior to 2013, the Bureau of Labor Statistics' Consumer Price Index was used to convert to 2013 dollars.

One factor that impacts the severity of oil spills is oil type. This analysis assumes that all oil spilled would be medium crude, which is the substance that would be transported across Cook Inlet via tankers and the pipeline under the baseline and alternative, respectively.

This analysis considers only impacts of potential spills for the sub-sea portion of the pipeline and does not separately assess the risk of spills occurring along the above-grade section of the pipeline.

This analysis should be considered in the context of these assumptions and limitations.

1.4 Report Layout

The remainder of the report is divided into three sections:

Section 2 details estimation of costs under the baseline for four different oil spill scenarios. This section also details the methodologies used in the calculation of estimated costs under both the baseline and alternative.

Section 3 summarizes costs under the alternative.

Section 4 defines the benefits accrued under the alternative and compares net present value of benefits and costs, as well as BCRs for the four spill scenarios.

2 Baseline (Without Pipeline)

This section presents estimated costs under the baseline (without pipeline). Table 3 summarizes the net present value (NPV) of costs across operating and spill impact cost categories for four oil spill scenarios:

1. Moderate (median) sized spills, as estimated using spill frequency and volume projections by Glosten;
2. Single large spill in Y2030, plus moderate spills (as estimated in Scenario 1);
3. Single large spill in Y2030 only; and
4. Single worst case scenario spill in Y2030.

Table 3 includes only those cost categories for which this analysis was able to calculate estimates. Notably excluded are DRT O&M costs, as well as vessel damages and human injuries and fatalities resulting from tanker spill incidents. Exactly what constitutes each of these spill scenarios is explained later in this section.

The difference in NPV of costs across the four spill scenarios indicates that the occurrence of a single large or worst case spill increases total costs by more than two orders of magnitude, while the variable inclusion of moderate, or median, volume spills adjusts total costs only incrementally. The NPV of total costs under the median spills scenario (Scenario 1) are 0.8 percent of costs under the single large spill scenario and just 0.2 percent of costs under the single worst case spill scenario.

Cleanup costs, socioeconomic damages, and environmental damages constitute the largest value impact categories for three scenarios that include a large or worst case spill, while expenditure on LSFO is the largest cost item under spill scenario 1. The value of spilled oil represents a relatively small portion of total costs under scenarios 2-4 but, for each of these scenarios, is greater than the NPV of total costs for scenario 1.

Table 3. Summary of Net Present Value of Costs for Various Spill Scenarios under Baseline

	Scenario 1 Median Spills Only	Scenario 2 Single Large Spill Only	Scenario 3 Single Large Spill and Median Spills	Scenario 4 Worst Case Spill Only
	Cost/Value			
Cost Category	**($1,000)**	**($1,000)**	**($1,000)**	**($1,000)**
LSFO – tankers	2,929.0	2,929.0	2,929.0	2,929.0
Spilled oil value	10.3	8,342.1	8,352.1	25,946.4
Cleanup costs	832.4	280,931.7	281,741.3	873,442.1
Environmental damage	474.2	144,939.3	145,400.5	450,629.3
Socioeconomic damage	673.6	214,724.8	215.380.1	667,599.0
Net Costs	**4,919.4**	**651,866.8**	**653,802.9**	**2,022,471.9**

Note: Columns may not sum to total due to rounding. A discount rate of seven percent is applied to all costs.
Source: Glosten 2013; Jensen 2014; Northern Economics estimates.

2.1 Overview

The baseline assumes that tanker vessel trips will continue at a rate of 38 per year and that no alternative for the transport of crude between DRT and Nikiski will emerge over the assumed life of the pipeline (under the with pipeline scenario), from 2015–2044. Analysis of the baseline attempts to estimate all costs associated with the transport of crude from DRT to Nikiski without construction of the sub-sea pipeline.

2.2 Costs

Central to analysis of the baseline is consideration of the costs of vessel tanker oil spills across various impact categories. The methodologies applied to the estimation of these costs are described in detail below.

Under the baseline, DRT would remain in operation, incurring O&M costs. However, this analysis was unable to obtain an estimate for annual O&M costs for DRT. Operations costs under the baseline also include the cost of LSFO and MGO, required for the operation of the tanker vessels that transport crude between DRT and Nikiski. This analysis considers these fuel costs to the extent that data were available. Depreciation to tanker vessels resulting from the 38 one-way trips between the west and east sides of Cook Inlet each year are not included in this analysis.

2.2.1 LSFO for Tanker Vessels

Vessel tankers transporting crude between DRT and Nikiski burn an average of four tons of LSFO per one-way trip during summer, when they pass directly north of Kalgin Island, and nine tons of LSFO per one-way trip during winter, when they travel south of Kalgin Island and icy conditions are prevalent. This analysis assumes an equal distribution of trips alternately burning four and nine tons of LSFO, or 19 trips each, as well as an average LSFO weight of 7.25 pounds per gallon (Flint Hills Resources 2003). The calculation of the cost of LSFO also assumes a fuel cost for 2014 equivalent to the average cost of marine diesel at the port of Homer, averaged across the months July 2013 to June 2014 (Fisheries Economics Data Program 2014). The rate of change in LSFO price from 2015–2044 is assumed equivalent to that of medium crude, as projected by the U.S. Energy Information Administration (EIA 2013).

2.3 Frequency and Severity of Potential Spills

The two components of risk related to oil spills are frequency and severity. Glosten provided an estimate of 0.0030 vessel tanker spills per traffic-day. Assuming 38 one-way crude carrier transits across Cook Inlet each year, or 35.1 vessel traffic-days, this translates to an annual average of 0.1053 tanker spills (Glosten 2013). Thus, this analysis estimates that roughly three median sized spills will occur over a 30-year period. As exhibited in Table 3, however, these three spills combined incur costs amounting to less than one percent of the NPV of costs from a single large or worst case spill in year 16 under the alternative.

Glosten separately estimated spill volumes from a double-hulled crude tanker for impact, non-impact, and transfer error incidents, as exhibited in Table 4. Impact incidents include collisions, allisions, and groundings; non-impact incidents include fires, equipment failures, and operations errors; and transfer error incidents include both cargo transfers and bunker errors. The spill volume percentile for each incident type indicates the percentage of spills estimated to be smaller than that percentile. For example, 50 percent of impact, non-impact, and transfer error spills are estimated to be smaller than 20,000, 2,000, and 10 gallons, respectively.

Table 4. Spill Volumes from a Double Hulled Crude Tanker

Incident Type	Small (25th percentile (gallons)	Moderate (50th percentile) (gallons)	Large (95th percentile) (gallons)	Worst Case Discharge (gallons)
Impact	500	20,000	15,000,000	28,500,000
Non-Impact	100	2,000	8,000,000	28,000,000
Transfer Error	1	10	2,000	75,000,000

Source: Glosten 2013.

Importantly, the volumes in the moderate spill size column are median predicted spill sizes; mean estimated spill volumes may be substantially greater. An overall median estimated spill size was calculated by multiplying the moderate spill volume for each incident type by its respective share of Cook Inlet spill incidents from 1995–2010 and summing these three values.[2] Over the time period 1995–2010, impact, non-impact, and transfer error incidents represented 11 percent, 49 percent, and 40 percent of total product and crude tanker spill incidents, respectively. The multiplication of these weights by their respective estimated moderate spill volumes (from Table 4) yielded an overall median spill volume of 3,204 gallons.

A BCA that assumes only the occurrence of median-size spills at the estimated spill frequency fails to capture the potentially far more severe consequences of larger spill scenarios. Thus, while this analysis uses the median estimated spill volumes to calculate estimated spill costs for each year during the assumed life of the proposed pipeline, it alternately assumes the occurrence of a large or worst case spill in 2030 (year 16 of the project under the alternative) to capture the avoided costs of the type of spill (i.e. a large one) whose preclusion would be the greatest intended benefit of the pipeline. Estimated volumes of large and worst case scenario spills were calculated similarly to the estimated moderate spill volume, but include only impact and non-impact incidents. This analysis considers highly improbable the prospect of transfer errors resulting in the spillage of many thousands of gallons of oil. As shown in Table 5, the weighted estimated volume of large spills, estimated to be larger than 95 percent of all spills, is less than one-third of the size of a worst case spill.

Table 5. Calculation of Estimated Spill Volumes under Large and Worst Case Scenarios

Spill Size	Impact		Non-Impact		Weighted Estimated Spill Volume (gallons)
	Volume (1,000 gal)	Share of Spills (%)	Volume (1,000 gal)	Share of Spills (%)	
Large (95th percentile)	15,000	19	8,000	81	9,166,667
Worst Case	28,500	19	28,500	81	28,500,000

Source: Glosten 2013; DEC 2013; Northern Economics estimates.

2.4 Spill Costs

While Glosten's projections suggest that no oil from tanker incidents will be spilled in nearly 9 out of 10 years, it is beneficial in a BCA that assigns a discount rate to benefits and costs to spread out those

[2] Oil spill data came from the Alaska Department of Environmental Conservation Oil Spill Database. Each spill type's share of total spills was determined using all 45 spills that occurred in Cook Inlet over the years 1995–2010 that resulted in at least one gallon of spillage. The share of spill types for product and crude tanker spills only were nearly identical to those of the larger sample of 45 spills.

estimated costs across the full BCA timeline. This particularly applies to the current analysis, since the timing of tanker spills that would occur from 2015 to 2044 constitutes an unknown. Thus, the estimated median spill size of 3,204 gallons was used to calculate costs across the various impact categories, but these costs were then spread evenly across the 30-year timeframe of the current analysis. Contrasting this approach is the assignment of all large or worst case spill costs to a single year (i.e. Y2030) under the three spill scenarios that assume the occurrence of such an incident.

This analysis relied on the Environmental Protection Agency Basic Oil Spill Cost Estimation Model (EPA BOSCEM) to estimate cleanup costs, as well as environmental and socioeconomic damages. Based on a data set of 42,860 oil spills of at least 50 gallons that occurred between 1980 and 2002, D.S. Etkin developed the model to estimate the costs of oil spills occurring in navigable inland waterways in the EPA Jurisdiction Oil Spill Database. EPA BOSCEM allows for the incorporation of spill-specific factors that variably influence costs, including spill amount, oil type, response methodology and effectiveness, type of impacted medium, location-specific socioeconomic value, freshwater vulnerability, habitat/wildlife sensitivity, and location type (Etkin 2004). The sections below explain the application of specific factors to the estimation of cleanup, environmental, and socioeconomic costs.

2.4.1 Value of Spilled Oil

This analysis used projected prices of medium crude oil (Brent spot price) from the EIA (2013) to calculate the value of spilled oil for each spill scenario. For each scenario, the estimated volume of spilled oil was multiplied by the price per gallon for each year of the current analysis. A value of spilled oil for each scenario is shown in Table 3.

2.4.2 Cleanup Costs

EPA BOSCEM provides for the estimation of oil spill cleanup costs based on four criteria: type of oil, spill volume, type of cleanup method used, and effectiveness of cleanup method. Heavy, persistent oils, such as heavy crude and lube oil, have the highest starting cost per gallon, followed by (medium) crude oil, volatile distillates, and light fuels. While the model allows for modification of the per gallon cleanup cost depending on the primary cleanup method, this analysis assumes that only mechanical methods would be applied to Cook Inlet tanker spills, thus excluding dispersants and in-situ burning.

Table 6 displays per gallon oil spill cleanup costs for crude oil and mechanical removal only, as applied by EPA BOSCEM. The model assigns higher per gallon cleanup costs to smaller spills, with the per gallon cost of the largest category of spills less than half that of the smallest spills. Also, not surprisingly, the model assigns higher per gallon costs to spills for which mechanical cleanup is less effective. Table 3 displays estimated cleanup costs for each of the four spill scenarios.

Table 6. Per Gallon Oil Spill Response Costs Applied in EPA BOSCEM, Crude Oil and Mechanical Removal Only

	0 Percent Reduction	10 Percent Reduction	20 Percent Reduction	50 Percent Reduction
Spill Volume (gallons)	Per Gallon Cost of Oil Spill Response ($)			
<500	220	199	189	153
500-1,000	218	197	187	151
1,000-10,000	215	195	185	149
10,000-100,000	195	185	174	138
100,000-1,000,000	123	118	113	92
>1,000,000	92	82	76	64

Note: Per gallon costs in this table are in 2004 dollars but have been converted to 2013 dollars for this analysis.
Source: Etkin 2004.

2.4.3 Environmental Damages

EPA BOSCEM provides for the modification of environmental damages based on four criteria: spill volume, location medium type, vulnerability of nearby freshwater sources, and habitat sensitivity. The beginning per gallon environmental cost is higher for smaller crude oil spills, ranging from $30 per gallon for spills over one million gallons to $90 per gallon for spills under 500 gallons.

Location medium type modifiers range from 0.5 for pavement/rock to 1.6 for wetlands areas. The model's default modifier of 1.0 for open water/shore was applied to this analysis, as the location medium of potential spills is unknown.

Freshwater modifiers range from 0.4 for fresh water sources used for industrial purposes to 1.7 for areas characterized by wildlife use. Since it is unknown whether potential tanker spills would impact freshwater sources, the model's default non-specific modifier of 0.9 was applied to this analysis.

The final modifier applied to estimation of environmental damages in the EPA BOSCEM model is the sensitivity of wildlife and habitat in the affected area. This modifier ranges from 0.4 for urban/industrial areas to 4.0 for wetlands. The default value of 1.5 was applied for this analysis.

2.4.4 Socioeconomic Damages

EPA BOSCEM allows for the adjustment of socioeconomic costs according to three criteria: spill volume, oil type, and socioeconomic and cultural value of the affected area. Unlike cleanup and environmental costs, beginning per gallon socioeconomic costs are lowest for the smallest crude oil spills (under 500 gallons) and highest for median-sized spills (those between 1,000 and 10,000 gallons). Per gallon costs for crude oil spills decline as spill volumes continue to increase.

Notably, EPA BOSCEM assigns lower beginning per gallon socioeconomic costs to crude oils than to any other type, including volatile distillates and light fuels.

The modifier for the socioeconomic and cultural value of the affected area ranges from 0.1 (characterized by heavy industry or dump sites) to 2.0 (characterized by subsistence and commercial fishing and/or aquaculture). As the CIRA Consequence Analysis Report assigned generally high socioeconomic receptor scores to a crude oil spill at Drift River and low scores to a diesel spill at Nikiski, this analysis assigned an EPA BOSCEM socioeconomic modifier of 1.0 to the current analysis (Nuka Research & Planning Group, LLC 2013). This modifier denotes areas with high socioeconomic and cultural sensitivity, often characterized by recreational areas with sport fishing opportunities.

3 Alternative (With Pipeline)

This section presents estimated costs under the alternative (with pipeline). Table 7 summarizes the NPV of estimated costs across operating and spill impact cost categories for the alternative. Less than $150 of the nearly $112 million NPV of costs under the alternative are attributable to pipeline spills. Clearly, nearly all of the cost under the alternative falls under pipeline construction and O&M costs. This represents a significant departure from the composition of costs under the baseline and is discussed further in Section 4.

Table 7. Summary of Net Present Value of Estimated Costs under Alternative

Pipeline Costs ($1,000)		Pipeline Oil Spill Costs ($)				Net Cost ($1,000)
Capital costs	O&M	Spilled oil	Cleanup	Envir.	Socioecon.	
51,505	60,306	1	53	29	42	111,708

Note: A discount rate of seven percent is applied to all costs.
Source: Glosten 2013; Jensen 2014; Northern Economics estimates.

3.1 Overview

The baseline assumes that all crude produced on the west side of Cook Inlet will be transported to the east side by way of the pipeline and that existing tanker vessel transport for the purpose of crude transport will be eliminated. This analysis assumes construction of the pipeline in 2014 and full pipeline operation beginning in 2015. While similar pipelines have been proven safe for operation for longer periods of time, this analysis assumes a 30-year design life. A 30-year design life does not indicate that the pipeline and associated structure will require major maintenance or replacement after 30 years, but rather that the pipeline's systems, components, and structures will perform their primary functions at acceptable safety, regulatory, and environmental performance levels for 30 years and will not experience major failures or require significant repairs (Michael Baker Jr., Inc. 2013).

3.2 Costs

This analysis applied the same methodologies to the estimation of costs of spilled oil, spill cleanup, environmental damages, and socioeconomic damages as those used under the baseline. The major costs associated with the alternative, however, are those of pipeline construction and annual O&M. The total cost of construction is $55 million, with annual O&M costs of $5.2 million (Tesoro 2014). The cost of fuel consumed in the operation of vessel tankers disappears under the alternative.

3.3 Frequency and Severity of Potential Spills

Table 7 displays the NPV of costs resulting from pipeline spills. The NPV of these costs range from $1 for the value of spilled oil to $53 for spill cleanup. That these cost estimates are so low is rooted primarily in the exceedingly low probability of a spill occurring, as well as the relatively small spill volumes at the various ends of the spill size distribution. As shown in Table 8, a median, or moderate, spill is expected to be five gallons, while 95 percent of spills from the Trans-Foreland pipeline are expected to result in the spillage of 571 gallons of crude or less. A worst-case spill from the pipeline, meanwhile, would consist of the discharge of 100 percent of the maximum pipeline volume of 232,227 gallons (Glosten 2013).

Table 8. Estimated Spill Volumes from Trans-Forelands Pipeline

Small (25th percentile (gallons)	Moderate (50th percentile) (gallons)	Large (95th percentile) (gallons)	Worst Case Discharge (gallons)
<1	5	571	232,227

Source: Glosten 2013.

As noted above, the low risk of spills from the pipeline also is attributable to the low probability of a spill occurring. Glosten estimates that the pipeline will result in 0.0018 spills per year, or approximately two spills per thousand years. Thus, the costs associated with crude spills appear to be mitigated almost entirely under the alternative.

4 Benefit-Cost Analysis

Benefit-cost analyses typically attempt to capture all benefits and costs accruing to members of society for the various project alternatives. This analysis considers only one alternative, which consists of the construction of a pipeline that would carry crude oil from the west side of Cook Inlet to the east side and that would eliminate the need for tanker vessel trips.

Benefits under the alternative consist of avoided costs that would be incurred without implementation of the alternative. In this case, avoided costs of tanker vessel oil spills primarily comprise the benefits under the alternative. As the expected costs from pipeline oil spills are almost negligible, costs under the alternative are constituted almost entirely of pipeline construction and O&M.

Table 9 displays the composition of the NPV of estimated benefits and costs, as well as the BCR for the alternative under each of the four spill scenarios. The inclusion of only median spills in the calculation of the BCR yields a BCR of 0.05. However, the avoided costs of a single large spill alone cause the BCR to spike to 5.8, and a worst case scenario spill yields another jump in the BCR to 18.1.

Table 9. Net Present Value (NPV) and Benefit-Cost Ratio of the Alternative under Four Spill Scenarios

	Life-cycle Costs	Benefits (Avoided Costs) ($1,000)			
Benefit/Cost	($1,000)	Scenario 1 Median Spills Only	Scenario 2 Single Large Spill Only	Scenario 3 Single Large Spill and Median Spills	Scenario 4 Worst Case Spill Only
NPV (7%) – Total Costs	**111,708**				
Capital Costs	51,402				
O&M	60,306				
NPV (7%) – Total Benefits		**5,124**	**652,072**	**654,008**	**2,020,711**
Tanker Vessel Fuel		3,134	3,134	3,134	3,134
Spilled Oil		10	8,342	8,352	25,936
Cleanup Costs		832	280,932	281,741	873,429
Environmental Damage		474	144,940	145,401	450,623
Socioeconomic Impact		674	214,725	215,380	667,589
BCR		**0.05**	**5.8**	**5.9**	**18.1**

Note: The NPV of life-cycle costs is equivalent for each of the four spill scenarios.
Source: Glosten 2013; Jensen 2014; Etkin 2004; Northern Economics estimates.

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