Conceptual Engineering / Socioeconomic Impact Study - Alaska Spur Pipeline

DOE-NETL Contract Number: DE-AM26-05NT42653

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Executive Summary

Study Objectives

The objective of the Conceptual Engineering/Socioeconomic Impact Study – Alaska Spur Pipeline (spur pipeline) commissioned by the U.S. Department of Energy-National Energy Technology Laboratory (DOE-NETL) is to provide current information pertaining to the potential construction of a buried spur pipeline that would bring gas from the proposed Alaska North Slope (ANS) gas line to Interior and Southcentral Alaska. The study is intended to provide comparative information for each of two currently proposed spur line routings. The study presents findings, conclusions, and vital information considered, but does not include recommendations for construction of any particular pipeline configuration along any route.

Two spur pipeline route corridors were evaluated: Fairbanks Spur and Delta Junction Spur (Figure ES.1) The Fairbanks Spur corridor generally follows the Parks Highway through the Alaska Range and terminates at an existing ENSTAR gas transmission pipeline near Wasilla. The Delta Junction Spur corridor generally follows the Richardson Highway through the Alaska Range to the Glennallen area, then follows the Glenn Highway through the Matanuska Valley and terminates at the same ENSTAR transmission pipeline approximately 30 miles further to the east near Palmer. Figure ES.1 shows alignment options evaluated within the two corridors. It should be noted that the pipeline is assumed to be buried for the majority of each alignment and does not have above ground sections, due in part to ambient gas temperatures.

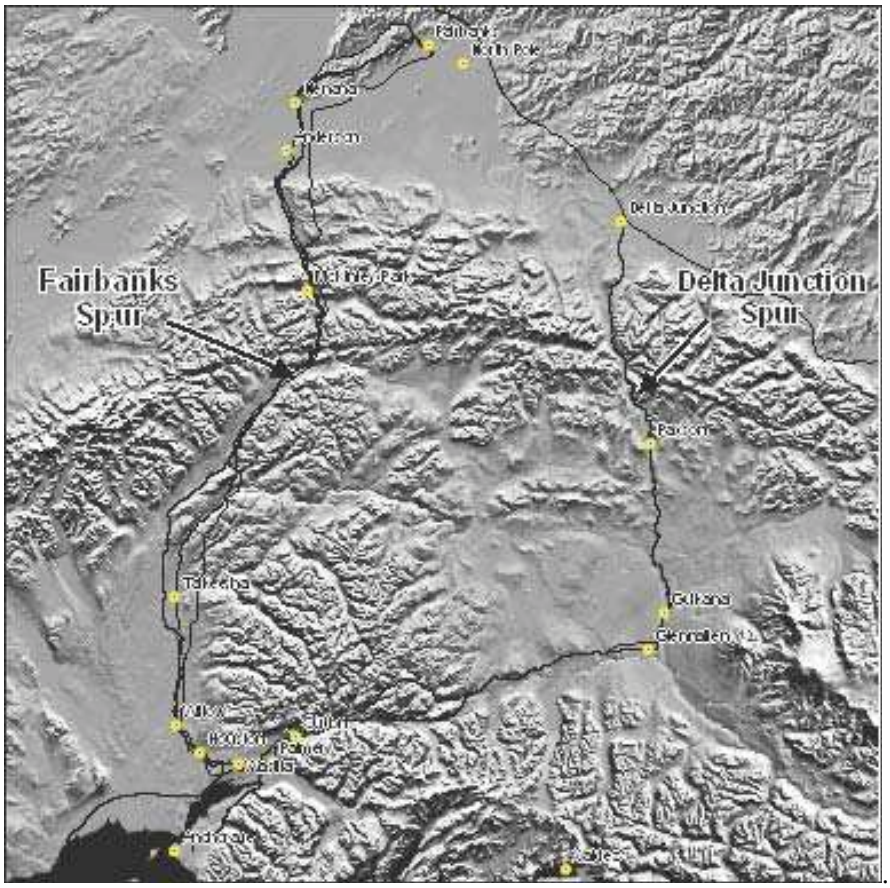


Figure ES.1: Fairbanks and Delta Junction Spur Route Corridors

Work Approach

The study team was comprised of subject experts from Arctic Slope Regional Corporation Constructors, Inc. (ACI); NORSTAR Pipeline Company (NORSTAR) (an affiliate of ENSTAR Natural Gas Company [ENSTAR], which is a division of SEMCO Energy Inc.); and the engineering firm Michael Baker Jr., Inc. (Michael Baker). ACI managed the overall study and addressed permitting, socioeconomic impact and public outreach planning. NORSTAR addressed right-of-way (ROW) considerations, availability of gas for local distribution along the two routes and methods to meet Cook Inlet peak winter gas demand. Michael Baker addressed pipeline sizing and compression; conceptual pipeline design and engineering; estimation of pipeline tariffs including capital cost estimates and economic analysis; and prepared an engineering primer regarding natural gas and cold region pipeline design.

Information in the Conceptual Engineering/Socioeconomic Impact Study was developed based on accepted industry practices, codes and standards; experience and judgment of the study team; and select information from previous studies completed for an Alaskan spur pipeline. Previous studies include:

- SAIC 2005. *Alaska Natural Gas Needs and Market Assessment*. Prepared for the National Energy Technology Laboratory.
- Denali Pipeline Company 1993. *The Denali Pipeline Project (1993)*.
- Alaska Natural Gas Development Authority (ANGDA) 2005. *Permitting Comparison of Parks Highway and Glenn Highway Natural Gas Pipeline Rights-of-Way*. Prepared by Bristol Environmental Services for ANGDA.
- Michael Baker 2005a. *Transport of North Slope Gas to Tidewater.* Prepared by Michael Baker for ANGDA.
- Shaw-Stone & Webster 2006. *Spurline Terminal Conceptual Design*. Prepared by Shaw-Stone & Webster Management Consultants for ANGDA.
- Harding Lawson 1988. *Trans-Alaska Gas System, Final Environmental Impact Statement*. U. S. Department of the Interior, Bureau of Land Management (BLM). Prepared by Harding Lawson Associates for the BLM.
- Alaska Department of Natural Resources (ADNR) 2006. *Alaska/Alberta Working Group, Alaska Natural Gas Pipeline, Natural Gas Composition*.
- Michael Baker 2005b. *Glennallen to Palmer Spur Pipeline – Engineering Report*. Prepared by Michael Baker for ANGDA.

The study team used two specific gas demand scenarios as described in the *Alaska Natural Gas Needs and Market Assessment* (Gas Market Assessment) in the completion of this effort, the study team discussed options for the spur pipeline diameter based on projected demand per the Gas Market Assessment and a determination of whether removal of gas from in-ground storage to meet peak seasonal demand is economically feasible.

Pipeline sizing and compression was addressed by estimating cost of service (COS) for a wide range of pipeline diameter and compression configurations subject to gas flow rates equal to and larger than those described in the Gas Market Assessment. Hundreds of hydraulic simulations and subsequent economic analyses were completed to generate the COS values that were plotted as a function of gas flow to concisely present the vast amount of economic data generated. This COS information could be used by potential future spur pipeline sponsors to evaluate gas demand scenarios that include, but are not limited

to, those presented in the Gas Market Assessment. A discussion of pipeline sizing and compression options for the two gas flow scenarios from the Gas Market Assessment were prepared based on the graphical information in the COS plots.

Specification of compression for a given pipeline was determined via hydraulic simulation. Hydraulic simulation addresses the impacts of pipeline length, alignment elevation changes, internal pipe diameter, pipe wall thickness, operating pressure and design codes. Detailed thermal-hydraulic analysis required to accurately determine pipeline operating temperatures was outside the scope of this study.

In order to meet the study schedule, pipeline sizing and compression were completed concurrent with ROW characterization and selection of pipeline alignments within the two spur pipeline corridors. COS calculations were based on a preliminary alignment along the Fairbanks Spur route. This COS information is applicable to both the final selected Fairbanks and Delta Junction Spur pipeline alignments.

Conceptual pipeline engineering and design consisted of evaluating pipeline alignment options on a segment-by-segment basis within each of the Fairbanks and Delta Junction Spur corridors based on ROW considerations, geological, hydrological, and geotechnical obstacles, and an assessment of pipeline constructability. A total of 63 potential alignment options within the two corridors were evaluated. A matrix of alignment issues was prepared for each route corridor and used to select the final alignments.

The last engineering-related task of the Conceptual Engineering Study was to estimate a tariff rate for transportation of gas through the spur pipeline. The team was directed to calculate delivered price as the sum of the spur pipeline tariff and the expected price of North Slope gas including an estimate of the transportation cost from the North Slope to the spur pipeline. Spur pipeline tariffs were calculated for both the Fairbanks and Delta Junction Spur routes based on the two prescribed demand scenarios from the Gas Market Assessment.

During a mid-project review meeting, NETL representatives, the Advisory Committee and the study team agreed that spur pipeline tariffs would be based on installation of a 20 inch diameter pipeline with an operating pressure of 2,500 pounds per square inch gage (psig). This representative pipeline configuration was selected in order to provide flexibility for future flow capacity expansion via addition of compressor stations and the option to transport large quantities of non-methane hydrocarbons in the dense phase (Section 2). Pipeline capital cost estimates were developed for the Fairbanks and Delta Junction Spur routes based on the alignments selected during the engineering design.

A natural gas processing plant would be required at the spur pipeline inlet to adjust the gas composition prior to entering the spur pipeline. One of the two gas demand scenarios would require a natural gas plant at the spur pipeline terminus in Cook Inlet to separate utility gas from hydrocarbon liquids. Capital and operating costs for the gas plants were included in the overall spur pipeline tariff. Information extracted from the Gas Market Assessment was used to determine both the expected price of North Slope gas and the cost to transport the gas from the North Slope to the inlet of the spur pipeline.

Title investigation and analysis were conducted to support future ROW and permitting objectives along either major route. Information gathered for this analysis was integrated into a computerized land data base. The information was used to identify land ownerships which could affect the complexity of easement acquisition or permitting challenges. Additionally, existing ROW were identified which are available to be utilized for a pipeline project. This analysis does not recommend a particular route.

Existing studies and publications, state and federal regulations, and team knowledge were utilized in analyzing permitting and regulatory issues. The permit matrix was developed in order to provide an organized means of presenting a list of potentially required permits. Previous socioeconomic investigations of the potentially affected areas, State of Alaska records, and existing pipeline studies were used in evaluating the potential socioeconomic impacts of a spur pipeline.

This report is organized as follows:

Section 1 - Introduction and Project Description;

Section 2 - Engineering Design Concepts;

Section 3 - Pipeline Sizing and Compression;

Section 4 - Pipeline Routing and Alignment;

Section 5 - Right-of-Way Considerations;

Section 6 - Permitting and Regulatory Issues;

Section 7 - Socioeconomic Considerations;

Section 8 - Delivered Cost of North Slope Gas to Southcentral Alaska;

Section 9 - Considerations for Future Work

Section 10 - References and Resources; and

Appendices.

A brief description of each section of the study follows.

Section 2: Engineering Design Concepts

A section explaining engineering design concepts was included to provide persons not experienced in natural gas or the design of pipelines that traverse permafrost with basic information and concepts necessary to understand study results. The section contains hypothetical examples and discussions that explain underlying trends that influence spur pipeline design. The section contains a discussion of geotechnical considerations that would impact pipeline design including frost heave and thaw settlement.

Collectively, information in the section supports the following conclusions regarding design trends for a spur pipeline:

- A natural gas highly enriched in non-methane hydrocarbons can be transported in the dense phase via a high pressure pipeline without liquid condensation and formation of slug flow.
- Pipelines traversing discontinuous and sporadic permafrost must be designed with consideration of long-term formation of frost heave and/or thaw settlement and resultant differential movement of the soil.
- Joule-Thompson (J-T) coefficient (temperature drop per unit of pressure drop) depends on the methane content of the gas. A natural gas enriched in non-methane hydrocarbons will experience less J-T cooling than a pipeline transporting utility gas.
- For the same gas flow and composition
    - pressure gradient (pressure drop per unit length of pipe) will be less for a higher pressure than a lower pressure pipeline;
    - J-T coefficient of a methane rich natural gas will be less for a higher pressure pipeline than a lower pressure pipeline; and
    - J-T cooling (temperature drop per unit length of pipe) of a methane rich natural gas will be less for a higher pressure pipeline than a lower pressure pipeline, thereby tending to flatten the pipeline operating temperature profile.

- Weight of a highly enriched natural gas will cause pipeline gas to expand or compress with elevation change thereby influencing local operating pressure and temperature of the pipeline.
- Excluding consideration of frost heave and thaw settlement, capital costs of a pipeline and compression system can be minimized by installing the least number of compressor stations with large sized equipment installed at each station.
- Configuring the pipeline and compressor stations to restrict the range of allowable pipeline operating temperatures, thereby mitigating potential development of adverse frost heave and thaw settlement will add cost to the overall system.

Section 3: Pipeline Sizing and Compression

Pipeline gas flow capacity depends on the pipeline diameter, operating pressure and number of compressor stations installed periodically along the route. Pipeline sizing and compression analyses consisted of generating plots of lifetime COS values at various gas flow rates for a wide range of pipeline and compression configurations. The plots of COS as a function of flow rate can be used to quickly assess the relative economics of a number of pipeline and station configurations.

A gas hydraulic simulation was completed to determine the compression required to achieve a particular flow rate through a given pipeline. Capital costs for the pipeline and gas compression were estimated based on simulation output. An economic analysis was then completed to determine the difference between the gas sale and purchase price required to obtain a 10 percent return on the capital invested. COS was determined as the difference between the gas sale and purchase prices.

Return-on-investment (ROI) was used because it is a relatively simple analytical approach that is independent of financing assumptions. For pipelines, a 10 percent ROI is usually equivalent to a utility type return-on-investment in the range of 12 percent to 13 percent.

A plot of pipeline COS as a function of increasing flow rate is referred to as a "J-curve" because the shape of the curve resembles a backwards "J". Each data point on a J-curve is generated by completing a pipeline hydraulic simulation at the given flow rate followed by capital cost estimation and economic analysis to determine the corresponding COS.

All points on a J-curve reflect scenarios in which gas flow starts at the given rate and remains the same over the life of the project. J-curves are very useful for general comparison of pipeline options, but do not address the impact of flow ramp-up on project economics. Economic impact attributed to flow ramp-up is addressed in the tariff calculations in Section 8.

J-curve plots were constructed to allow general comparison of a wide range of pipeline configurations subject to a wide range of gas flow rates, and to screen candidate configurations for selection as the basis for estimation of delivered gas price to Cook Inlet as described in Section 8. J-curve analyses were based on a preliminary, but representative, route from Fairbanks to Cook Inlet in order to meet the project schedule. J-curve results are applicable to the final alignments selected for both the Fairbanks and Delta Junction Spur pipeline routes.

The study team was directed to specifically address pipeline sizing and compression for Gas Scenarios 1 and 2 as described in the Gas Market Assessment.

Gas Scenario 1

Gas Scenario 1 (Figure ES.2) as described in the Gas Market Assessment is based on delivery of utility grade natural gas to Cook Inlet beginning at an average annual rate of 110 million standard cubic feet per day (MMscfd) progressively increasing to approximately 300 MMscfd over a 20-year period. It was recommended in the Gas Market assessment that the spur pipeline be sized for 300 MMscfd plus 50

MMscfd of additional flow coupled with 80 MMscfd of gas removed from storage to meet a winter seasonal demand of approximately 435 MMscfd.

Estimates of the delivered price of gas to Cook Inlet were based on Gas Scenario 1 after modification to accommodate a 33 year project life and means of meeting seasonal winter demand specified by the study team. The annual increase in flow for the last few years of the 20 year schedule presented in the Gas Market Assessment was used to extend the demand curve for an additional 13 years. The gas flow rate projected for year 33 is approximately 350 MMscfd. It is the opinion of the study team that peak seasonal winter demand could be met by a combination of removal of gas from in-ground storage and LNG imported to Cook Inlet without necessarily needing to increase pipeline capacity over the average annual rate. Delivered gas price to Cook Inlet was based on a pipeline configured to deliver a minimum of 350 MMscfd in the 33rd year of the project.

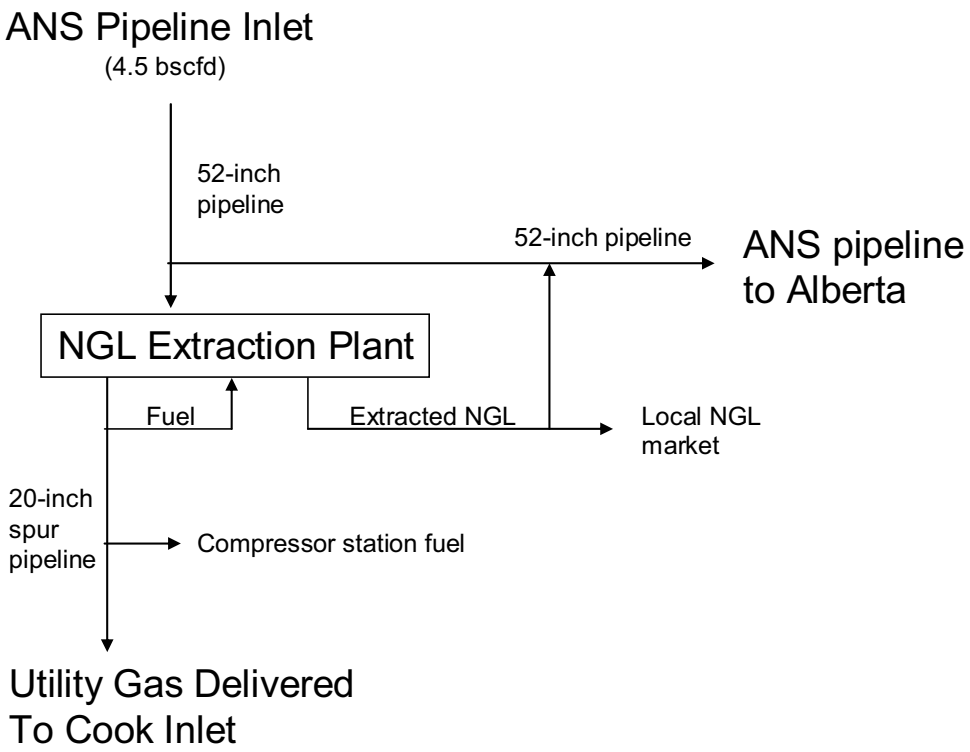


Figure ES.2: Gas Scenario 1 - Project Configuration

Gas Scenario 2

Gas Scenario 2 (Figure ES.3) as described in the Gas Market Assessment is the same as Gas Scenario 1 with the addition of 75,000 barrels per day (bpd) of ethane for feed to a petrochemical plant in Cook Inlet, 63,000 bpd of propane and butane mix for sale as liquefied petroleum gas (LPG), and 15,000 bpd of pentane and heavier components sold for gasoline blending. It was recommended in the Gas Market Assessment that the spur pipeline be designed for 590 MMscfd of gas flow.

Estimates for the delivered price of gas to Cook Inlet per Gas Scenario 2 were based on the 33-year utility demand schedule described above plus addition of sufficient ethane and heavier components to deliver 75,000 bpd of ethane to Cook Inlet. The composition of the ANS pipeline gas as described on the Alaska Governor's website regarding state negotiations with the North Slope gas producers was used for the calculations of delivered gas price instead of the ANS pipeline gas composition contained in the Gas

Market Assessment. The information on the Governor's website was posted after issue of the Gas Market Assessment and was considered to be more timely and representative of probable conditions than the gas compositional information in the Gas Market Assessment.

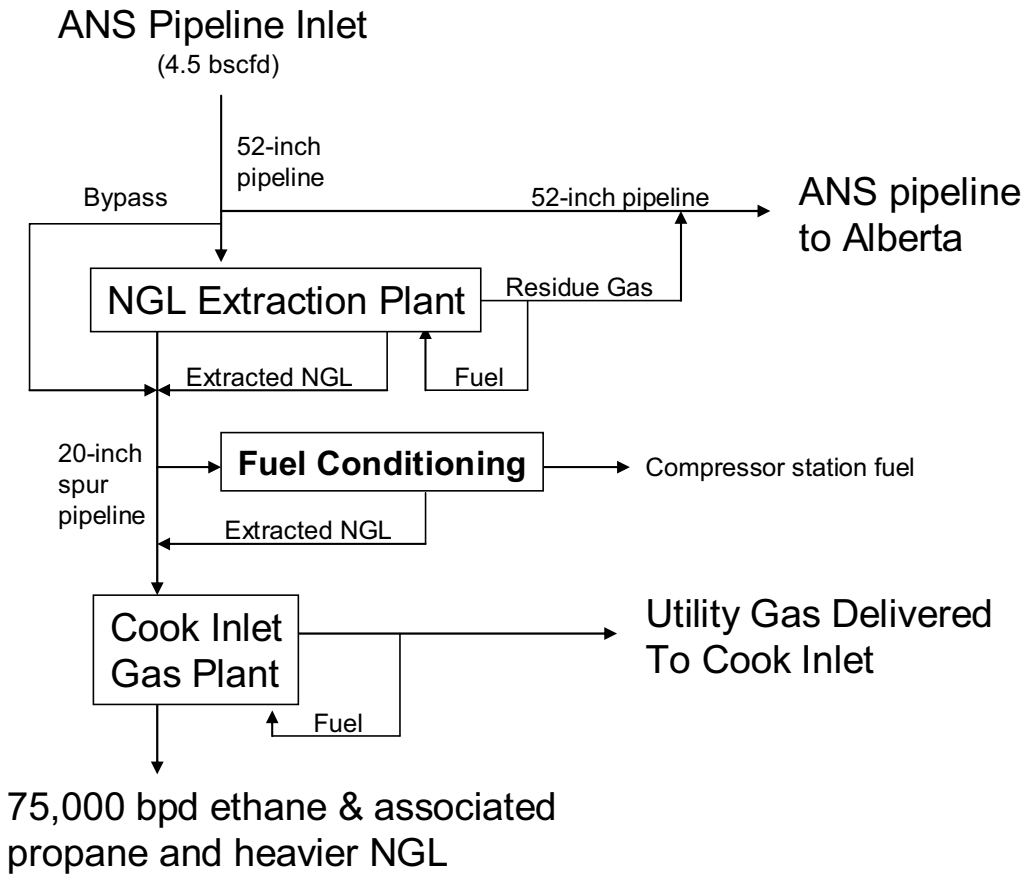


Figure ES.3: Gas Scenario 2 – Project Configuration

J-curve Results - General

J-curves were prepared for a range of pipeline diameters and operating pressures to accommodate the largest flow rate identified in any of the scenarios identified in the Gas Market Assessment. J-curve plots are contained in Appendix 3-7 and address transport of utility gas during the summer subject to all possible combinations of the following:

- Outside pipeline diameters of 18, 20, 24 and 28 inches
- Operating pressures of 1,480 and 2,500 psig
- Gas compressor sets of 7,700; 10,000; 13,000 and 20,000 horsepower (hp).

J-curves allow concise presentation of a large amount of economic data generated via a huge amount of supporting work. Information presented in the J-curves contained in Appendix 3-7 support the following conclusions:

- COS for a given pipeline will decline with flow as compression is added to a point at which COS values will rise because costs to add large amounts of incremental compression do not justify the incremental increase in flow;

- Smaller diameter pipelines have a lower COS and are more economical at lower flow rates;
- At higher flow rates there may be multiple diameter and compression combinations that are economically equivalent and the option may exist to install a smaller diameter pipeline with more stations or a larger diameter pipeline with fewer stations;
- High-pressure pipelines are less economic than low-pressure pipelines for transport of utility gas at relatively low flow rates; the economics of high and low pressure pipelines approach one another as flow rate increases and high-pressure pipelines may be more economical at high flow rates;
- Size of the turbine compressor set at the stations has little influence on the pipeline COS, but does impact the maximum flow capacity of a given pipeline and station system.

J-curve Results – Gas Scenario 1

J-curves for the flow ranges per Gas Scenario 1 are shown in (Figure ES.4). Compression at the maximum volume of each curve is provided in the figure legend.

Utility grade gas per Gas Scenario 1 can be transported via a low-pressure (1,480 psig) pipeline. Selection of a low-pressure pipeline would forever preclude transport of large amounts of non-methane hydrocarbons in the dense phase. J-curves for high pressure (2,500 psig) pipelines are included to show relative costs to provide for potential future transport of an enriched natural gas.

Individual J-curve data points are based on a constant pipeline flow rate over the life of the project. Annual average flow through the pipeline will ramp-up slowly from approximately 110 MMscfd at start-up to approximately 350 MMscfd by the end the assumed 33 year project life. Spur pipeline project economics will be greatly influenced by time value of money and the protracted ramp-up schedule. Detailed economic analyses based on flow ramp-up are required to definitively determine the relative economics of configurations where J-curves cross within the flow ramp-up range.

A pipeline and station configuration that exhibits greater COS values than an alternative configuration at all flow rates under consideration for Gas Scenario 1 can be deemed as being less economic. When J-curves cross, the configuration with the higher COS values at lower flows that occur earlier in the project life should be less economically favorable due to discounting for time value of money.

The following can be inferred based on the information from Gas Scenario 1:

- A 24 inch diameter high pressure pipeline can be excluded from consideration since the COS values are greater than those of all other options at all flow rates except the highest rates that would not occur until late project life;
- A 20 inch diameter high-pressure pipeline should be less economic than an 18 inch diameter high pressure pipeline since the COS values for a 20 inch pipeline are greater than those of the 18 inch diameter pipeline at all flow rates except the highest rates that would not occur until late project life;
- Economics for 18 inch and 20 inch diameter low pressure pipelines over the life of the project may be roughly equivalent since the respective J-curves cross within the range of flow ramp-up;
- A 24 inch diameter low pressure pipeline should be less economic than an 18 inch diameter high pressure pipeline since the COS values for a 24 inch low-pressure pipeline are greater at all flow rates except the highest rates that would not occur until late project life; selection of

an 18 inch high pressure pipeline would provide for transport of a natural gas enriched in non-methane hydrocarbons.

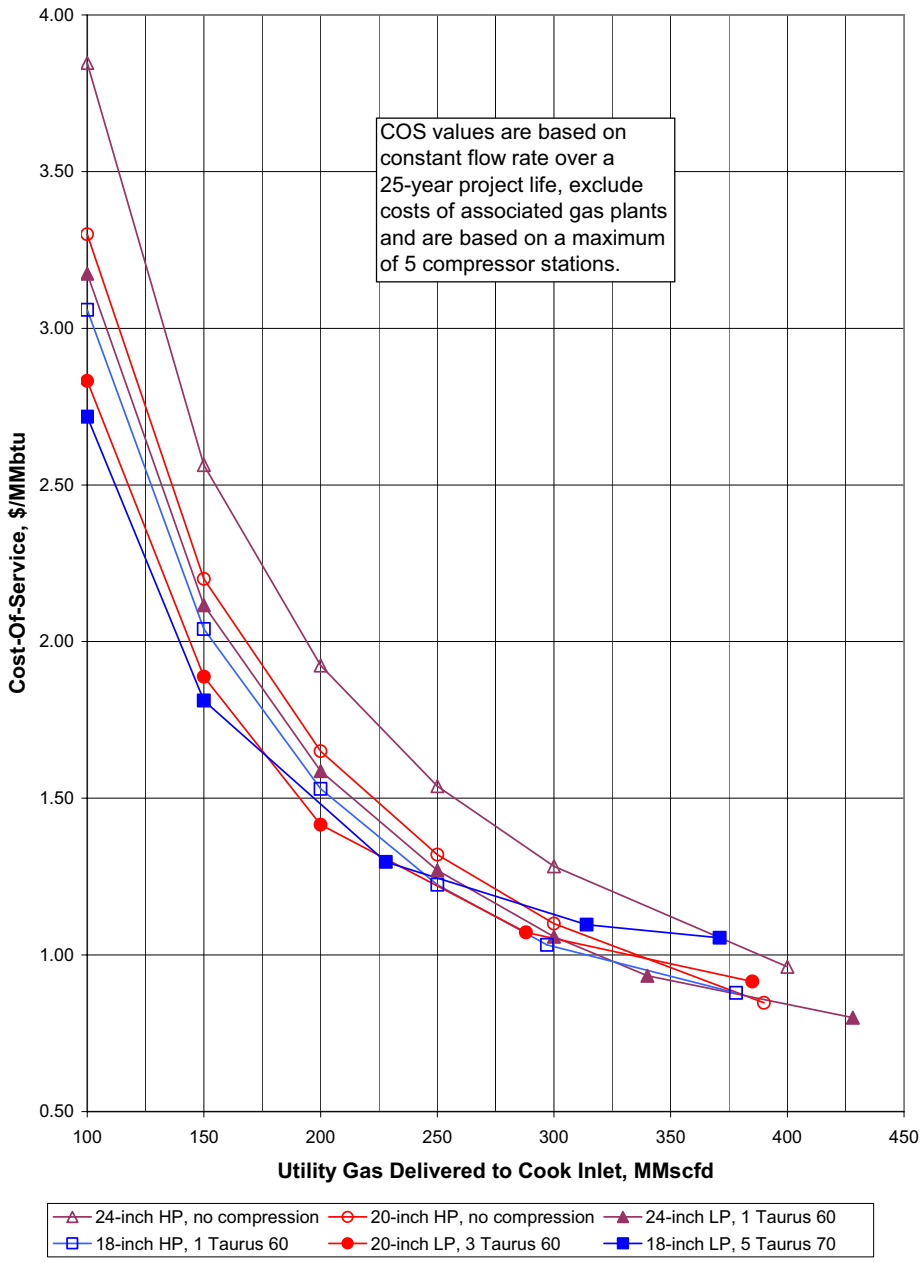


Figure ES.4: J-curves for Gas Scenario 1

J-curve Results – Gas Scenario 2

Procedures used to prepare J-curves for Gas Scenario 2 are identical to those of Gas Scenario 1 except that only high pressure pipelines were considered since Gas Scenario 2 involves transport of an enriched natural gas. J-curves for Gas Scenario 2 are shown in Figure ES.5.

Gas Scenario 2 is the same as Gas Scenario 1 except that approximately 215 MMscfd of non-methane hydrocarbons would be blended with the utility gas. Flow rate along the x-axis of Figure ES.5 refers to

the rate of utility gas delivered to Cook Inlet and excludes NGL hydrocarbons extracted in Cook Inlet. Relatively flat or upward sloping portions of the curves reflect the impact of incremental capital costs for addition of compression.

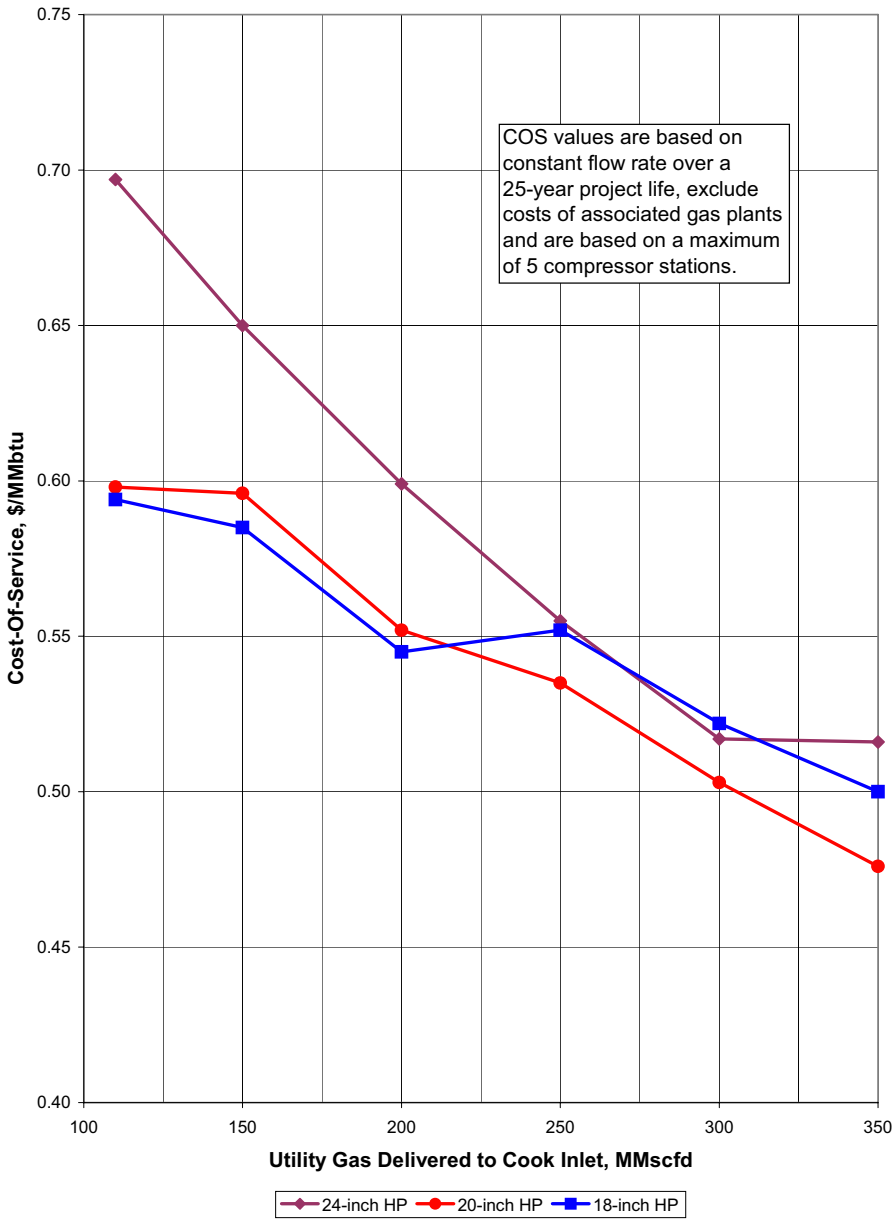


Figure ES.5: J-curves for Gas Scenario 2

Similar to the logic described for evaluation the J-curves for Gas Scenario 1, the following can be inferred for Gas Scenario 2 based on the information shown in Figure ES.5.

- A 24 inch diameter pipeline can be excluded from consideration since the COS exceeds that of a 20 inch diameter pipeline at all flow rates;

- Economics for 18 inch and 20 inch diameter high pressure pipelines over the life of the project should be roughly equivalent since the COS values are similar in early life and the J-curves cross within the flow ramp-up range.

Pipeline COS expressed on a thermal basis varies significantly with gas composition and will be lower for a given flow rate if the natural gas is enriched with non-methane hydrocarbons. However, transport of an enriched gas may require installation of large natural gas processing facilities at the spur pipeline starting point to acquire more non-methane hydrocarbons as well as facilities at the pipeline terminus to extract those hydrocarbons and produce a utility (primarily methane) gas. Capital costs for natural gas processing plants and the resultant impact on spur pipeline economics are addressed in the tariff calculations contained in Section 8.

Section 4. Pipeline Routing and Alignment

Alignment Selection Methodology

Pipeline alignments were developed for both the Fairbanks and Delta Junction Spur corridors. Selection of the respective alignments within the two corridors reflects a quantitative and qualitative balance of the following issues and criteria:

- Minimize total length of route;
- Avoid environmentally sensitive areas;
- Minimize the number of stream and river crossings;
- Minimize blocking cross drainage;
- Avoid geohazardous areas;
- Provide for a high degree of pipeline constructability;
- Maximize routing in geotechnical conditions favorable to pipeline operating characteristics;
- Use existing infrastructure to the extent possible and appropriate;
- Locate pipeline to facilitate maintenance and repair work; and
- Minimize costs related to engineering, construction and maintenance.

Alignments within both the Fairbanks and Delta Junction Spur corridors were to be identified without bias or regard to which corridor would ultimately be selected by an eventual spur pipeline sponsor. Conclusions and information presented in this study should not be construed as a recommendation for either route option.

Each corridor was divided into logical segments with multiple alignment options. Candidate alignments included ROW for highway, electrical power transmission lines, the Alaska Railroad, abandoned roads and pipeline projects that have been proposed, but not built.

Alignment options within a segment were compared based on four categories: engineering obstacles and opportunities; permitting; socioeconomic impacts; and ROW issues. A relative ranking was assigned to each alignment option on a category-by-category basis. Relative rankings addressed physiographic, meteorological, hydrological (including wetlands), biological (fish and wildlife), and human resources characteristics.

Categories within a given segment were weighted by importance. The final rankings of alignment options within a segment were the product of the category relative ranking multiplied by the weighting factor for each category. Rankings were input into a matrix of alignment characteristics that includes geotechnical, environmental, permitting, construction, land ownership and other issues that influence route alignment selection (Appendix 4-2). Portions of the matrices are presented in Tables 4.3 through 4.15 of the study. Comparisons between the selected alignments for the two routes do not constitute recommendation of a preferred route.

Several site visits were conducted for areas deemed costly or difficult to traverse based on "desk top" evaluation of available information. Information gathered during the site visits was used determine the degree of difficulty and likely construction productivity rates for input into the pipeline capital cost estimates.

Alignment Sheets

Alignment sheets were generated for the respective alignments selected within the Fairbanks and Delta Junction Spur routes. Elevation profiles on the alignment sheets were generated by draping the alignments over digital elevation modeling (DEM) data that is publicly available. The alignments sheets contain plan-view detail to provide background images along the alignment that is a combination of aerial photography and satellite imagery, which was patched together where necessary. Land ownership data, compressor station locations, material laydown areas, camp locations, and other pertinent information are provided in the data bands along the top and bottoms of the plan and profile windows. Alignment sheets are provided in Appendix 4-4.

Conclusions

Alignments were identified within both the Fairbanks and Delta Junction Spur corridors which could be constructed. Although both routes contain challenging issues that would need to be addressed in the future, neither route corridor contains an insurmountable problem that would preclude it from consideration for a spur pipeline.

Both corridors have similar physical features. Each contains broad river valleys and is crosscut by the rugged mountainous terrain of the Alaska Range. Both routes traverse areas of permafrost and wetlands. Both corridors support important wildlife and fishery resources. Both corridors cross seismically hazardous areas and active faults. Excluding beginning and end terminuses, neither corridor intersects large population centers, although a few mid-size communities exist in each: Nenana, Healy and Willow in the Fairbanks Spur corridor, and Glennallen in the Delta Junction Spur corridor. A few smaller communities are in both corridors located within and to the south of the Alaska Range. Both spur corridors terminate at logical locations for tie into the same existing ENSTAR utility gas line between Beluga and Anchorage.

Differences between the routes would impact construction and capital costs. At approximately 322 miles, the length of the Fairbanks Spur route is approximately 41 miles longer than the 281-mile Delta Junction Spur route. The Delta Junction Spur route traverses more permafrost and soils prone to frost heave and thaw settlement. All compressors along the Delta Junction Spur route would likely require chilling of the discharge gas before it reenters the pipeline, whereas the last compressor on the Fairbanks Spur route would likely discharge warm gas back into the pipeline. Overall, the terrain along the Delta Junction Spur route is more rugged because it traverses a second mountainous area along the Matanuska Valley. Construction costs on a per foot basis would be higher for the Delta Junction Spur route because of rugged terrain. The maximum elevations of the Fairbanks and Delta Junction alignments are approximately 2,400 and 3,600 feet above mean sea level, respectively.

The selected Fairbanks alignment crosses Denali National Park and Preserve and passes through Denali State Park on the existing ROW for the Parks Highway. Acquisition of a ROW permit to cross Denali

National Park and Preserve would need to be completed well in advance of any potential construction along this route. In 2002, Congress passed Public Law 107-223 which authorized the Secretary of the Interior to issue ROW permits for natural gas pipelines within the boundaries of the Great Smoky Mountains National Park. Similar legislation would need to be passed to authorize the Secretary of the Interior to grant a ROW permit for the construction and operation of a natural gas pipeline through or across Denali National Park and Preserve lands.

The Delta Junction Spur route passes along the Delta River, segments of which are designated as wild, scenic or recreational under the authority of the Wild and Scenic Rivers Act (16 USC Chapter 28). Alignment along the Delta River should not pose a permitting issue as long as it remains outside of the area designated as wild and scenic.

Section 5. ROW Considerations

A land title investigation was conducted by NORSTAR for both spur pipeline alignments. Nearly all of the selected alignment land parcels for both the Fairbanks Spur and the Delta Junction Spur are situated within the limits of the existing highway ROW limits, section line easements, and some powerline ROW. However, some limited segments of ROW would need to be acquired for pipeline alignment. Those segments may be needed to ameliorate topographic or constructability issues and access challenges. A temporary ROW width between 60 and 100 ft would provide enough for construction and installation of a pipeline.

Temporary ROW up to 0.5 mile wide may be required. A 0.5 mile wide temporary ROW is thought to affect only governmental lands for purposes of accessibility. After construction, a reduced permanent ROW, sufficiently wide to allow monitoring and maintenance of the pipeline and related pipeline facilities would be required. A typical permanent ROW width for similar pipelines ranges between 20 and 50 ft.

The location of land parcels and the type of land ownership would determine if a ROW exists and is available to be utilized for pipeline alignment and it would also determine what type of ROW would be asserted. ROW determinations and acquisition would be accomplished in two ways. First, lands owned or managed by the various governmental agencies and public land trusts are regulated and managed under specific agency regulations and land disposition policy. The process for acquisition may include easement applications, applications for permits, surveys, mapping, and in some cases, public hearing. The second general method relates to privately owned lands. These include properties within private sector ownership and some quasi-private lands that may be under the control of Alaska Native corporations (e.g., Native allotments and trust lands). ROW acquisition may require fair market value appraisals, legal documentation and monetary compensation. After a pipeline alignment is established, home and business relocation and other issues to be revealed would need a detailed evaluation.

Thousands of land parcels were researched along both the Fairbanks Spur and Delta Junction Spur. Table 5.1 in section 5 summarizes the breakdown of land parcel ownership between routes. Many of the parcels have an existing Public Land Order (PLO) ROW or a Section Line (RS2477) ROW available for project utilization. These ROW would be acquired by permits, etc. as described above. Land parcels owned by federal, state, borough and Alaska Railroad Corporation (ARRC) would have ROW created by the same agency permitting application methods. As a result of existing and permitted ROW, only 25% of the total parcels would require actual ROW purchases.

Approximately 75 percent of the land adjacent to the selected pipeline alignments is publicly owned or designated for highway ROW, parks, forests, or public recreation. Some lands are under the jurisdiction of the military and coordination would be needed to assure that adverse impacts to military operations would be avoided or minimized in such areas.

A description of the various ROW types, their statutorial and regulatory basis and history was developed for this report. Particularly important are the ROW on federal lands within Denali National Park and Preserve, military reserve lands, and lands in Interim Conveyance to Native corporations. For lands in Interim Conveyance, BLM or Bureau of Indian Affairs (BIA) have jurisdiction and, with the consent of the appropriate Native entity, would issue ROW permits and other easement authorizations.

Where the spur alignment passes through municipal or borough lands, ROW would also be subject to the planning, platting, and land use authority of those jurisdictions. These may include the City of Fairbanks, City of Palmer, City of Wasilla, the Matanuska-Susitna Borough, the Denali Borough, and the Fairbanks North Star Borough.

Land ownership information is shown on the alignment maps. Typical land title records frequently change because of sale or agency conveyance actions and some portions of the alignment may need updating in the future. Figures 5.1 through 5.23 graphically portray the land ownership situation on both spur route alignments.

Section 6. Permitting and Regulatory Issues

The permitting process for the spur pipeline project would not be significantly different between the Fairbanks and the Delta Junction Spur routes. Permitting details may vary based on physiographic, hydrological, and land use specifics particular to each route. Development of a comprehensive project description would be vital for creating permit applications to be submitted to local, state and federal agencies.

The timeframe for completion of all studies, conceptual engineering design, and conducting the NEPA process would require a minimum of two years. A minimum of two field study seasons would be necessary for conducting crucial geophysical, wetland and hydrological surveys, seismic hazards assessment, and wildlife and fish surveys.

Key permits for the project include:

- Clean Water Act Section 404 - U.S. Army Corps of Engineers (USACE)
- National Pollutant Discharge Elimination System (NPDES) - U.S. Environmental Protection Agency (EPA)
- Clean Air Act air quality modeling, permitting and monitoring - EPA, ADEC
- State Pipeline ROW –ADNR coordinated by the Joint Pipeline Office (JPO)
- Federal Pipeline ROW – Federal Energy Regulatory Commission (FERC)

The National Environmental Policy Act (NEPA) process would be initiated by the project sponsor's preparation of an Environmental Evaluation Document (EED) to be used by the lead agency (determined at the time a project is sufficiently developed to initiate permit applications) in preparing an Environmental Assessment (EA) the results of which would be either a Finding of No Significant Impact (FONSI) or the requirement to conduct a full Environmental Impact Statement (EIS). Public meetings and workshops with stakeholder groups would commence with the completion of the EED and agency EA process. If based on the EA, it was determined that an EIS is warranted, a more detailed, comprehensive and formal public hearing process would be conducted. Similar EIS processes have taken an average of 18 months to complete. Regulatory authorization by FERC or the Regulatory Commission of Alaska (RCA) may also be required depending on the nature of the project.

Once Notice to Proceed is acquired, numerous permits relating to the construction of the spur pipeline would be necessary. In seeking these permits careful attention would be paid to the central issue of

regulatory compliance and the design of a plan to mitigate potential adverse effects on the physical, biological and human environments. Mitigation measures are designed around avoidance (of sensitive areas e.g., wetlands, fish and wildlife habitat; minimization (limit the extent or magnitude of an action to keep unavoidable adverse effects as small as feasible); rectification (of an adverse effect by repair, rehabilitation, reclamation, or restoration of the damaged environmental feature as closely as feasible to pre-project conditions); reduction (measures taken by stages over time to reduce the adverse effect's severity or extent); and compensation (create a new environmental feature comparable in value to that feature that was adversely impacted).

An in-house comprehensive quality assurance and quality control program should be designed and implemented to assure compliance with applicable requirements of statutes, regulations, environmental and technical stipulations, and final design specifications.

Other important permit and compliance related features of the program may involve identification and protection/avoidance of archaeological and historic sites; air quality modeling and monitoring; water quality and water consumption monitoring; liquid, solid, and hazardous waste management programs.

A list of permits and estimated duration of time required for obtaining such permits that may be required for all phases of a spur pipeline project along the Fairbanks or Delta Junction Spur is located in Appendix 6-1. Without further field study and finalization of route selection for each route, it is difficult to determine the actual length of time required for permitting along the Fairbanks or Delta Junction Spurs. Issues related to extent of wetlands crossed, design and engineering concerns, routing through Denali National Park and Preserve, and NEPA are some of the factors that may impact the duration of permitting along either spur.

Section 7. Socioeconomic Considerations

This section describes the various governmental jurisdictions and unorganized communities located within both the Fairbanks and Delta Junction Spur corridors, the salient demographic features characterizing each, identified historical and archaeological properties, recreational areas, and subsistence use areas. The Fairbanks Spur corridor crosses three boroughs: the Fairbanks North Star Borough, the Denali Borough, and the Matanuska-Susitna Borough. The Delta Junction Spur corridor crosses the Matanuska-Susitna Borough.

In the Alaska system of municipal incorporation, larger communities such as Fairbanks, Palmer and Wasilla, are designated as First Class Cities responsible for levying local taxes (these vary from property to sales taxes) and providing most public services other than schools and may have land use management responsibilities. Some smaller communities are designated as Second Class Cities. These usually have very limited jurisdictional powers and other than town councils and the responsibility for conducting elections and promulgating case specific public ordinances, they do not have land planning and management authority. Second Class Cities may lie within organized boroughs, or as is the case for many rurally dispersed communities, are considered part of the unorganized borough which contains state supervised school districts and other public services.

A quasi-governmental entity consists of communities lying within lands owned by Native corporations. Native corporations exercise land planning and management upon lands within their region.

Historical and archaeological properties include sites of prehistoric occupation and use by indigenous populations and historic sites. Because the spur pipeline alignments fall relatively close to present highway, railroad and utility corridors, many sites have been previously surveyed and identified.

Subsistence use in both corridors is heavy because the road network provides access to major fishing and hunting areas. In this regard, the two corridors differ from most of the rest of Alaska which is roadless. The impacts that the spur pipeline may have on subsistence relate both to protection of the resources (fish

in anadromous fish streams, terrestrial mammals [caribou, moose, bears, wolves, furbearers], birds and waterfowl) and access to those resources, especially access from the road network. A spur pipeline would not produce incremental impacts on fish and wildlife subsistence resources in either corridor with the possible exception of temporary impacts during the construction phase, and would neither enhance nor reduce access for hunters and fishermen since construction would occur primarily within existing ROW. However, where the pipeline routing deviates from existing ROW, new access routes to the backcountry may be opened.

Recreational uses are the dominant activities within most parts of both corridors, although subsistence should not be considered as a recreational activity as it is a basic socioeconomic institution upon which both Native and non-Native rural populations depend for annual family and household incomes. Designated recreational areas (national and state parks and preserves) would be minimally impacted by the construction phase.

Businesses within both corridors are largely associated with tourism and recreational activities. There is heavy use of the highways (and the railroad in the case of the Fairbanks corridor) during the summer months to transport sightseers, hikers, wildlife observers and photographers. These service area businesses would not be affected negatively by pipeline construction insofar as access to them is not restricted for more than brief periods during construction and might well benefit from providing services to the construction contractors.

Spur pipeline construction could temporarily increase local wage employment opportunities in the construction phase. The project could add to the tax revenues of local governmental jurisdictions as well as to rental earnings of land-owners (public and private). The project could enhance the availability of local energy supplies by take-off and conditioning of natural gas fuels at various locations. This would be true for either of the proposed spur pipeline routes.

Section 8. Delivered Price of North Slope Gas to South Central Alaska

Evaluation Methodology

Delivered price of North Slope gas to Cook Inlet in Southcentral Alaska was estimated for both the Fairbanks and Delta Junction Spur options. The price of gas delivered to Cook Inlet was calculated as the sum of:

- Price of gas entering the ANS gas pipeline;
- Tariff to transport spur pipeline gas through the ANS line to spur pipeline takeoff point;
- Spur pipeline tariff including capital and operating costs for the associated gas plants.

Gas price entering the ANS gas pipeline was assumed to be that of the base case as described in the Gas Market Assessment. Per the Gas Market Assessment, the base case gas price at the outlet of the ANS pipeline near Chicago will range from $5.00 to $6.00 per million British thermal unit (MMbtu). An average of $5.50/MMbtu was assumed for the delivered price near Chicago. An ANS pipeline tariff of $2.30/MMbtu at a flow rate of 4.5 billion standard cubic feet per day (bscfd) was described as the base case in the Gas Market Assessment. A fundamental premise of the Gas Market Assessment is that the price of gas at the inlet of the ANS pipeline at the North Slope would be determined by subtracting the ANS pipeline tariff from the price of gas in Chicago. The 4.5 bscfd ANS pipeline flow premise was adopted for calculation of delivered gas price to Cook Inlet, thus the price of gas at the inlet to the ANS pipeline was assumed to be $3.20/MMbtu ($5.50 - $2.30).

Estimates for tariffs on spur pipeline gas transported via the ANS pipeline contained in the Gas Market Assessment were used for calculation of the delivered price of gas to Cook Inlet. ANS pipeline tariffs

presented in the Gas Market Assessment are based on the premise that gas destined for the spur pipeline would bear a higher tariff for transport from the North Slope to the spur pipeline take off than other gas so that downstream consumers would bear no adverse economic impact due to the associated reduction in flow. ANS pipeline tariffs of $0.47 and $0.57/MMbtu were derived from the Gas Market Assessment and used for transport of spur pipeline gas to Fairbanks and Delta Junction, respectively. The difference in tariffs is because Delta Junction is located approximately 540 miles from the North Slope along the ANS pipeline route; whereas the corresponding distance to Fairbanks is approximately 450 miles.

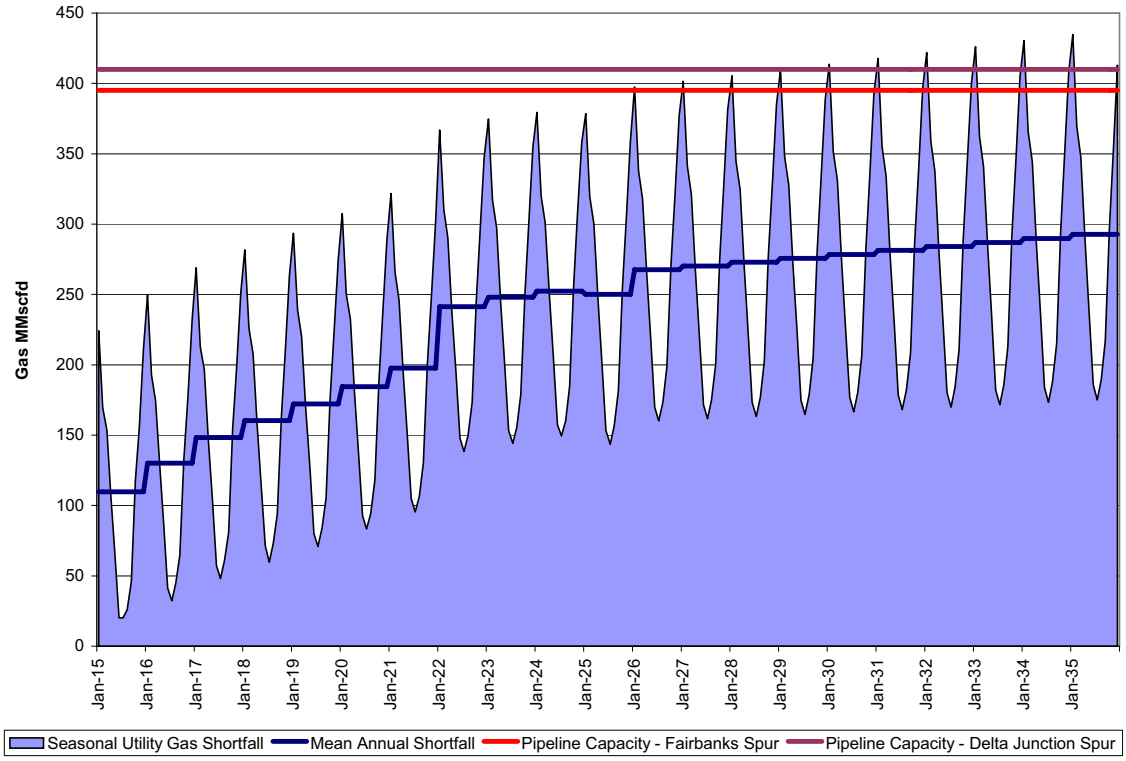
A return on equity (ROE) analysis was completed to determine the tariff of the spur pipeline and associated gas processing plants. Material balances were completed to establish flow rates and compositions on an annual basis for the ANS pipeline and spur pipeline systems. Hydraulic simulations of the spur pipelines were completed to determine when compressor stations would be needed as a function of flow and thereby establish the schedule for capital outlays. Capital cost estimates were prepared for the spur pipeline and compressor stations. Capital costs for the gas processing plants were based on information contained in a report from ANGDA. The ROE analyses were completed by financial consultants of the brokerage firm AG Edwards based on information provided under the direction of Michael Baker. Unlike the J-curve analysis, which is based on the assumption of constant flow throughout the life of the project, the impact of flow ramp-up is included in the tariff calculations.

During a mid-project review meeting held in May of 2006, NETL representatives, the Advisory Committee and contractor team agreed that the delivered price of gas to Cook Inlet would be based on the installation of 20 inch, 2,500 psig pipelines for both Gas Scenarios 1 and 2. **A 20 inch, 2,500 psig pipeline was selected only for the purposes of estimating the delivered price of gas to Cook Inlet and is not to be construed as a recommendation for final selection of a pipeline configuration. Final selection of a gas flow scenario and pipeline configuration would be done by the spur pipeline project sponsors.** The selection of pipeline and station configurations for tariff calculation was based on:

- Estimated capital costs through start-up to provide 110 MMscfd of utility gas flow;
- Estimated cumulative capital costs through late life to accommodate 350 MMscfd of utility gas flow during both summer and winter operation;
- Comparative COS values from J-curve analyses;
- Potential for capacity expansion; and
- Ability to provide for the option of future transport of NGLs.

Hydraulic Simulation Results

Capacity of a 20 inch, 2,500 psig pipeline without compressor stations exceeds the demand for Gas Scenario 1 as derived from the Gas Market Assessment. Hydraulic simulation results for Gas Scenario 1 are shown in Figure ES.6. Gas rate in this figure refers to the rate of utility grade gas delivered via the spur pipeline to Cook Inlet.



NOTE: Labels on x-axis are in years (i.e. 2015 – 2035).

Figure ES.6: Cook Inlet Demand and Summer Spur Pipeline Capacity, Gas Scenario 1

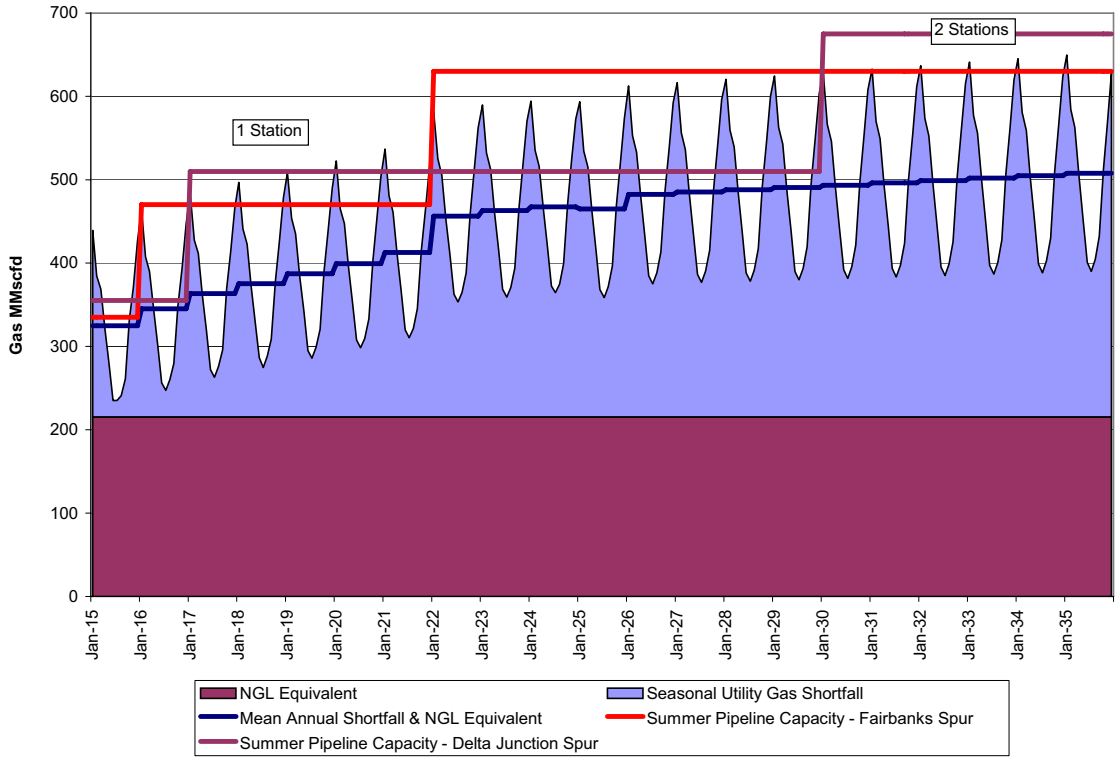
Hydraulic simulation results for Gas Scenario 2 are shown in ES.7. Spur pipeline flow per Gas Scenario 2 exceeds that of Gas Scenario 1 due to spiking of approximately 215 MMscfd gas equivalent of NGL into the gas. Compressor stations for Gas Scenario 2 were assigned whenever the average annual gas demand exceeded the summer pipeline capacity.

Demand values shown in ES.6 and ES.7 reflect seasonal swings in demand, but not the peak daily demand that may be encountered. Pipeline capacity will increase during the winter and it was assumed that shortfalls in between pipeline capacity and seasonal demand would be made up with gas from LNG imports and in-ground gas storage. A discussion of the Cook Inlet gas storage is contained in Section 8.11.

Two compressor stations are required to accommodate late life flow rates for both the Fairbanks and Delta Junction Spur options per Gas Scenario 2. Station locations were selected in order to achieve the maximum possible flow through the respective pipelines even if the resulting flow rate was well in excess of the mean annual Cook Inlet demand.

An evaluation of on-line availability of the spur pipeline is outside the scope of this report. Capital costs for pipeline compressor stations include the installation of an off-line spare gas compressor. All hydraulic results are based on 100 percent on-line availability of the pipeline, compressor stations and associated gas plants.

Spur pipeline capacity will be less in the summer than winter because flow varies inversely with gas temperature and the flowing temperature of the gas will be greater during the summer. Summer pipeline capacities were used for the assignment of compressor stations thereby providing a degree of conservatism regarding installed capacity.



NOTE: Labels on x-axis are in years (i.e. 2015 – 2035).

Figure ES.7: Cook Inlet Demand and Summer Spur Pipeline Capacity, Gas Scenario 2

Capital Cost Estimates and Economic Results

Budget level pipeline capital costs for a 20 inch, 2,500 psig spur pipeline were estimated at $730 million (2006) and $774 million (2006) for the Delta Junction and Fairbanks Spur routes, respectively. Elements that affect capital cost include pipeline size, pipeline length, pumping requirements, environmental factors, and construction challenges.

Compressor station capital costs were based on equipment to provide late life flow rates and were estimated at $36.1 million (2005) for the Fairbanks Spur and $43.4 million (2005) for the Delta Junction Spur. Hydraulic simulation results were used to estimate pipeline gas compression fuel at 0.25 percent and 0.50 percent of pipeline inlet on a thermal basis for one and two stations respectively. Operating cost for the compressors was estimated as five percent of installed capital.

Capital costs for gas processing plants were estimated by factoring cost information contained in the report *Spurline Terminal Conceptual Design* prepared in 2006 by Shaw-Stone & Webster Management Consultants for ANGDA. Capital cost of the gas plant at the inlet of the spur pipeline for Gas Scenario 1 was estimated at $227 million (2006). Capital costs for gas plants at the inlet and outlet of the spur pipeline for Gas Scenario 2 were estimated at $760 million (2006) and $302 million (2006) respectively. Plant fuel was estimated at one percent of feed on a thermal basis. Operating costs for the gas processing plants were estimated as five percent of installed capital.

Overall tariffs for the spur pipeline project, including gas processing facilities at the pipeline inlet and outlet (Gas Scenario 2 only), were calculated by AG Edwards based on input provided by Michael Baker. The price of all hydrocarbons delivered to Cook Inlet, after extraction of fuel for the spur pipeline, Cook

Inlet processing plant and NGL facility, was adjusted until a ROE of 12 percent was obtained over a 33 year project life. The overall tariff for the NGL extraction plant, spur pipeline with stations and Cook Inlet processing plant was determined as the difference between the delivered hydrocarbon price in Cook Inlet and the price of gas purchased from the ANS pipeline. Tariffs were based on the thermal content of the hydrocarbons delivered to Cook Inlet after removal of fuel. Fuel is valued at the price of gas purchased from the ANS pipeline.

Economic premises used by AG Edwards to calculate the tariff for the spur pipeline are the same as those used for the ROI analysis (Appendix 3-6) with the following exceptions:

- Sales price adjusted to yield return-on-equity of 12 percent
- Debt Service Coverage Ratio: Minimum of 1.25x
- Minimum Cash on Hand: $100,000,000
- Debt-Equity Financing: 70-30; equity paid up front
- Debt Structure Assumptions:
    - First Debt Issuance: 2012
    - Last Debt Issuance: 2016 for Gas Scenario 1, 2015 for Gas Scenario 2
    - Principal Payment Amount: equal principal from first principal payment date to last principal payment date
    - First Principal Payment Date : 2021 (consistent in all four scenarios)
    - Last Principal Payment Date (dictated by first year coverage ratio): 2033 for Gas Scenario 1, 2034 for Gas Scenario 2
    - Term of financing: 21 years and 22 years from first debt issuance to last principal payment date for the Gas Scenario 1 and Gas Scenario 2, respectively

Price of gas delivered to Cook Inlet was estimated as the sum of the price of gas at the inlet of the ANS pipeline on the North Slope, the tariff to transport the spur pipeline gas through the ANS pipeline to the spur pipeline take off point and the tariff from the inlet of the NGL plant at the spur pipeline inlet to delivery at Cook Inlet. A summary of the tariff results and estimated delivered price of gas to Cook Inlet are contained in the following table:

Table ES.1: Estimated Price of Gas Delivered to Cook Inlet, $/MMbtu

	Gas Scenario 1 Delta Junction Spur	Gas Scenario 1 Fairbanks Spur	Gas Scenario 2 Delta Junction Spur	Gas Scenario 2 Fairbanks Spur
ANS purchase price	3.20	3.20	3.20	3.20
ANS tariff	0.57	0.47	0.57	0.47
Spur pipeline tariff	1.68	1.75	1.30	1.33
Delivered price	5.45	5.42	5.07	5.00
All values are expressed in $/MMbtu				

Delivered prices in the above table do not contain charges for transportation through ENSTAR's distribution system. ENSTAR estimates the distribution fee at approximately $0.25/MMbtu.

For the same gas scenario, there is no substantial difference in the price of gas delivered to Cook Inlet via the Fairbanks and Delta Junction Spur options. The two spur pipeline options are economically indistinguishable based on the level of accuracy of the capital costs and the supporting engineering specification.

A premise of the Gas Market Assessment is that the price of gas entering the ANS pipeline on the North Slope will be the delivered gas price at the ANS pipeline terminus near Chicago minus the ANS pipeline tariff. The price of gas entering the ANS pipeline will thus be tied to the price of gas near Chicago.

The highest price for gas delivered to Cook Inlet calculated for either Gas Scenario 1 or 2 is $5.45/MMbtu. Economic results support the conclusion that a spur pipeline off of the main ANS pipeline can deliver gas to Cook Inlet at or below the price of gas delivered to the Chicago area via the ANS pipeline. This trend regarding the relative price differential between gas near Chicago and Cook Inlet will hold regardless of the price of gas near Chicago.

This study used the volume ramp up scenarios from the SAIC report. A protracted flow ramp-up as described in the Gas Market Assessment underutilizes the installed capacity of the spur pipeline with a negative impact on project economics. A scenario that might be viable would be to import LNG to replace the projected Cook Inlet gas shortfall and defer installation of the spur pipeline for a number of years to allow the annual shortfall to increase. Deferring construction would enhance the spur pipeline economics by providing a greater flow rate immediately after commissioning, thereby utilizing the installed pipeline capital more efficiently.

The economics of pipeline projects are strongly influenced by the outlay of capital for design, procurement, and construction. Although small compared to the ANS pipeline, the 300 mile spur pipeline would be a significant project by itself. Simultaneous construction of the ANS pipeline and the spur pipeline could result in competition for limited resources. Procurement and construction for the spur pipeline would need to be scheduled to avoid such competition.

Section 9. Considerations for Future Work

Any potential spur pipeline would need to provide a highly reliably source of utility gas to Cook Inlet. Pipeline operability reviews would need to be completed to ensure that the overall pipeline and compression system, including gas processing facilities, would operate safely, reliably and in accordance with all regulatory criteria.

An operability review should, at the minimum, address the following:

- Operation at each discrete ramp-up increment projected for the project;
- Contingency plans for operation if one or more compressor stations or gas processing facility is off-line;
- Operation subject to planned maintenance;
- Procedures for pressure reduction and removal of a high-pressure pipeline from service for scheduled or unscheduled maintenance; and re-pressurization of the pipeline to return it to service;
- Re-wheel of pipeline gas compressors installed early in the project as flow increases; detailed review of the operation of individual gas compressors must be completed to ensure adequate operation over all flow rates;

- Detailed review of the operation of the gas refrigeration systems at peak summer loads and subject to winter temperatures when minimum loads are encountered or possibly the system is not required at all; and
- Seasonal project capacity with respect to peak seasonal and daily loads requiring gas removal from storage in Cook Inlet.

Future work requirements would be predicated upon selection of a single spur pipeline route prior to beginning detailed studies. The future work would include but not be limited to:

- Develop a public outreach program for the project.
- Engage FERC and other regulatory agencies in pre-application dialogue to ensure that the NEPA process is completed in the shortest timeframe possible.
- Preparation of a Geographical Information System (GIS) database for use as a single data repository for the project.
- Preparation of a permit plan and schedule for all phases of the project.
- Start field work including:
    - Surface and sub-surface geo-technical investigations
    - Stream crossing surveys to include fisheries impacts and construction methodologies
    - Initial selection of compressor stations sites
    - Initial selection of material storage and camp sites
    - Initial selection of mining sites
    - Detailed analysis of the route options to finalize a preferred optimum alignment
    - Initial evaluation and selection of access roads required for construction as well as operation and maintenance of the spur pipeline
- Continue to refine the ROW ownership records for the project.
- Define the gas processing requirements including whether the gas will include non-methane components.
- Evaluate potential take-off points for distribution of gas at communities along the spur pipeline.
- Conduct an open season to determine the gas volume that would have to be transported on the spur pipeline.
- Improve the detail and quality of the capital estimates for the project.
- Prepare a project schedule up to and through commissioning of the system.
- Prepare critical material lists for the project.
- Prepare construction and material specifications for the project.