Fairbanks North Star Borough

Gas System Distribution Analysis

Preliminary Executive Summary Report

February 14, 2012

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Executive Summary

Residents in the Fairbanks North Star Borough currently face the double impact of high energy costs and reduced air quality, especially during winter months with cold-weather inversions. As one of its continuing actions to address both problems, the borough asked for engineering and economic input to define an optimal plan for the rapid build-out of the region's energy distribution infrastructure. The anticipated build-out plan would provide natural gas to the largest number of borough residents, businesses, and industrial facilities; as well as to improve air quality.

This Executive Summary outlines preliminary findings from an ongoing analysis of the current issues; the final project report is due in May of 2012. A consolidated file with selected maps is included with this summary.

The first map in the included binder of maps illustrates the Fairbanks North Star Borough PM2.5 non-attainment zone.[1] This map, when coupled with high-density demand estimates discussed in the following section, suggests areas where natural gas could reduce energy costs while improving air quality. Currently, development efforts in much of the borough are limited by conditions of the PM2.5 non-attainment zone; air quality permits cannot be obtained if development will increase the amount of PM2.5 emissions.

Table 1 shows the potential savings for heating, using conversion to natural gas over an equivalent heating amount of fuel oil (105,600,000 gallons) at $4 per gallon. Since 2008, natural gas has cost $23.35 per thousand cubic feet (Mcf) in Fairbanks. The table shows projected savings at that price point and at several others down to $14.00 per Mcf as compared with the current fuel oil price of $4.00 per gallon. The final report will include a number of price points for both fuels along with estimates of conversion rates over time.

Table 1. Potential Conversion Savings, Natural Gas Over Fuel Oil Equivalent, Selected $/Mcf

Natural Gas, $/Mcf	Savings, $
23.35	114,180,000
23.00	118,800,000
20.00	158,400,000
17.00	198,000,000
14.00	237,600,000

Source: Northern Economics Inc.

Market Estimate

Table 2 summarizes preliminary estimates of potential natural gas demand in three sectors: residential, commercial (including an estimate for non-taxable government structures), and industrial. It is estimated that 13.2 billion cubic feet (Bcf) of natural gas per year would be required to meet existing space heating requirements in all three sectors. In addition, if converted, power generation and refinery processing would require an additional 7.7 Bcf per year, for a total of 20.9 Bcf per year.

[1] PM2.5 refers to particulate matter 2.5 microns and smaller.

Table 2. Estimated Annual Residential, Commercial, and Industrial Sector Natural Gas Requirements for Heating, Power Generation, and Industrial Processing

Category	Count (# of units)	Area (square feet)	Estimated Demand (Bcf/year)
Residential Sector	24,986	57,573,880	5.7
Commercial Sector			
Taxable Structures	978	10,576,081	3.9
Non-Taxable Structures		2,340,000	0.9
Industrial Sector			
Space Heating	571	5,318,832	2.7
Power Generation			2.9
Refinery Processing			4.8
Total	**26,535**	**75,808,793**	**20.9**

Source: Michael Baker, Jr. and Northern Economics, Inc.

Figure 3 in the map binder illustrates the higher density residential and commercial zones.

Natural gas demand estimates for heating are primarily based on the Borough's Geographical Information System (GIS) and the Assessor's database of all taxable structures. These databases provided estimates of total square footage for residential, commercial, and industrial structures.

Analysts estimated heating loads using heat loss calculations based on similar structures in Fairbanks and Anchorage (as adjusted for degree-day differences). In addition, team analysts provided an estimate of natural gas demand for heating non-taxable segments, such as the federal, state, and municipal government buildings. The team also estimated the power sector demand assuming conversion of Golden Valley Electric Association's 60-megawatt combustion turbine at the North Pole facility that currently burns naphtha, and industrial sector demand assuming conversion of Flint Hills and PetroStar refineries to natural gas for their refinery processing.

Low, Medium, and High Demand Zones

Project economists and engineers developed three zones within the borough, reflecting high, medium, and low demand areas, based on population and structure density. Figure 5 is a map in the included binder file that displays these three zones, with an estimated build-out in 1 to 5 years for the high demand area, and 6 to 10 years in the medium density zone; low density energy needs will continue to be met with fuel oil, and, perhaps, propane or compressed natural gas.

Conceptual Design

Figure 7 in the included map binder file shows a conceptual distribution system layout for natural gas distribution within the high and medium density zones, using four types of piping:

- Transmission lines. These are 8-inch and 10-inch steel transmission pipe, estimated at 111 miles (total) for both high and medium density lines.
- Distribution feeder lines. These lines are 6-inch diameter plastic pipes with an estimated total of 118 miles required for both zones.
- Distribution lines. These pipes are local and 2-inch in diameter, with a total estimate of 804 miles required, both zones.

- Service lines. These are small diameter (5/8 and 1-inch) plastic pipe, with an estimated total of 325 miles required, both zones.

Preliminary Pipeline Cost Estimate

Cost estimates are preliminary and they are considered Level 4 (+50% to -30%), on a scale of 1 to 5, from the Association for the Advancement of Cost Engineering. Table 3 provides a summary by phase, cost center and low and high ranges. These will be revised and included in the final report, due in May.

Table 3. Total Cost Estimate

Phase	Low Estimate (in $ millions)	High Estimate (in $ millions)
1 - High Demand		
Engineering, Permitting and ROW	8.8	18.9
Construction	167.1	358.2
Phase 1 Total	176.0	377.1
2 - Medium Demand		
Engineering, Permitting and ROW	6.5	14.0
Construction	126.4	270.9
Phase 2 -Total	132.9	284.9
Total, Phase 1 and 2	**308.9**	**662.0**

Source: Michael Baker, Jr. Inc. 2012

A conceptual project schedule suggests preliminary engineering could begin in 2012 and proceed through year five.

Business Models

Natural gas markets will ultimately determine the financial viability of natural gas distribution within the two zones, and that, plus financing, will guide how the business model will be structured. Fairbanks Natural Gas, LLC (FNG), for example, holds a certificate to operate from the Regulatory Commission of Alaska (RCA) but it is not economically regulated at the current number of accounts and volumes of gas. The strengths and weaknesses of several models will be analyzed and provided as part of the final report.

Financial Analysis, Cost of Service

Current natural gas prices are $23.35 per Mcf, a price that includes both cost-of-service and transportation costs. Historically, prices have ranged from $8.56 per Mcf in 2002 to $23.35, from 2008 to the present. There are economies of scale that will take effect once a larger system is constructed and lower costs to consumers are the result of this increased scale.

Conversion costs for residential homes in the borough range from a lower estimate of $1,000 to $1,500 to replace a burner gun, to as much as $20,000 to remove a boiler and install a natural gas system and chimney. The current system and type of home will drive most of these costs, with more specific figures projected in the final report.

FNG's financial statements filed with the RCA indicate the company has approximately $26.7 million of total assets (2010) and it generated $3.0 million of net income on $16.1 million of revenues (gas, operating). This is an income margin of 18.6 percent, which indicates FNG is a profitable company.

Team analysts prepared a series of standard financial statements, including a pro forma (estimated) balance sheet and income statement, using published ratios. The larger natural gas distribution segment

represented 27 utilities with an average of $162.3 million of total assets and an average of $256.2 million in sales; the average profit before taxes was $26.4 million, or a ratio of approximately 10.3 percent.

Air Quality

The non-attainment designation for the Fairbanks area is a cause for concern for several reasons. First, the local population is at increased risk for respiratory and circulatory health problems. Secondly, the designation negatively affects economic growth in the area. Air quality permits for any commercial or industrial activity cannot be obtained if the activity will increase the amount of PM2.5 emissions over current amounts. Because of this restriction, growth of existing commercial and industrial activity will likely not occur, and new commercial and industrial activities will likely not take root in the Fairbanks area until the U.S. Environmental Protection Agency is satisfied that compliance with the ambient PM2.5 standard is attained and a plan is in place to maintain compliance with the ambient standard.

Natural gas conversion in Fairbanks will reduce the emissions of PM2.5 from residential and commercial facilities. The conversion to natural gas will also reduce Oxides of nitrogen (NOX) and Sulfur dioxide (SO2) emissions, which are precursors to the formation of secondary PM2.5 in the atmosphere. The reduction will help bring the Fairbanks area into attainment with the ambient PM2.5 air quality standard.

Environmental engineers based potential reductions in emissions on a five-year build-out of natural gas distribution with the high demand (high density) zone. Preliminary results, using stated assumptions, suggest reductions in PM2.5 emission of up to 95 percent are possible. Table 4 illustrates these results.

Table 4. Change in Emissions Due to Conversion in the High Demand Zone

	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
Category			**(%)**			
Residential	-50	-94	-94	-94	-95	-95
Commercial	-35	9	-71	-69	-100	37
Total	-43	-93	-93	-93	-97	-95

Source: SLR International Corp 2012
Notes: CO = Carbon monoxide; VOC = volatile organic compounds.

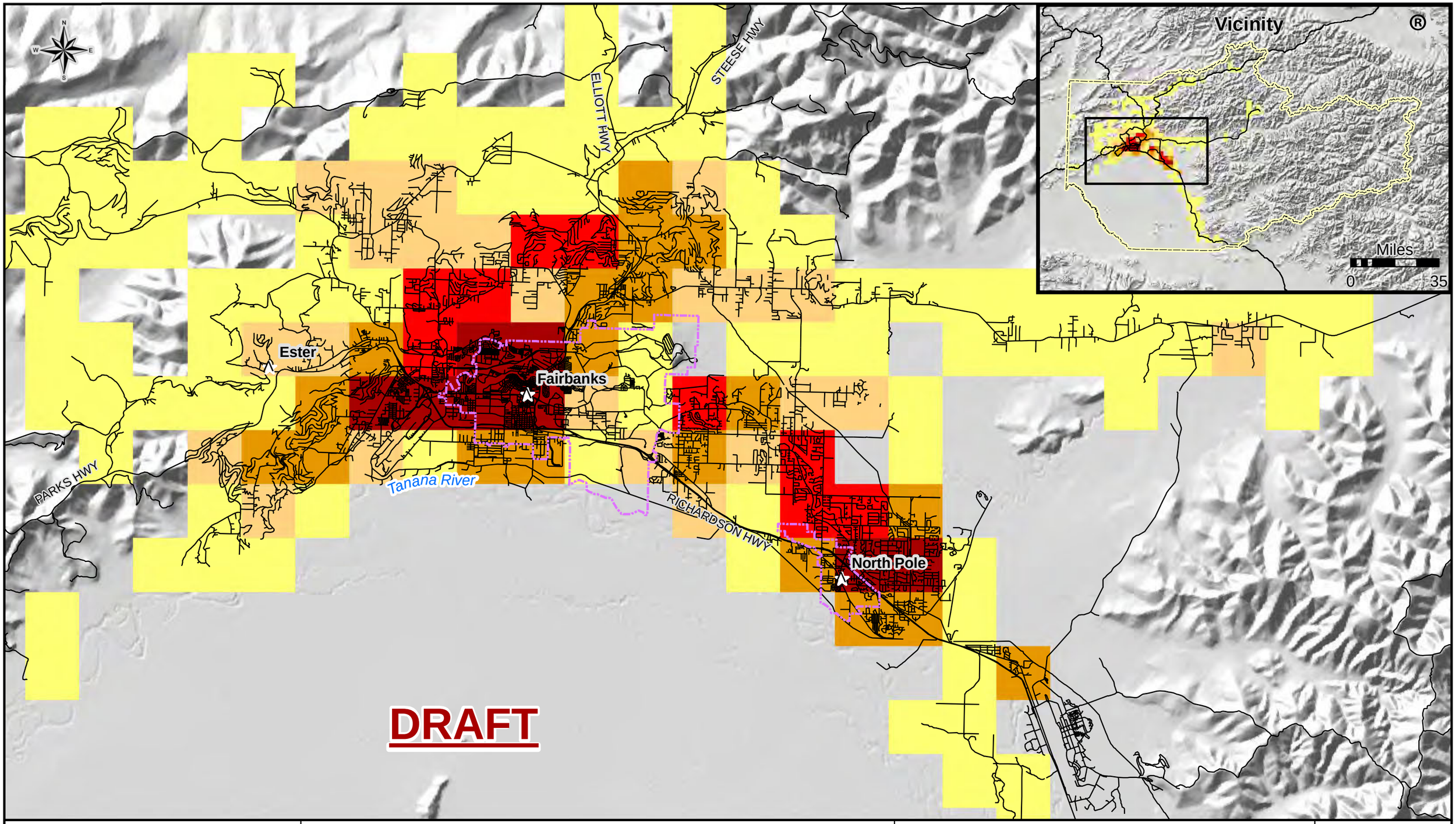

Figure 3
Residential and Commercial Structure
Total Area

SCALE	1 in = 3 miles
DATE	01/30/2012

Baker

Legend

- Road Centerlines
- City Boundary
- Borough Boundary

Residential and Commercial Sq. Feet

- 192 - 196,346
- 196,347 - 545,065
- 545,066 - 959,169
- 959,170 - 1,939,942
- 1,939,942 - 5,557,905

Fairbanks North Star Borough
Gas Distribution Analysis

0 1.5 3 6 Miles

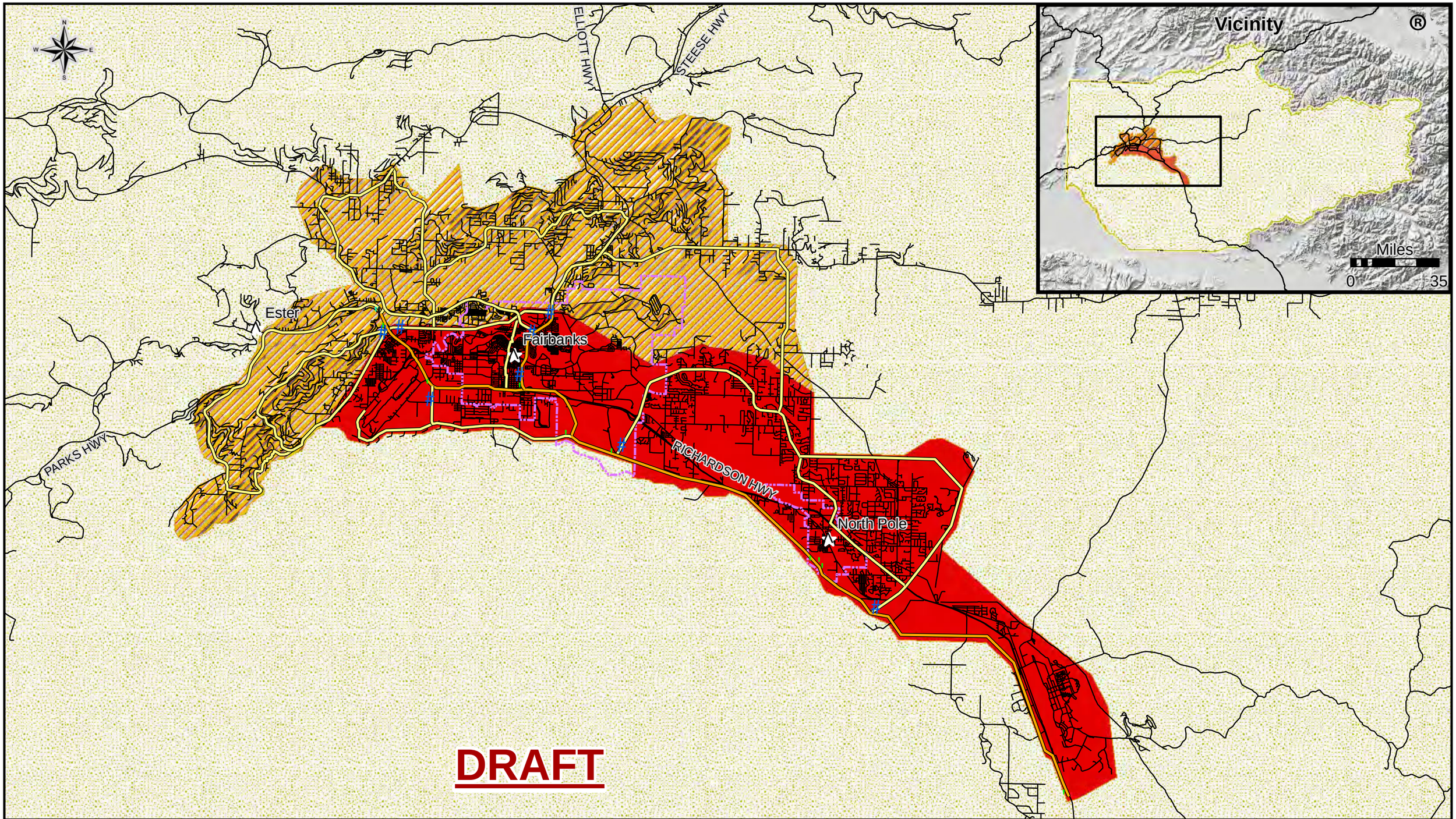

Figure 5
High, Medium, and Low Demand Areas

SCALE	1 in = 3 miles
DATE	01/24/2012

Baker

Legend

- Gas In Point
- Gate Station
- # Reg Station
- Roads
- Distribution Pipeline
- Transmission Pipeline
- City Boundary
- Borough Boundary

Demand

- High
- Medium
- Low

Fairbanks North Star Borough
Gas Distribution Analysis

0 1.5 3 6 Miles

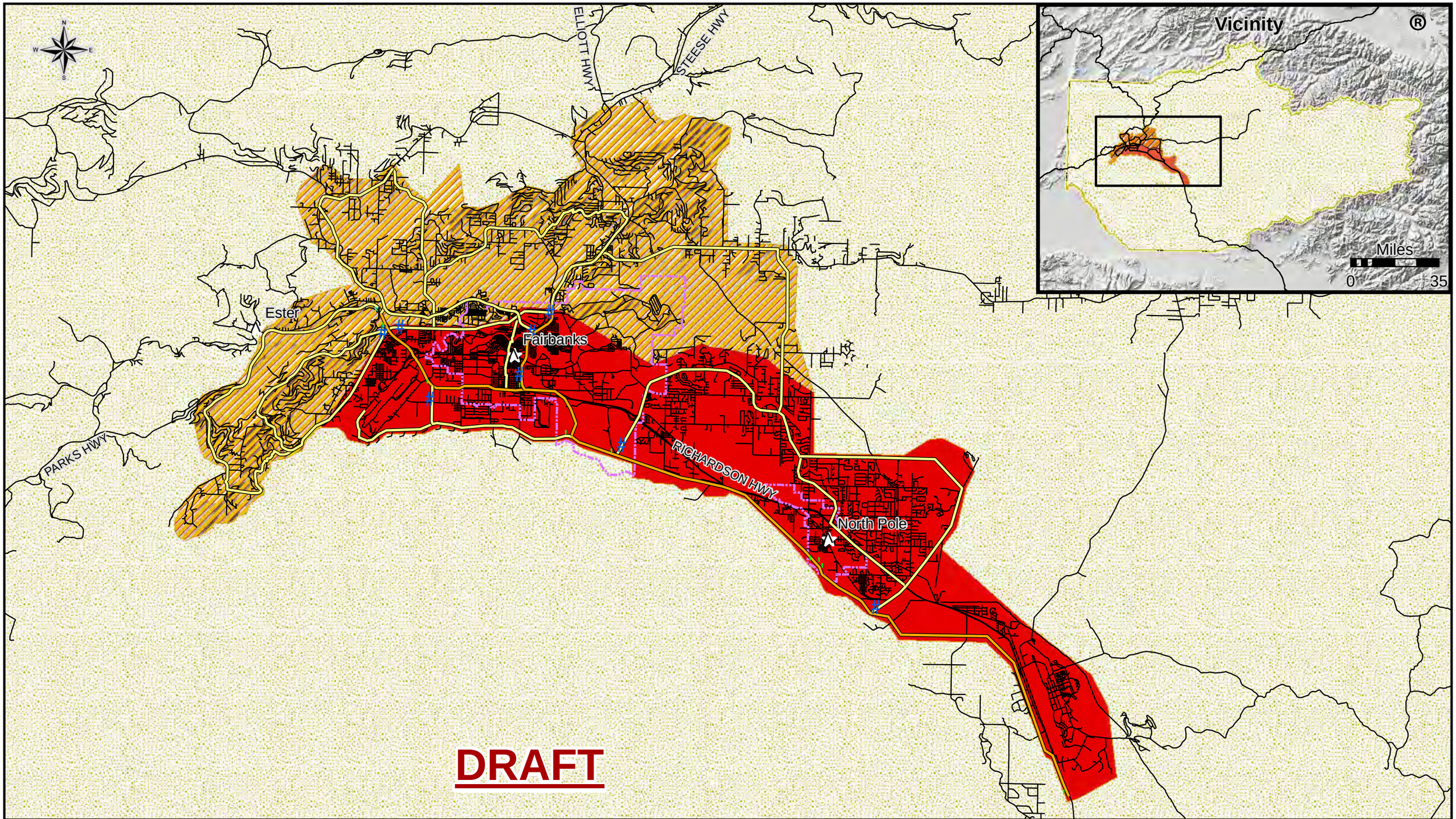

Figure 7
High, Medium, and Low Demand Areas

SCALE	1 in = 3 miles
DATE	01/24/2012

Baker

Legend

- Gas In Point
- Gate Station
- # Reg Station
- Roads
- Distribution Pipeline
- Transmission Pipeline
- City Boundary
- Borough Boundary

Demand

- High
- Medium
- Low

Fairbanks North Star Borough
Gas Distribution Analysis

0 1.5 3 6 Miles

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Abbreviations

Bcf	Billion cubic feet
Btu	British thermal units
CNG	Compressed Natural Gas
CO	Carbon monoxide
EPA	U.S. Environmental Protection Agency
FNG	Fairbanks Natural Gas, LLC
FNSB	Fairbanks North Star Borough
GVEA	Golden Valley Electric Association
LNG	Liquefied Natural Gas
Mcf	Thousand cubic feet
MMBtu	Million British thermal units
MMcfd	Million cubic feet per day
MW	megawatt
NOX	Oxides of nitrogen
PM	Particulate matter
RCA	Regulatory Commission of Alaska
RMA	The Risk Management Association
ROW	Right-of-way
SO2	Sulfur dioxide
TIC	Total Installed Cost
TPY	Tons of pollutant emitted per year
VOC	volatile organic compounds

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- Sierra Research, air quality advisors.

1 Introduction

In November of 2011, the Fairbanks North Star Borough (FNSB) solicited proposals from consulting teams to develop an optimized plan for a rapid build-out of the borough's energy distribution infrastructure, and to assess the effect of the build-out on air quality in the FNSB's PM2.5 non-attainment zone. Northern Economics, Inc. assembled a team of engineers, air quality specialists, and experienced natural gas utility managers and submitted a proposal in December, one that was accepted and signed.

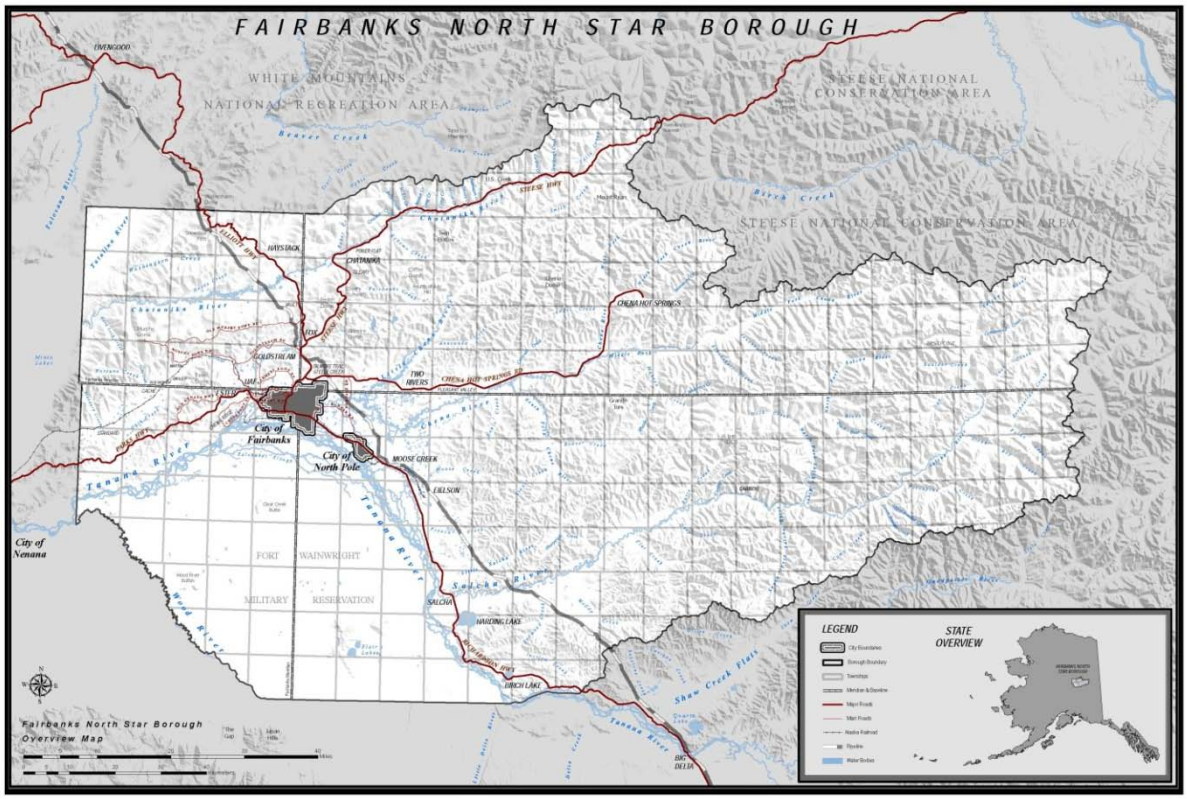
Northern Economics' proposal acknowledged the need for a Preliminary Executive Summary Report, a document that would summarize initial results and prepare order of magnitude demand and gas distribution costs. This document is the Preliminary Executive Summary Report and it provides maps, natural gas demand estimates by category (residential, commercial, and industrial), conceptual pipe layout and design, and preliminary cost estimates. The full report will be submitted as a draft in May 2012 and a final report in June.

1.1 Project Goals

The FNSB set two overarching goals for the project:

- To define a supply-neutral optimized plan for the rapid built-out of the FNSB's energy distribution; one that delivers propane or natural gas as affordably as possible, to the largest number of borough residents, business, and business and residential properties. Figure 1 is an overview map of the borough.

Figure 1. Overview, Fairbanks North Star Borough

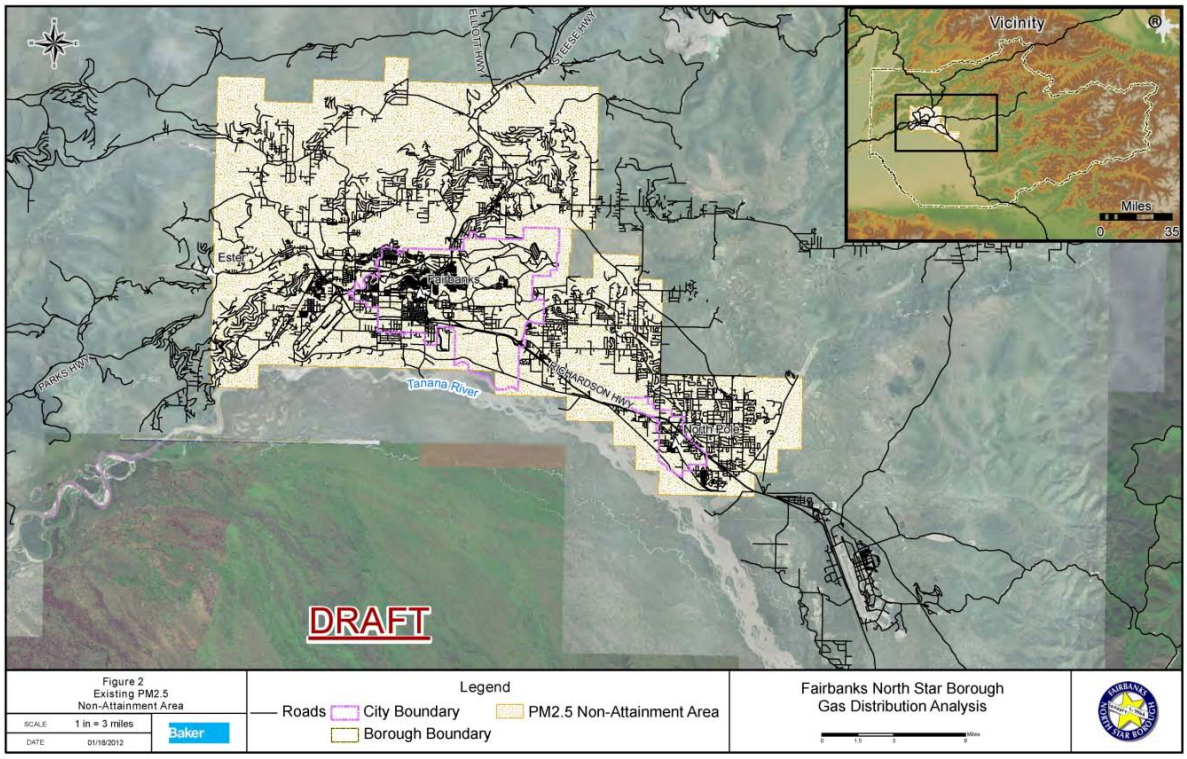


Source: FNSB, 2011b.

- To assess the impact of the proposed infrastructure build-out on air quality in the FNSB non-attainment zone.

The borough's air quality non-attainment zone is also labeled as the PM2.5 area, reflecting the 2.5 micron and smaller particles that exceed the United States Environmental Protection Agency (EPA) air quality standards. Figure 2 illustrates the PM2.5 Non-attainment zone in relation to the borough, the City of Fairbanks and the City of North Pole.

Figure 2. Fairbanks North Star Borough PM2.5 Non-attainment Zone



Source: Michael Baker, Jr. Inc, adapted from FNSB GIS Maps

2 Preliminary Market Estimate

The market potential for natural gas within the entire Fairbanks North Star Borough jurisdiction is estimated to be about 21 billion cubic feet (Bcf) per year or roughly 57 million cubic feet per day (MMcfd). This market size (demand) is defined in terms of annual natural gas consumption for heating, power generation, and industrial processing of all structures and entities located within the borough's geographic jurisdiction.

Table 1 summarizes the estimated annual residential, commercial, and industrial sector demand for natural gas in the FNSB region. The total potential demand represents an energy estimate in numbers of Bcf per year of the total natural gas requirements for:

- heating all the existing residential, commercial and industrial structures, including government buildings;
- power generation assuming conversion of an existing 60 MW combustion unit that burns naphtha to natural gas; and
- processing needs of the existing refineries.

Table 1. Estimated Annual Residential, Commercial, and Industrial Sector Natural Gas Requirements for Heating, Power Generation, and Industrial Processing

Category	Count (# of units)	Area (square feet)	Estimated Demand (Bcf/year)
Residential Sector	24,986	57,573,880	5.7
Commercial Sector			
Taxable Structures	978	10,576,081	3.9
Non-Taxable Structures		2,340,000	0.9
Industrial Sector			
Space Heating	571	5,318,832	2.7
Power Generation			2.9
Refinery Processing			4.8
Total	**26,535**	**75,808,793**	**20.9**

Source: Michael Baker, Jr. and Northern Economics, Inc., adapted from FNSB Property Database.

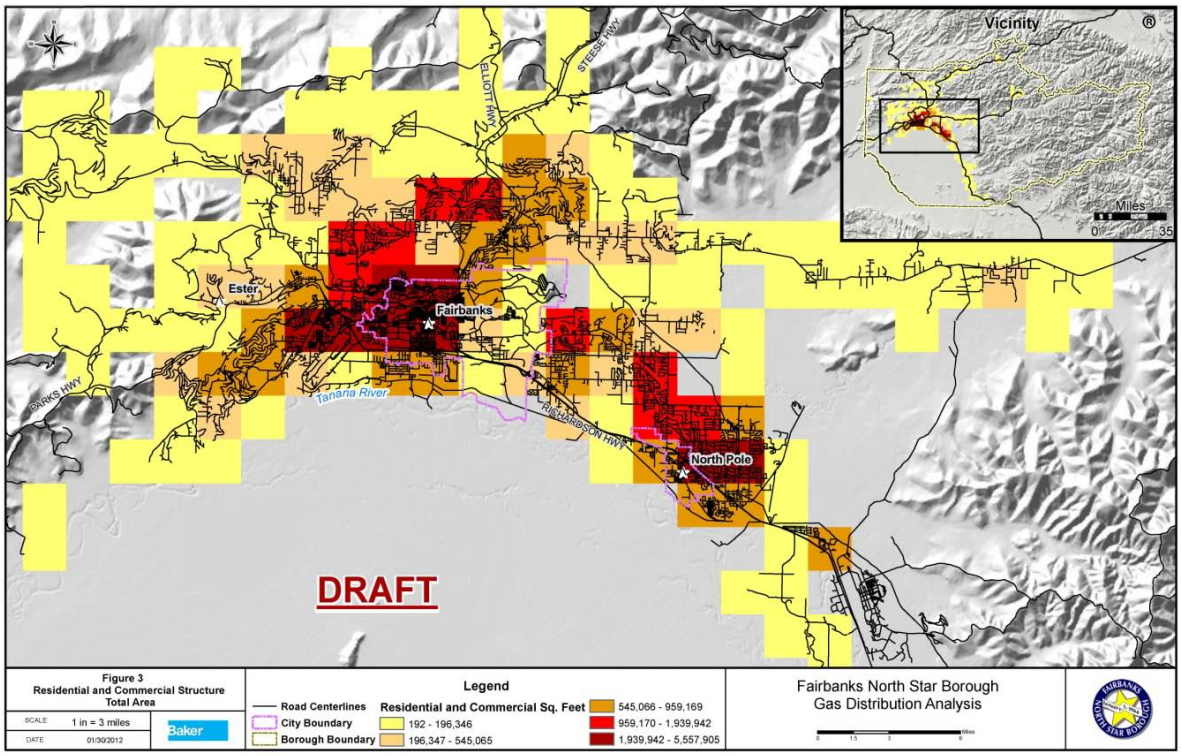
The estimates were derived using the FNSB Assessor's property database[1], which has information on existing taxable structures within the borough, secondary data to determine potential load of non-taxable structures, as well as data on potential industrial energy requirements obtained from interviews and published sources.

Note that the total potential natural gas demand for the residential and commercial sectors represents 100 percent market penetration. The probability of conversion to natural gas use for heating and the timing of conversion will be incorporated into the benefit-cost analysis and economic evaluation of the proposed project which will be provided in the full report. Potential future demand or the growth in the existing loads will also be quantified and provided in the full report.

[1] The Assessing Department maintains two databases, one that identifies full parcel ownership (GIS) and another with real property information such as structural square footage (Assessor's Office). There are inconsistencies between the property database and GIS files that are known and will be corrected for the final project report.

Figure 3 displays estimated heat loads for residential and commercial structures within the borough, based on structural square footage, a key indicator of heat loss and actual (total) heat load, as shown in the prior table. Estimates do not include energy (heat) needed for non-taxable buildings, an amount that will be added in the final report after data is located. Each square in the figure is approximately 1.8 miles on each side, original scale.

Figure 3. Fairbanks North Star Borough, Residential and Commercial Structural Area



Source: Michael Baker, Jr. Inc., FNSB data files

Market penetration for natural gas in the region has been limited to date due to supply constraints, as ready access to Cook Inlet natural gas has been increasingly challenging. Natural gas in the form of liquefied natural gas (LNG) is currently being transported approximately 300 miles by truck from Point MacKenzie (located west and south of Wasilla) to an LNG storage and liquefaction facility in Fairbanks.

The existing natural gas distribution infrastructure in Fairbanks serves the space heating needs of approximately 1,120 residential and commercial customers within the city. The FNSB assessor's property database identified approximately 26,000 residential units and commercial structures within the borough's jurisdiction. This means that less than five percent of the residential and commercial sector market is supplied with natural gas for its heating requirements.

Most residential and commercial customers in the borough use heating oil for space heating and domestic hot water, though some use propane, wood, or coal. There are a number of coal-based power generation facilities in the region including those that serve the university and the military. Golden Valley Electric Association (GVEA), which is the largest power utility in the region, generates power locally using oil and coal.

Access to natural gas and expansion of the existing natural gas distribution infrastructure are necessary in order for the market for natural gas to grow. Environmental constraints form another

market factor, with the EPA labeling much of the borough's residential and commercial sectors as a non-attainment zone for PM2.5 (See Figure 2). As discussed in Section 6 of this preliminary executive summary report, environmental concerns may limit potential growth in the more settled parts of the borough.

The following sub-sections provide more details on the preliminary estimates of the current natural gas demand for the residential sector, commercial sector, and industrial sector, respectively.

2.1 Residential Sector

Residential sector consumption refers to natural gas used in private dwellings (including multi-residential units or apartments) for heating, air conditioning, cooking, water heating, and other household uses.

It is estimated that 5.7 Bcf per year or 15.6 MMcfd of natural gas will be required to meet the heating requirements of existing residential structures in the borough. The FNSB Assessor's database identified 24,986 residential units within the borough's jurisdiction, including all the structures identified as: 1) Residential; 2) Resi-Condo; 3) Multi-family; 4) Mobile Home; and 5) Trailer Court.

Of the roughly 25,000 residential structures, only 463 are being served by Fairbanks Natural Gas (FNG). (FNSB 2011a) Hence, less than two percent of the existing residential sector market for natural gas is being met by the current FNG distribution system.

Table 2 summarizes market information for the Residential Sector. The estimates include residential customers that already use natural gas for heating (FNG customers) and all the other potential customers classified as residential structures in the Assessor's database. No assumption regarding the number of these residential structures that would convert to natural gas has been incorporated in these estimates.

Table 2. Residential Sector: Number of Units, Area, and Estimated Natural Gas Requirements

Category	Total
Number, parcels	24,986
Area, lots, number of acres	63,605
Area, total building square footage	57,573,880
Area, average building square footage	2,304
Natural Gas Requirement per day (MMcfd)	15.6
Annual Natural Gas Requirement (Bcf)	5.7

Source: Michael Baker Jr. estimates.

The estimated residential sector load was derived using the following information:

1. Number and area (in square footage) of all taxable, including "exempt" residential structures identified in the FNSB Assessor's database.
2. Average base and heating loads as shown in Table 3. Base heating loads consist of natural gas consumed during summer months, with virtually no space heating requirements.

Table 3. Average Base and Heating Loads in Thousand Cubic Feet (Mcf) per Year by Size of Residential Structure

Range (Square Footage)	Base Load (Mcf/Year)	Heating Load (Mcf/Year)	Total (Mcf/Year)
0-499	15.40	48.29	63.69
500-999	30.80	96.59	127.38
1,000-2,499	48.04	150.68	198.72
2,499 and larger	76.99	241.47	318.46

Source: Michael Baker Jr. estimates; FNSB property database.
Note: The loads are based on ENSTAR heat loss data for Anchorage structures adjusted for Fairbank's heating degree days.

According to FNG data provided in 2009, their residential customers on average consumed about 190 Mcf per year (Northern Economics, 2009). At that time, total residential sector consumption was about 64,000 Mcf per year. In comparison, the average estimated load across the range of sizes shown in Table 3 is 177 Mcf per year, which is within a ten percent variance.

2.1.1 Estimated Residential Savings

The current natural gas cost in Fairbanks is $23.35 per Mcf and heating fuel is $3.84 per gallon, at its best rate, delivered, and quoted by two suppliers. Converting to an equivalent heat basis, natural gas costs $23.35 per million British thermal units (MMBtu) and heating oil is $27.67 per MMBtu, an approximate savings of $4.32 per MMBtu.

An average residential home consumes approximately 190 Mcf per year (2009) for a projected natural gas cost of $4,437 per year, versus heating oil of $5,257. This results in an estimated $820 of savings per year, for the average-size home.

Larger natural gas distribution will lead to economies of scale and potentially reduce prices. Team analysts reviewed a range of natural gas prices from $23.35/MCF to $11.00/MCF in $3.00 increments; potential savings ranged from $114 million to $238 million.

2.2 Commercial Sector

Commercial sector consumption refers to gas used for space heating by non-manufacturing establishments primarily engaged in the sale of goods and services such as hotels, restaurants, wholesale and retail stores, and other service enterprises. For the purpose of this preliminary estimate and report, the commercial sector also includes local, state, and federal government agencies. As data are located, the potential government demand will be quantified in a similar manner.

In 2011, FNG served 622 small commercial customers and 34 large commercial customers, a total of 656 commercial customers. (FNSB 2011a) There are 978 commercial establishments identified in the Assessor's database. These numbers imply that roughly 64 percent of the current commercial sector market for natural gas is already being met, strictly on a per-account basis. It should be noted however, that the market size of the commercial sector for this study is solely dependent on the Assessor's database identification of "commercial" structures. Actual market penetration is in fact less than 64 percent since the Assessor's database does not include non-taxable structures.

As expected, market penetration in the commercial sector is higher compared to the residential sector. Economies of scale with respect to conversion costs are achieved with the commercial establishment's higher heating loads.

As shown in Table 4, the estimated commercial sector heating requirements is about 5 Bcf per year or 13.1 MMcfd. This estimated load includes the 656 commercial customers that are already being served by FNG and all the other potential commercial sector customers identified in the Assessor's database as commercial structures. No assumption regarding the number of these commercial structures that would convert to natural gas has been incorporated in these estimates.

Table 4. Commercial Sector: Number of Units, Area, and Estimated Natural Gas Requirements

Category	Total
Number, parcels (taxable)	978
Area, lots, number of acres (taxable)	3,010
Area, average building square footage (taxable)	10,814
Area, total building square footage	
Taxable structures	10,576,081
Non-taxable/government agencies	2,340,000
Natural Gas Requirement per day (MMcfd)	
Taxable structures	10.7
Non-taxable/government agencies	2.4
Total:	13.1
Annual Natural Gas Requirement (Bcf)	
Taxable structures	3.9
Non-taxable/government agencies	0.9
Total:	4.8

Source: Michael Baker Jr. estimates; FNSB property database and Northern Economics estimates, based on federal GSA office space use figures (GSA, 1997);
Note: The loads are based on ENSTAR data for Anchorage, adjusted for Fairbank's heating degree days.

The estimated commercial sector load for taxable structures was derived using the following information:

1. Number and area (in square footage) of all commercial structures identified in the FNSB Assessor's database.
2. Average base and heating loads as shown in Table 5. Base load, again, reflects natural gas consumed during summer months with essentially no heating load but the base load does include air conditioning, hot water heating, and cooking during warmer months.

Table 5. Average Base and Heating Loads in Mcf per Year by Size of Commercial Structure

Range (Square Footage)	Base Load (Mcf/Year)	Heating Load (Mcf/Year)	Total (Mcf/Year)
0-2,500	83	92	175
2,500-3,500	221	243	464
3,500-5,000	617	679	1,297
5,000 and larger	3,631	3,998	7,630

Source: Michael Baker Jr. estimates; FNSB property database.
Note: The loads are based on ENSTAR data for Anchorage, adjusted for Fairbank's heating degree days.

In comparison, historical FNG data indicate average yearly consumption of 650 Mcf per year for "small" commercial customers, 4,000 Mcf per year for "medium," and 8,000 Mcf per year for their "large" commercial customers. (Northern Economics, Inc. 2009).

The estimated heating load for the non-taxable commercial structures, primarily federal, state and municipal government agencies is presented in Table 6. The estimates were derived using the following information:

1. Federal, state, and local government employment data from Alaska Department of Labor and Workforce Development (2011)
2. Average U.S. government usable space in square feet per person including office plus associated storage and special use from the federal government's General Services Administration (GSA, 1997)Estimated average natural gas requirement in Mcf per year to heat a commercial structure of 3,500 square feet in area (1,297 Mcf/Year), from Michael Baker estimates as shown in Table 5.

Table 6. Estimated Natural Gas Requirements for the Non-Taxable Government Facilities

	Employment	Workspace per Employee	Estimated Total Workspace	Estimated Natural Gas Requirement	
Category	**(# of workers)**	**(square feet)**	**(square feet)**	**(MMcfd)**	**(Bcf/year)**
Federal Government	3,600	200	720,000	0.7	0.3
State Government	5,400	200	1,080,000	1.1	0.4
Local Government	2,700	200	540,000	0.5	0.2
Total	**11,700**	**600**	**2,340,000**	**2.4**	**0.9**

Source: Northern Economics estimates.
Note: Natural gas requirements for base and space heating were estimated using an average load of 1,297 Mcf per year for commercial structures with an area of 3,500 square feet.

2.3 Industrial Sector

Industrial sector consumption refers to three types of natural gas use—fuel for heating, for electricity generation, and for processing needs. Preliminary estimate of the total industrial sector demand for natural gas is about 10.4 Bcf per year or 28.5 MMcfd.

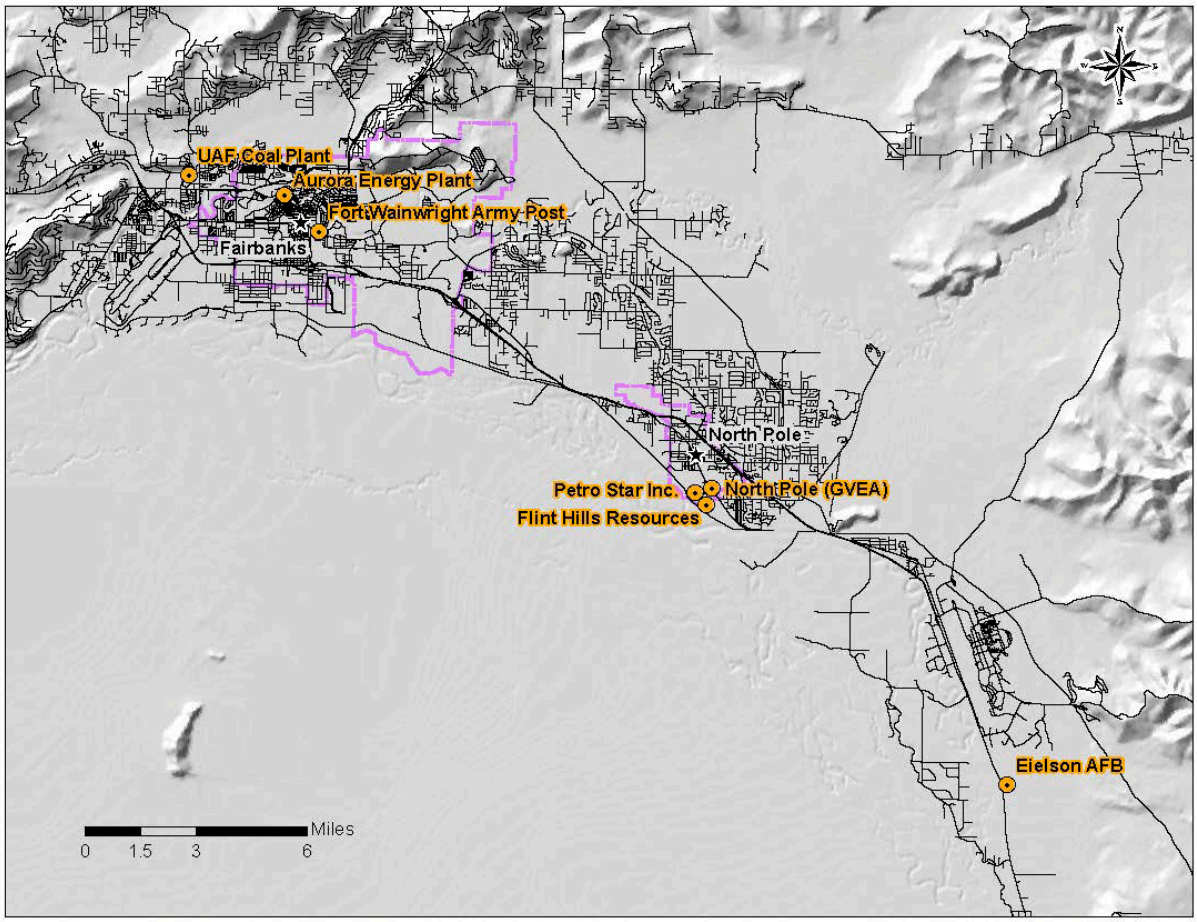
Figure 4 shows the location of seven major facilities that potentially could use natural gas for electricity generation and for processing needs. These facilities include:

- the Central Heat and Power Plant at the University of Alaska
- the Aurora energy plant
- GVEA
- the Flint Hills Refinery and the Petro Star Refinery in North Pole
- Eielson Air Force Base and Fort Wainwright

It is unlikely that the facilities that use coal for heating and power generation would switch to natural gas in the near future. The existing coal-based facilities include Eielson Air Force Base, Fort Wainwright, Aurora Energy, and the Central Heat and Power plant at the University of Alaska

Fairbanks[2]. If these facilities convert to natural gas, it is estimated that they will require about 8.9 Bcf of natural gas per year. This potential demand is not included in the total estimated industrial sector demand of 10.4 Bcf per year. The conceptual design of the transmission lines do allow for these coal-based facilities to be served in the event that they convert in the future.

Figure 4. Industrial Facilities, Fairbanks North Star Borough



Source: Michael Baker, Jr. Inc., FNSB data files

2.3.1 Industrial Heating Load

The Assessor's database identifies 571 existing industrial structures within the borough's jurisdiction. The estimated space heating load for these structures is estimated to be 2.7 Bcf per year (or 7.4 MMcfd). Table 7 summarizes the information for this sub-sector. As noted in the previous section, the estimate provided here is dependent on the Assessor's database identification of "industrial" structures. The estimate includes industrial customers that are already using natural gas for heating their buildings as well those that may or may not convert to natural gas.

The project team will review structures currently classified as industrial within the property database; most of these structures will be re-coded as medium or large commercial structures and will be

[2] Note that the Central Heat and Power Plant at UAF also uses some natural gas and oil besides coal for generation of power and heat.

included in the commercial sector load in the full project report. This reallocation of space heating load will not affect the total estimated demand.

Table 7. Industrial Sector: Number of Units, Area, and Estimated Natural Gas Requirements (Heating)

Category	Total
Number, parcels	571
Area, total building square footage	5,318,832
Area, average building square footage	9,314
Natural gas requirement in million cubic feet of natural gas per day (MMcfd)	7.4
Annual natural gas requirement in billion cubic feet of natural gas (Bcf/year)	2.7

Source: Michael Baker Jr. estimates; FNSB property database.

2.3.2 Electricity Power Plant Load

Preliminary power sector demand is estimated to be about 2.9 Bcf per year. Unlike the residential and commercial sectors, the estimated demand for the power sector only represents a portion of the total power sector market. The demand estimate reflects 20 percent of the total existing generation capacity of GVEA.

GVEA is the primary utility that provides electricity in the region and it utilizes a diverse mix of fuel including oil, coal, natural gas, and hydroelectric. The utility serves about 44,000 customers in the Fairbanks, Delta Junction, Nenana, Healy, and Cantwell area.

The GVEA combustion turbine (GT3) at their North Pole facility is the most likely to convert to natural gas (IIC, 2009). The GT3 is a 60 MW LM6000 combined cycle unit that currently fires naphtha, a clean burning fuel, produced at the Flint Hills refinery located nearby. Based on previous data provided by GVEA in 2009, the GT3 unit consumes 22.6 million gallons of fuel per year. Given a heat content (Btu) of 127,500 per gallon of naphtha, the estimated natural gas requirement for GT3 is about 2.9 Bcf per year.

Note that the steam headers at the North Pole expansion facility were double-sized to prepare for a possible expansion. Adding another 60 MW of generating capacity could double the power sector natural gas demand to 6 Bcf per year. Furthermore, the original 120 MW capacity North Pole plant that has the GT1 and GT2 units could also be retrofitted with natural gas. However, currently there are no plans to retrofit these units to natural gas due to design issues.

2.3.3 Industrial Processing Load

The estimated load for industrial processing refers to the natural gas requirements of the two existing refineries in the region.

Flint Hills Resources' North Pole refinery is located southeast of Fairbanks in North Pole. The refinery is the largest in Alaska with a crude oil processing capacity of 220,000 barrels per day. The facility consumes about 64,000 barrels of North Slope crude oil per day to produce various petroleum products including gasoline, jet fuel, heating oil, diesel fuel, gasoil and asphalt for supply to Alaska markets. The refinery uses a portion of the crude stream to fire boilers and the distillation tower for the production of liquid fuels. (IIC 2009)

The Petro Star refinery is also located in North Pole. This refinery has a capacity of 22,000 barrels per day, producing kerosene, diesel, and jet fuels. The refinery uses both crude oil and non-condensable gases to fuel its crude oil refining process. (IIC 2009)

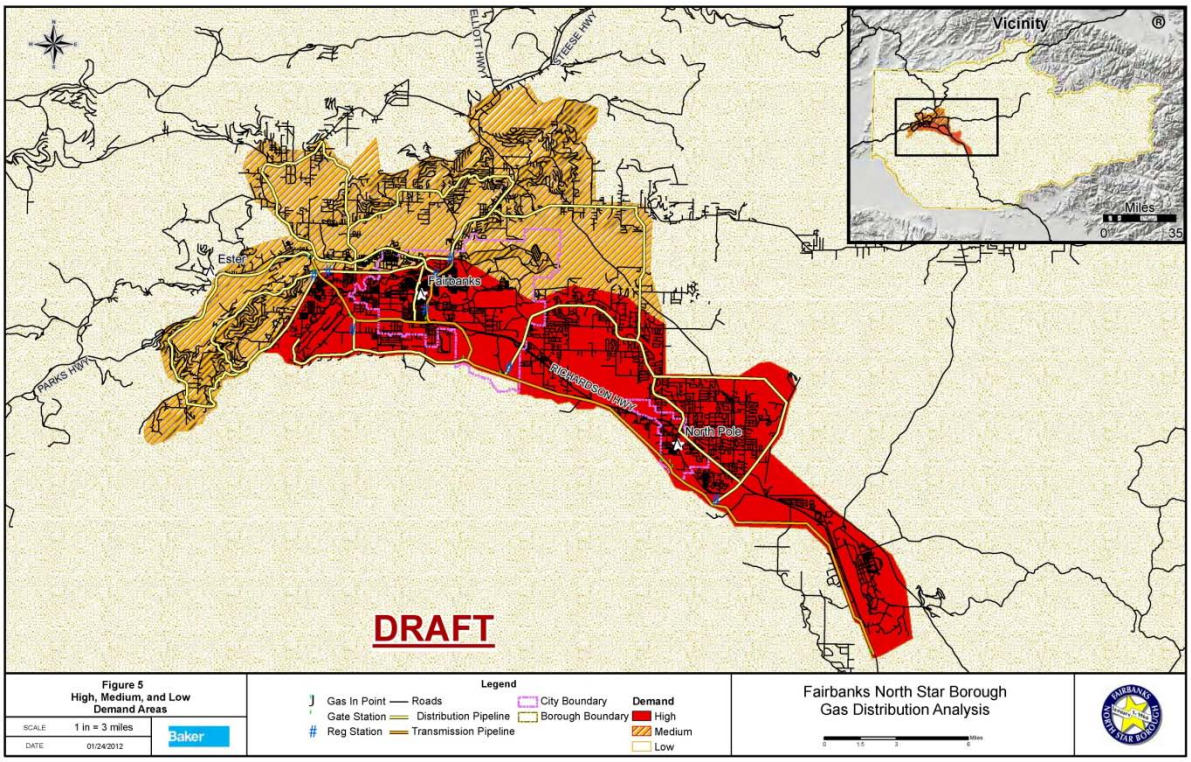
Both refineries are expected to switch to use of natural gas to meet their process needs. It is estimated that the two refineries will require a total of 4.8 Bcf of natural gas per year or 13.2 MMcfd for their processing needs.

In summary, the total industrial sector load is estimated to amount to 10.4 Bcf per year or 28.5 MMcfd, that is 2.7 (space heating) + 2.9 (power generation) + 4.8 (refinery processing)

2.4 Low, Medium, High Demand Borough Areas

Figure 5 displays three types of demand zones within the FNSB. The high demand areas are noted with red cross-hatch, the medium demand is noted with blue diagonal lines, and the low demand areas are noted with grey diagonal lines. The high demand area is assumed to be built out in one to five years. The medium demand area is assumed to be built out within 6 to 10 years, and the low demand area is assumed to be served by propane or compressed natural gas for the foreseeable future.

Figure 5. Map of Fairbanks North Star Borough with Three Zones of Demand



Source: Michael Baker, Jr. Inc, adapted from FNSB GIS Maps

3 Conceptual Design

Project team engineers used demand estimates to prepare a conceptual pipeline design, for the primary and discontiguous zones identified in the prior report section.

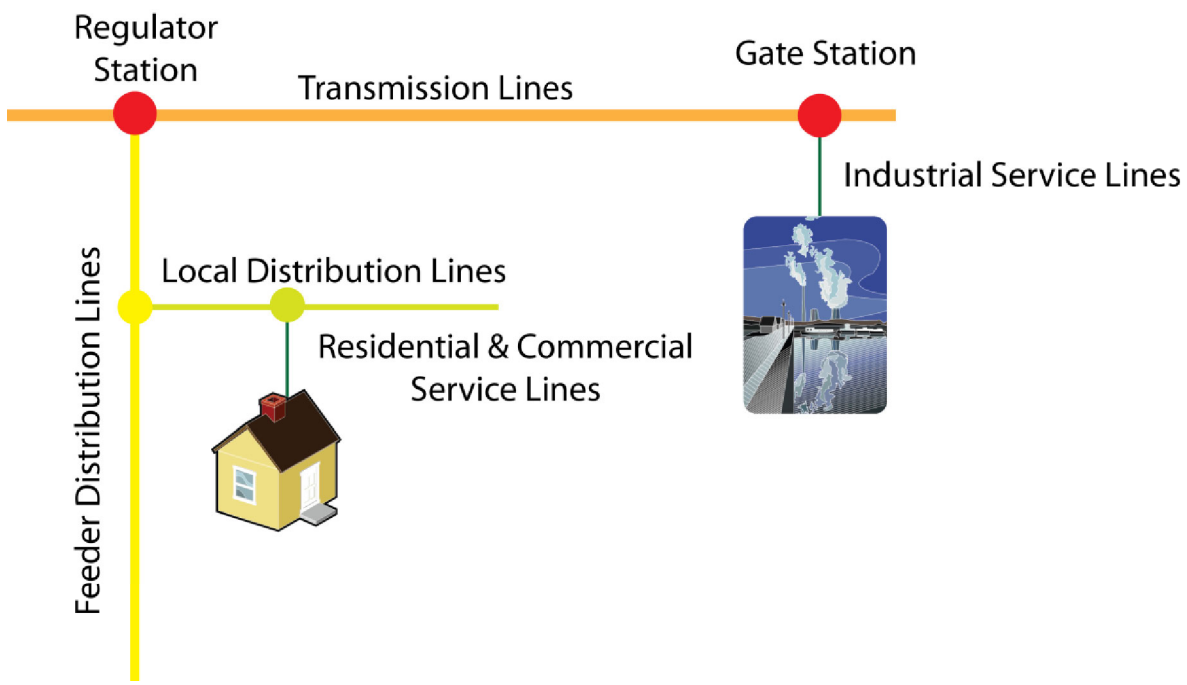
3.1 Pipeline Layout

The piped natural gas distribution system concept layout provides service to the high and medium demand locations, which includes residential, commercial, and industrial users. The system is laid out assuming it will tie into the existing FNG distribution system. The concept system consists of:

- Transmission lines providing natural gas to feeder distribution lines and industrial users
- Feeder distribution lines providing natural gas to local distribution lines
- Local distribution lines providing natural gas to service lines
- Service lines providing natural gas to individual residential and commercial user service connections
- Pressure regulating stations which drop the high pressure of the transmission lines to lower service line pressure

A schematic characterizing the relationship between the different types of lines is shown in Figure 6.

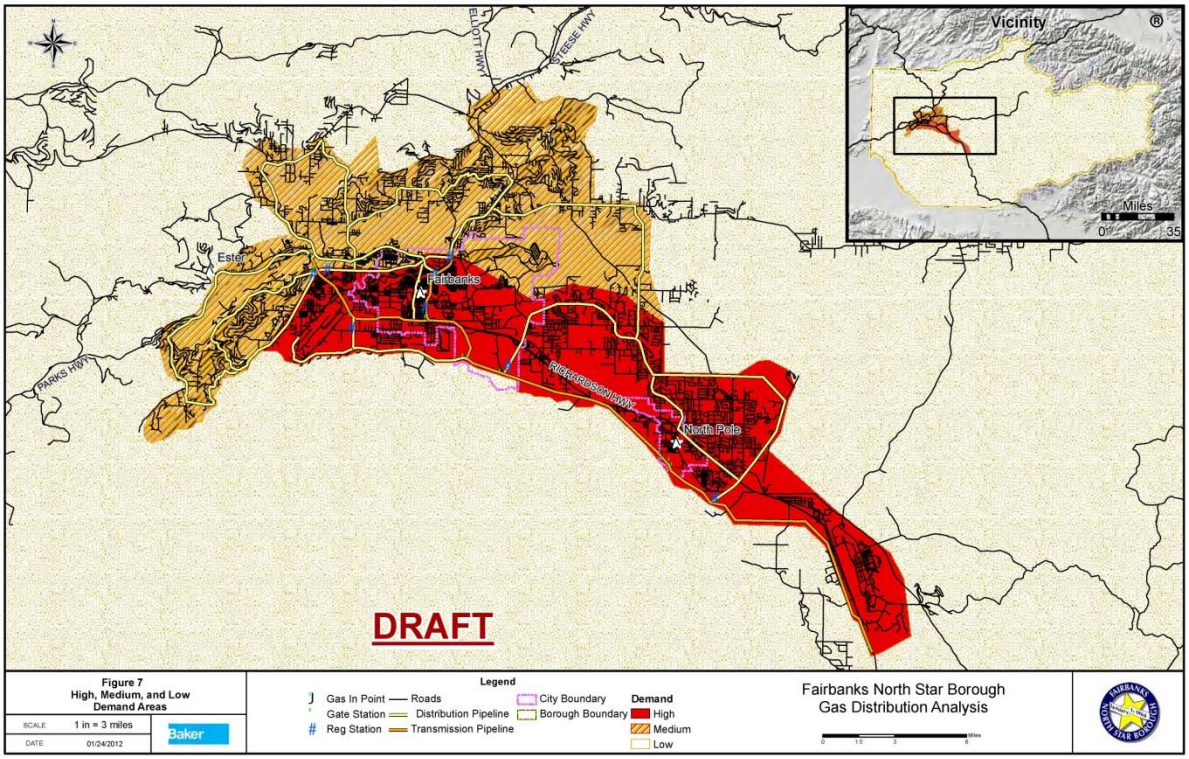
Figure 6 Schematic Pipe Relationship



Source: Michael Baker, Jr. Inc.

The concept natural gas distribution system layout is shown in Figure 7.

Figure 7 Conceptual Distribution System Layout



Source: Michael Baker, Jr. Inc.

Transmission Lines. The system includes two transmission lines. One line starts at an assumed tie-in point located west of Fairbanks near the intersection of the Parks Highway and Geist Road. The line runs southeast along the Parks Highway to the Mitchell Expressway, where it turns to the east until intersecting the Richardson Highway. It then runs southeast along the Richardson Highway for about two miles before veering south to Saddle Avenue. The line continues along Saddle Avenue until rejoining the Richardson Highway south of North Pole. The line ends at Eielson Air Force Base. A 10-inch diameter steel pipe with a total length of 31.9 miles is proposed. Future potential industrial users serviced by this line include University of Alaska Coal Plant, Aurora Energy Plant, Fort Wainwright, PetroStar Refinery, Flint Hills Resources Refinery, and the Golden Valley Electric Association North Pole plant.

The other transmission line consists of an 8-inch diameter steel pipe that connects with the other transmission line at the intersection of the Mitchell Expressway and the Richardson Highway. The line runs north along the Richardson Highway and continues north along the Steese Highway until terminating at the Johansen Expressway, where it connects with two feeder distribution lines. This length of this line is estimated at 3.1 miles.

Feeder Distribution Lines. The feeder distribution lines are configured to provide service to Fairbanks and the outlying areas extending to Ester, the Goldstream Valley, and North Pole. The distribution lines run along the major roadways, including Chena Ridge Loop Road, Chena Ridge Road, Sheep Creek Road, Farmers Loop Road, Chena Hot Springs Road, Nordale Road, and Badger Road. The feeder distribution system is configured as a loop system, maintaining flow from multiple directions to minimize service interruptions. Six-inch diameter plastic pipe is proposed for the feeder distribution lines. These lines are estimated to total 118.2 miles of pipe.

Local Distribution Lines. The local distribution piping provides service to individual residences and commercial users. The layout is based on the local street network. Two-inch diameter plastic pipe is proposed for the local distribution lines with an estimated 804.4 miles of pipe.

Service Lines. Service lines connect individual users to the distribution system. Residential customers will be serviced with a 5/8-inch diameter plastic line. Commercial customers will be serviced with a 1-inch diameter plastic line. The estimated total is 325.3 miles of pipe.

Pressure Regulating Stations. The system uses two types of pressure regulating stations to reduce the pressure from the transmission lines. Gate stations reduce the transmission line pressure to a user-specified pressure. Gate stations are provided for higher pressure feeder distribution lines and industrial users. Nine gate stations are proposed for the system. Regulator stations reduce the pressure from the transmission line to 60 pounds per square inch (psi) for the lower pressure distribution and service lines. Regulator stations are located where the lower pressure feeder distribution lines connect with the transmission lines. Nine regulator stations are proposed for the system.

3.2 Propane or Compressed Natural Gas (CNG) Zones

Borough areas outside of the high and medium demand zones primarily depend on fuel oil, wood, and propane. The use of propane or CNG is proposed for the low demand areas. One propane distributor noted a 50-mile operational radius for his firm in the Lower 48 states, but up to a 150-mile radius in Alaska. Propane from Fairbanks is routinely dispatched to Denali National Park, Delta Junction and north to Livengood. Compressed natural gas, if available, competes with both LNG and propane but is not generally used in the borough, though it is possible with the right infrastructure and delivery systems. (CCHRC 2009)

3.3 Initial Cost Estimate Basis

Total Installed Cost (TIC) estimates are developed with varying accuracy ranges at different stages in a project. For this project, with design at a conceptual level of 1 – 15 percent complete, the Association for the Advancement of Cost Engineering assumes an expected accuracy range of +50/-30 percent and labels it a Class 4 estimate. This initial construction cost estimate uses a factored approach. All costs are based on recent projects with similar demands. Prices have been scaled to account for differences in size, location, and constructability. Separate estimates were developed for the Phase 1, high demand locations (build-out in 1 – 5 years) and the Phase 2, medium demand locations (build-out in 6 – 10 years). It includes major materials, installed pipe, engineering, and permitting costs. Provisions for unknown costs are included in the estimate. Unknown costs account for the uncertainty due to the lack of detailed design and project development for the current level of estimate. The unknown costs are estimated at 50 percent of the installed costs for this estimate. All costs are in 2012 dollars.

The estimate is divided into four sections:

1. **Transmission Lines.** This section addresses the costs of installing the 10- and 8-inch diameter steel transmission pipe. Other costs covered in this section include cathodic protection, gate stations, and pigging equipment. All transmission lines will be installed during Phase 1 construction.
2. **Distribution Feeder Lines.** This section addresses the costs of installing the 6-inch diameter plastic distribution pipe. Regulator station costs are included in this section of the estimate. Distribution feeder lines will be installed during Phase 1 and Phase 2 construction.

3. **Local Distribution Lines.** This section addresses the cost of installing the 2-inch diameter plastic distribution pipe. Distribution lines will be installed during Phase 1 and Phase 2 construction.
4. **Service Lines.** This section addresses the costs of installing the small diameter (5/8 to 1 inch) plastic pipe. Service lines will be installed during Phase 1 and Phase 2 construction.

3.4 Preliminary Pipeline Cost Estimate

Table 8 summarizes the Class 4 Estimate for the piped gas distribution system. The total estimated costs range from $308,900,000 to $662,000,000. This estimate is based on limited information and analysis. The estimate will be updated as analysis and design development continues. A detailed Basis of Estimate and Cost Estimate are attached as Appendix A.

Table 8. Total Cost Estimate

Item	Estimated Cost Range ($)
Phase 1, High Demand Area	
Engineering, Permitting & ROW Services	8,800,000 to 18,900,000
Construction	167,100,000 to 358,200,000
Total	176,000,000 to 377,100,000
Phase 2, Medium Demand Area	
Engineering, Permitting & ROW Services	6,500,000 to 14,000,000
Construction	126,400,000 to 270,900,000
Total	132,900,000 to 284,900,000
Total Phase 1 and Phase 2	**308,900,000 to 662,000,000**

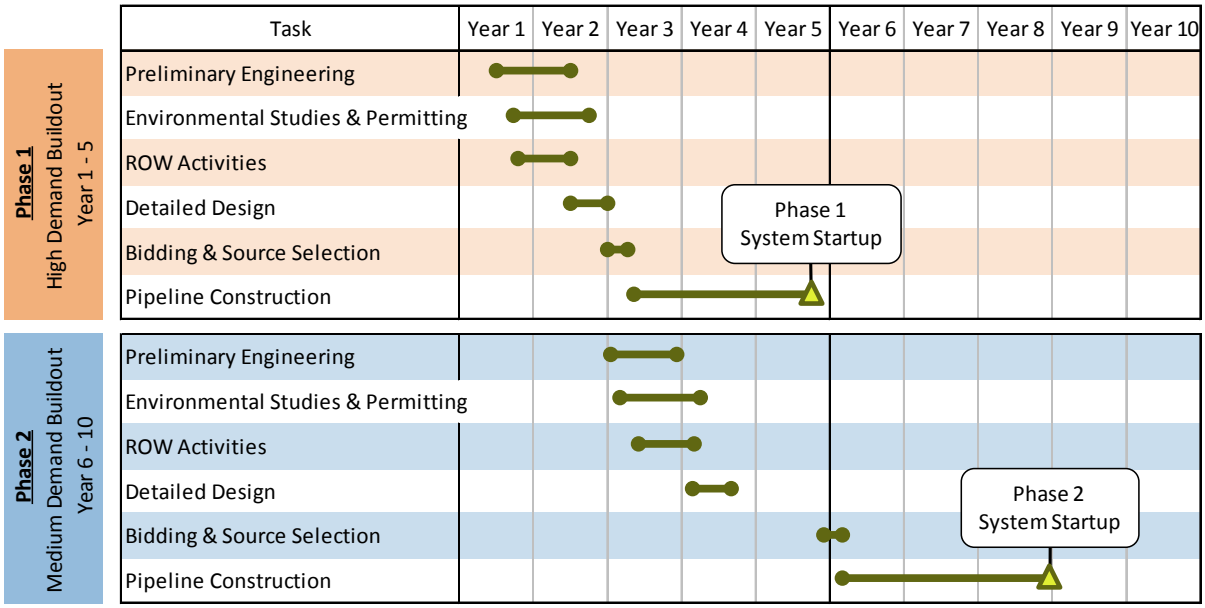
Source: Michael Baker Jr. Corporation 2012

The cost estimates presented here are based on a complete pipe delivery system. As part of the final report, alternative delivery systems will be evaluated to identify the least-cost system, one that is optimized for site-specific and area-specific plans. These will be included in the final report.

3.5 Preliminary Development Plan and Schedule

The project development plan identifies the major tasks required to build an operational piped natural gas distribution system. Tasks include engineering, environmental studies and permitting, right-of-way (ROW) acquisition, procurement, and construction. Figure 8 shows a concept development plan schedule for the project. The schedule is broken into two phases. Phase 1 addresses the high demand area, which is expected to be completed within the first five years. Phase 2 addresses the medium demand area, which is expected to be completed within the 6 to 10 year period. For both phases, preconstruction activities such as engineering, environmental studies, permitting, ROW acquisition, and procurement are planned for the first two years. Construction activities are planned for the last three years of each phase.

Figure 8 Proposed Concept Project Schedule



Source: Michael Baker Jr. Corporation 2012

A description of activities that occur during each major task is provided below.

Preliminary Engineering. Activities under this task will include existing data collection, concept pipeline layout and engineering field reconnaissance. The pipe network will be modeled to determine the size of pipe needed. Field surveys and utility locates will be accomplished to support detailed design. The preliminary engineering task is expected to last approximately one year.

Environmental Studies and Permitting. Construction and operation of the gas distribution lines in the FNSB may require federal, state, and local permits. If federal permits are required, completion of the National Environmental Policy Act (NEPA) process and formal public and agency scoping may be necessary. Wetland, raptor, fisheries, and cultural resources studies may be required if information does not exist on the project area of potential effect. These studies must be conducted during the growing season. This task is expected to last approximately one year.

ROW Activities. This task will include surveying and mapping existing property boundaries and then identifying land status and ownership. Land ownership must be determined prior to finalizing the list of necessary ROW permits. Temporary land use permits from federal and state land owners may be required for staging and temporary construction areas. ROW permits, easements, or acquisition efforts will then be completed. This task is expected to last approximately nine months; it could take longer depending on the complexity of any required ROW acquisition.

Detailed Design. Detailed design will include finalizing the pipe layout, sizes and associated infrastructure. Because of the long lead time required for fabrication, pipe and major equipment will be ordered when this task is approximately 70 percent complete. The detailed design task is expected to last approximately six months.

Bidding and Source Selection. Once the design is finalized, the project will be advertised for bid and a contractor selected. This task is expected to last approximately three months.

Pipe Distribution System Construction. Construction will begin when the required permits are in place, ROW activities are complete, and a contractor has been selected. Construction is expected to last three years.

4 Business Models

The business organization for the FNSB Natural Gas Distribution System will be determined in large part by the balance point between the ability to obtain project financing at a reasonable cost and local control of decisions, along with market acceptance. Some of the criteria that can be used to characterize this balance point include:

1. The capacity and cost-effectiveness of the business organization to raise capital or assume debt sufficient to cover project requirements. For example, the State of Alaska has a large capacity to assume debt through general obligation bonds or other bonding mechanisms. Private corporations have the capacity to raise capital for project financing by selling equity or stock in the company.
2. The amount of input and control that local ratepayers have on business decisions. In the case of a ratepayer owned cooperative such as Golden Valley Electric Association, the ratepayers own the business and control decisions through a board of directors. For a private utility corporation, ratepayers are represented through the Regulatory Commission of Alaska (RCA).
3. The capacity of the business organization to sustainably manage all aspects of the natural gas distribution infrastructure including operations and maintenance of the system as well as maintaining legal and financial capacity to negotiate and implement future improvements or expansions to the system.
4. The transparency and stability of the governance structure. Level of transparency on how decisions are made and how rate-payers are included in the process. Stability of organization to meet long term obligations and ability to re-organize or transfer authority if organization fails.

In addition to these characteristics, there are other factors that will determine key variables for the size, timing, and capacity of the system. These include:

1. How much and how quickly do energy costs in FNSB need to be reduced to achieve the economic development goals set by the community? The energy cost reduction and associated economic development will determine the size and timing of the benefit of State or other investment in the system.
2. It is preferred to have the natural gas system be located inside the boundaries of the City of Fairbanks so that municipal utility ownership is feasible or is a borough-wide system preferable?
3. What is the preferred balance between employing local labor to construct, operate, and maintain the natural gas system and implementing an operating agreement?

A summary of some of the characteristics that could be used to describe the balance point between local control and financing capacity are listed in the table below. The table includes some examples of the maximum or minimum level as applicable to the FNSB natural gas distribution project. Some example comments based on preliminary project specifications are included in Table 9.

Table 9. Business Strategy Characteristics for FNSB Natural Gas Distribution Project

Characteristic	Maximum	Minimum	*FNSB Project Strategy Example*
Financial Characteristics			
Capacity to raise capital or take-on debt (sufficient for project plan)	State of Alaska Large Private Corporation	Public cooperative	*Capacity to raise $310 to $662 million.*
Cost of capital	Access to lower interest rate on debt A/A long term credit rating	Higher Interest rates ABB-/Baa3 long term credit rating	*Should have good long term credit rating with potential backing from State and monthly billing revenue*
Cost-effectiveness of raising capital.	Large Private Corporation – can use debt or equity.	Public cooperative entity – debt decision can require public approval.	*Ability to raise new capital easily and at lower cost. Can fund future expansion and improvements.*
Organizational Characteristics			
Level of Local Control	Ratepayer ownership	Private ownership with regulatory oversight.	*More ratepayer ownership than other ownership.*
Systems operations and management	In-house (Large Private Gas Utility)	Operating Agreement	*Operating agreement with contractor that has the capacity to handle short construction season, specialized expertise required to successfully work in FNSB. Include local labor preference clause?*
Transparency of Governance	Public cooperative – volunteer board	Large Private Gas Utility with regulatory oversight.	*Governance with most transparency to ratepayers.*
Stability of organization	Ratepayer ownership	Private ownership with regulatory oversight.	*Organization that qualifies for long-term (40 year) debt obligations.*

Source: Alaska Energy Board.

5 Financial Analysis, Cost of Service

After market demand and conceptual costs are finalized, the potential (pro forma) costs of service and projected financial performance can be more closely approximated.

This section provides estimates of conversion costs and the projected financial statements for a natural gas distribution firm with total assets estimated between $100 million to $250 million, the largest natural gas distribution system category published by the Risk Management Association (RMA).

5.1 Preliminary Distribution Costs

It is too soon to develop preliminary distribution costs but, as a comparable, FNG states current costs of $2.335 per hundred cubic feet ($23.35 per thousand cubic feet [Mcf]), a customer cost that includes cost of service (and transportation) costs. As the project evolves, the number of miles of pipeline and the prospective connections per segment length will generate preliminary distribution costs.

5.2 Initial Residential, Commercial Conversion Costs

Table 10 shows three sets of cost estimates for residential conversion to gas. The estimates vary considerably, depending on the extent of the conversion. At the low end, Fairbanks Natural Gas (2005) gives a conversion cost of $1,000–$1,500 to replace an oil-fired gun with a gas-fired gun. At the high end, Laabs (2012) provided cost estimates for a complete replacement, reaching upwards of $12,000–$20,000 for a boiler replacement, chimney upgrade (or replacement) and other connections.

Table 10. Cost Estimates for Residential Conversion to Natural Gas

Source	Notes	Cost Estimate ($)
Fuhs (2010)	Space heater with flush mount exhaust, on-demand hot water heater, and 250 gallon buried tanks – to be refilled about once per month, depending on season	3,000
Fairbanks Natural Gas (2005)	Replacement of gun, residential	1,000–1,500
Laabs (2012)	Furnace replacement, mobile home	6,000–8,000
	Chimney replacement (if needed), mobile home	500–700
	Furnace replacement, residential	8,000–15,000
	Chimney replacement (if needed), residential	2,500–5,000
	Boiler replacement or conversion from oil to gas, residential	12,000–20,000
	Burner conversion with boiler brushed out, residential	3,500–6,500

Source: Northern Economics, from sources noted.

The cost for converting commercial systems is still under investigation, but given the number of commercial facilities that are now heating with gas, the conversion costs must not be an obstacle to using natural gas even at current natural gas prices.

5.3 Pro Forma Financial Statements

The following sections present a standardized balance sheet and income statement, based on financial data collected by RMA (2011) for natural gas distribution utilities with total assets of

$100 to $250 million. This information will be added for the proposed utility once the final cost and organizational structure are determined.

5.3.1 Balance Sheet

The estimated asset base, along with likely forms of financing (long term), will provide the basis for forecasting financial outcomes, especially the income or profit and loss statement. RCA reporting requirements use a Federal Energy Regulatory Commission model, as submitted by several natural gas utilities, include FNG.

A standardized balance sheet is presented in Table 11, based on data collected by RMA (2011). The balance sheet is based on 27 natural gas distribution companies with assets between $100 and $250 million, which is the largest asset class reported. Note that while the estimated cost for the proposed system exceeds this range, the RMA data is based on net assets, after depreciation. The average total asset value for the companies shown was $162.3 million. The average debt-to-equity ratio is 1.25, reflecting that debt for these companies is currently more than half of their assets.

Once the proposed project is farther along in its development process, it will be possible to determine the likely debt-to-equity ratio based on its total cost, organizational structure, and access to bond and equity capital.

Table 11. Standardized Balance Sheet, Utilities–Natural Gas Distribution, Asset Range $100-$250 Million

Account	Percent of Assets	Standardized Amount ($)
Assets		
Cash & equivalents	6.7	10,873,261
Trade receivables (net)	10.2	16,553,323
Inventory	6.3	10,224,111
All other current	4.6	7,465,224
Total current	27.8	45,115,920
Fixed assets, net	62.4	101,267,388
Intangibles, net	2.7	4,381,762
All other non-current	7.1	11,522,411
Total Assets	**100.0**	**162,287,481**
Liabilities		
Notes payable, short term	4.3	6,978,362
Cur Mat LTD	1.9	3,083,462
Trade payables	9.5	15,417,311
Income taxes payable	0.5	811,437
All other current	6.0	9,737,249
Total current	22.1	35,865,533
Long term debt	21.8	35,378,671
Deferred taxes	4.5	7,302,937
All other non-current	7.0	11,360,124
Total liabilities	**55.5**	**90,069,552**
Net Worth		
Net worth	**44.5**	**72,217,929**

Source: RMA (2011)

5.3.2 Income Statement

Initial revenue estimates will be based on FNG experienced ratios of Sales to Total Assets, along with time-based build-out plans. This information will be determined once a final cost estimate and organizational structure is determined for this project.

Standardized income statement data from RMA (2011) is shown in Table 12, again based on companies with the average total assets stated. On average total assets of $162.3 million, the average sales were $256.2 million, or $1.58 per dollar of total net assets. Operating expenses were 86.2 percent of sales, leading to an operating profit of 13.8 percent. The profit before taxes was 10.3 percent, about $0.16 per dollar of total net assets.

Table 12. Standardized Income Statement, Utilities–Natural Gas Distribution, Asset Range $100-$250 Million

Account	Percent of Sales	Standardized Amount ($)
Net sales	100.0	256,208,185
Operating expenses	86.2	220,851,456
Operating profit	13.8	35,356,730
All other expenses	3.5	8,967,286
Profit before taxes	10.3	26,389,443

Source: RMA (2011)

6 Air Quality

Conversion of heating system fuels such as wood, oil, and coal to natural gas will reduce the emissions of criteria air pollutants in the Fairbanks area. Criteria pollutants are regulated pollutants under the Clean Air Act, and include oxides of nitrogen (NOX), carbon monoxide (CO), particulate matter smaller than 10 microns in diameter (PM10), particulate matter smaller than 2.5 microns in diameter (PM2.5), sulfur dioxide (SO2), and volatile organic compounds (VOC).

A preliminary analysis has been prepared to estimate the annual amount of criteria pollutants from the heating systems for existing residential and commercial buildings in the FNSB. Table 13 provides a summary of the estimated current emissions from these sources, distributed between the high, medium, and low demand areas as described in Section 2.4. Note that the high and medium demand zones together approximate the area designated as the PM2.5 non-attainment area.

The residential emissions estimates were prepared using data from the 2010 Fairbanks Home Heating Survey report, prepared by Sierra Research for the Alaska Department of Environmental Conservation. This survey estimated the number of residential heating devices, types of fuel used, and amount of fuel used in the PM2.5 non-attainment area. The proportion of each fuel type was calculated, and the ratios applied to the estimated demand discussed in Section 2.

Annual emissions were calculated using an EPA reference document, Compilation of Air Pollutant Emission Factors. (EPA 2012a). The same method was used to calculate the emission estimates for the commercial sources, except the fuel type use data were provided by Tom Carlson of Sierra Research. (Sierra Research 2010) This calculation method assumes that the fuel use ratio is the same in the high, medium, and low demand zones.

Additional review, refinement, and quality control of all data used to calculate these emission estimates will occur as the feasibility study proceeds.

Table 13. Summary of Existing Emission Estimates in the FNSB, by Zone

Zone	Category	NO_X (tpy)	CO (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	SO_2 (tpy)	VOC (tpy)
High	Residential	293	263	234	205	175	146
	Commercial	242	225	208	191	174	158
	Total	535	488	442	396	350	303
Medium	Residential	201	6,364	785	674	229	5,032
	Commercial	43	22	7	7	67	1
	Total	244	6,386	792	681	296	5,033
Low	Residential	75	2,390	295	253	86	1,890
	Commercial	15	7	2	2	23	0
	Total	90	2,397	297	256	109	1,890
Overall	Residential	569	9,017	1,313	1,132	491	7,067
	Commercial	300	254	218	200	264	159
	Total	**869**	**9,271**	**1,531**	**1,332**	**754**	**7,226**

Source: SLR International Corp 2012
Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

6.1 Non-attainment Area

Particulate matter is a pollutant of special concern in the Fairbanks area. Exceedances of the ambient air quality standard for PM2.5 have been measured in Fairbanks. As a result, EPA has designated portions of the Fairbanks and North Pole areas as a non-attainment area for PM2.5. This non-attainment area is portrayed in Figure 2. Because of the very small size of the particle, PM2.5 can reach deeply into human respiratory systems and cause or aggravate serious health problems, including asthma, bronchitis, and heart attacks. (EPA 2012b)

The non-attainment designation for the Fairbanks area is a cause for concern for several reasons. First, the local population is at increased risk for respiratory and circulatory health problems. Secondly, the designation negatively affects economic growth in the area. Air quality permits for any commercial or industrial activity cannot be obtained if the activity will increase the amount of PM2.5 emissions over current amounts. Because of this restriction, growth of existing commercial and industrial activity will likely not occur, and new commercial and industrial activities will likely not take root in the Fairbanks area until EPA is satisfied that compliance with the ambient PM2.5 standard is attained and a plan is in place to maintain compliance with the ambient standard.

Natural gas conversion in Fairbanks will reduce the emissions of PM2.5 from residential and commercial facilities. The conversion to natural gas will also reduce NOX and SO2 emissions, which are precursors to the formation of secondary PM2.5 in the atmosphere. The reduction will help bring the Fairbanks area into attainment with the ambient PM2.5 air quality standard. The reduction in emissions is discussed further in section 6.2.

6.2 Potential Impacts, Conversion to Natural Gas

The FNSB and its advisory group reviewed the initial (conceptual) capital costs for the full 10-year project, leading the project team to focus conversion impacts on the first five years, the area with the most potential to reduce production and emission of PM2.5 particles. As final project design is completed, the team will revisit the proposed conversion area and add to it as deemed appropriate.

An analysis has been prepared to estimate the change in emissions resulting from conversion of the high demand zone to natural gas over a period of five years. The analysis assumes that residences will convert at a rate of 19 percent each year, for a total conversion rate of 95 percent after five years. The analysis assumes that commercial facilities will convert at a rate of 20 percent each year, for a total conversion rate of 100 percent after five years. The calculations assume that the rate of conversion for each original fuel type is the same and that none of the current structures are heating with natural gas. These assumptions will also be revisited as more precise and accurate information is developed. For this report, results of the analysis are shown in Table 14.

Table 14. Estimated Annual Emissions (tpy) After Conversion in the High Demand Zone, 5-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5
NO_X	Residential	293	263	234	205	175	146
	Commercial	242	225	208	191	174	158
	Total	535	488	442	396	350	303
CO	Residential	9,289	7,535	5,782	4,028	2,274	520
	Commercial	121	123	125	128	130	132
	Total	9,410	7,658	5,907	4,156	2,404	653
PM_{10}	Residential	1,145	930	714	499	283	68
	Commercial	41	35	29	23	18	12
	Total	1,186	965	743	522	301	80
$PM_{2.5}$	Residential	984	799	614	429	244	59
	Commercial	37	32	27	22	17	12
	Total	1,021	831	641	451	261	71
SO_2	Residential	335	271	208	144	81	18
	Commercial	372	298	223	149	75	1
	Total	707	569	431	294	156	19
VOC	Residential	7,344	5,950	4,556	3,163	1,769	375
	Commercial	6	7	7	8	8	9
	Total	7,351	5,957	4,564	3,170	1,777	384

Source: SLR International Corp 2012
Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 15 provides the overall estimated percentage change in emissions for the residential and commercial facilities in the high demand zone. The increases in CO and VOC emissions in the commercial sector are caused by the increased combustion of natural gas.

Table 15. Change in Emissions Due to Conversion in the High Demand Zone

Category	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
	(%)					
Residential	-50	-94	-94	-94	-95	-95
Commercial	-35	9	-71	-69	-100	37
Total	-43	-93	-93	-93	-97	-95

Source: SLR International Corp 2012

Table 16 demonstrates that conversion of residential heating systems from wood-fired to natural gas-fired has a greater effect on emissions reductions of all pollutants except NOX and SO2. The emissions of these two pollutants are reduced more effectively by conversion of oil-fueled systems to natural gas.

Table 16. Contribution to Emission Reductions, By Fuel Type, for Residences in the High Demand Zone

Fuel Type	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
	(%)					
Wood	29	87	96	96	4	99
Oil	58	0	1	2	86	0
Coal	14	13	2	2	10	1

Source: SLR International Corp 2012

Note: Percent reductions for each pollutant may not total 100 percent due to rounding.

7 References

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Appendix: Basis of Cost Estimation (Michael Baker, Jr. Inc.)

BASIS OF ESTIMATE

FNSB Natural Gas
Preliminary Cost Estimate

February 6, 2012

Michael Baker Jr., Inc.
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Rev.	Date	Comments	Prepared by:	Checked by:	Approved by:
0	1/24/12	Draft	KMJ	WJO	DMC
1	2/6/12	FNSB Review	KMJ	WJO	DMC

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INTRODUCTION

Total Installed Cost (TIC) estimates are developed for a number of reasons including: assessment of commercial opportunities, concept evaluation, and negotiations with third parties. Estimates are a key input to economic analysis to aid decision making at Capital stage gates and are developed throughout the project lifecycle. Estimates are prepared in Today's Money (present costs) and later, if required, escalated to Money-of-the-Day (future costs). Estimates encompass the complete scope of work for a project. The Association for the Advancement of Cost Engineering (AACE) classifies estimates by their accuracy and level of detail. For a project where design is 1-15% complete, for example a concept study or to evaluate feasibility, an expected accuracy range of +50/-30% is assumed, this is defined as a Class 4 estimate.

The project team members that contributed to the estimate development are shown below.

PROJECT ESTIMATE TEAM LOG			
Name	**Position/Role**	**Affiliation**	**Contact Info**
Derek Christianson, P.E.	PM	MBJ	273-1629
Bill Olzack, P.E.	Estimator QA	MBJ	273-1625
Vin Robinson, P.E.	Estimator	Enstar	230-4464
RaeAnne Hebnes, P.E.	CE/Design	MBJ	273-1618
Katie Johnson	EIT	MBJ	273-1621

PROJECT SCOPE

The purpose of this project is to define a supply-neutral optimized plan for the rapid build-out of the Fairbanks North Star Borough (FNSB) energy distribution infrastructure; one that delivers propane or natural gas by Liquefied Natural Gas (LNG) or pipeline, as affordably as possible, to the largest number of Borough residents and business properties. This cost estimate reports on the estimated cost of the construction of distribution and transmission lines to residential and commercial users within the vicinity of Fairbanks, Fort Wainwright, North Pole, and Eielson.

METHODOLOGY

At the time of estimate detailed design was not available. The pipeline construction estimate uses a factored approach for all aspects. All costs are based on recent projects with similar demands. Prices have been scaled to account for differences in size, location and constructability (e.g. presence of permafrost). Costs were split by construction phases, phase I areas of high (over 500 people/sq mile) and phase II in medium (100-500 people/sq mile) population densities.

COST BASIS

The Project Estimator uses the project work breakdown structure, material take-offs, labor productivity rates, price data, other unit rates, and factors to build spreadsheets to calculate the TIC estimate.

The following summarizes the various rates this estimate uses to calculate costs for the estimate.

Construction costs:

Pipe diameter [in]	Installed Cost	unit	Quantity High density	Quantity Medium density
10	$ 90	LF	168,494	0
8	$ 90	LF	16,149	0
6	$ 50	LF	275,435	348,820
2	$ 25	LF	2,190,664	2,250,976
1	$ 25	LF	57,075	16,300
0.625	$ 25	LF	934,950	861,000
HDD	$ 2,100	LF	3,200	0
Cathodic protection	$ 15,000	mile	35	0
Gate station	$ 1,250,000	each	9	0
Regulation station	$ 400,000	each	9	0
Pigging connection	$ 50,000	each	4	0

1. Bare steel pipe material priced at $2000/ton. High Frequency Induction (HFI) Welded material. Freight is included to Fairbanks.
2. FBE coating of steel pipe is estimated at $1.69/inch diameter, adjusted from Flowline Alaska quotation.
3. HDD costs assume 130 foot bank to bank length with 800 total length at each crossing, pilot hole with 1 reaming pass, four total crossings. Mobilization/demobilization is included in unit cost of $2,100/LF.
4. Cathodic protection is included for all steel pipe.
5. Gate stations are needed to house purchase meters for gas measurement and to reduce line pressures between the transmission line and a delivery line. Their cost is assumed to be $1,250,000 each.
6. Regulator stations are needed to reduce transmission line pressures to local distribution pressures (60psig). Their cost is estimated at $400,000 each.

Material costs:

Direct material costs		
Pipe diameter [in]	Pipe [$/LF]	Valves [$/Each]
10- steel	$ 53	$ 34,000
8- steel	$ 44	$ 20,000
6-plastic	$ 12	$ 13,300
2-plastic	$ 6	$ 6,200
1-plastic	$ 5	$ 500
0.625-plastic	$ 5	$ 500

1. Freight for pipe is included in the material cost
2. Pigging barrels are mobile 12-inch diameter, skid mounted and can be connected to 10 and 8-inch pipe. Unit cost of $300,000 for both a launcher and receiver.
3. Supplier Quality Surveillance (SQS) are tests to ensure quality materials are provided and used for the project. They are assessed at 2% of the material (valve and pipe) costs.
4. Procurement costs are assumed to be 4% of material costs.

Other costs:

1. Engineering is assumed to be 5% of pipeline construction cost.
2. Engineering for launcher/receive is assumed to be 30% of launcher/receiver construction cost.
3. Permitting based on current scope and region as compared to recent projects, estimated cost is $300,000 for phase I and $200,000 for phase II.

ALLOWANCES

A material allowance is included to account for items not identified by current level of design. These account for design modifications from the date of estimation to construction. Miscellaneous freight is applied to the material allowance. The costs below are part of the estimate allowances, and are included at the percentages shown.

Material allowances	
	Cost (relative to total cost of pipe & valves)
Materials- Design allowance	5%
Materials- Misc. Freight	2%

ASSUMPTIONS & DESCRIPTION OF WORK

The following are the assumptions that were applied to the pipeline, Launcher/Receiver, Gate and regulator stations, engineering and procurement estimates:

1. Adequate labor supply and life support (e.g., camp space, beds, transportation, etc.).
2. Contractor per diem is not included in the estimate.
3. Adequate funding available for this project.
4. All costs are based on 2012 dollars.
5. All materials and equipment will be on construction site as scheduled.
6. Estimated costs are based on factored costs from prior construction activities
7. Contractor markup and profit is included in factored price per linear foot for installation.
8. Weather delay costs are not included.
9. Engineering, procurement, and SQS based on percentages provided above.
10. Owner/operator will be responsible for procuring the major materials (valves, pipe).
11. Isolation valves required at each residence/commercial building and every 8 miles of transmission or distribution pipe.
12. Transmission lines shall be steel, distribution and service lines shall be plastic (PEX or HDPE).
13. Only 8 & 10 inch transmission lines shall be piggable.
14. 75 linear feet is assumed to be needed to tie houses/businesses to street level mainlines in areas of high population density. 100 linear feet is assumed to be needed in areas of medium population density. Areas of low population density have not been included.
15. For HDD it is assumed only for transmission and major distribution pipes crossing the Chena River

The following are the assumptions that were applied to the permitting and regulatory estimates:

1. NEPA report may not be required but is included in the anticipated permitting costs.
2. Field data is believed to exist in the project area. Therefore field study costs are not included in the estimate.

DESCRIPTION OF WORK

The following is the description of work tasks for the FNSB Natural gas study. Installation is planned for summer construction starting May 1 and ending September 30. Installation has been broken out into two phases of construction; phase I within 0-4 years centered in the high population density areas (over 500 people/sq mile), and phase II within 4-8 years centered in the medium population density areas (100-500 people/sq mile). Activities have been identified as being part of phase I, phase II construction, or both. Details on quantity can be found in estimate document.

- Transmission lines- installation of 10-inch steel transmission line from supply tie-in to Eielson and 8-inch line along Steese Highway terminating at the Johansen expressway all activities will occur in phase I and include:
    - Trenching and installation of 10" pipe
    - Trenching and installation of 8" pipe
    - Installation of isolation valves
    - Installation of gate stations for supply to industrial users (9)
    - HDD crossings of Chena River (2)
    - Connection to existing FNG lines as appropriate
    - Installation of connections for pigging (4)
    - Fabrication of mobile pig launcher and receiver (1 each)
    - Surface rehabilitation after construction (paving, seeding, etc)
- Installation of the primary feeder distribution lines (4 to 8-inch diameter) including:
    - Trenching and installation of linear feet of 6-inch pipe (phase I & II)
    - Installation of isolation valves (phase I & II)
    - Connection to existing FNG lines as appropriate (phase I)
    - Regulation stations for supply to domestic users (phase I)
    - HDD crossings of Chena River (phase I)
    - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)
- Installation of 2-inch diameter distribution lines along residential roads including:
    - Trenching and installation of 2-inch pipe (phase I & II)
    - Installation of isolation valves (phase I & II)
    - Connection to existing FNG lines as appropriate (phase I)
    - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)
- Installation of service lines to residential and commercial users including:
    - Trenching and installation of 1-inch pipe for commercial users (phase I & II)
    - Trenching and installation of 5/8-inch pipe for residential users (phase I & II)
    - Installation of isolation valves (phase I & II)
    - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)

UNKNOWN COSTS

The Unknown Costs (UC) calculation is used to cover the uncertainty and variability associated with a cost estimate, as well as unforeseeable elements of cost within the defined project scope. The unknown costs cover field uncertainties, inadequacies in complete project scope definition, estimating methods, and estimating data. Unknown costs specifically excludes changes in project

scope, and unforeseen major events such as earthquakes, prolonged labor strikes, failed HDD, weather delays, etc. The amount of UC is based on the AACE estimate class 4.

The UC level used for these estimates is +50%.

QUALITY ASSURANCE

The Baker estimate Quality Assurance lead, in consultation with the Baker Project Estimating Team members, will review the estimate to verify that it employs the appropriate, methodologies, assumptions and exclusions, appropriate rates and factors and addresses the entire project scope and nothing beyond the approved scope.

If the estimate is reasonable and adequately addresses the project scope and requirements, the Baker QA lead communicates acceptance of the estimate to the Baker Cost Estimating Function Lead/Project Manager. If the estimate is insufficient or the exclusions are not acceptable, the Baker Chief Engineer communicates the need to correct or improve the estimates to the Baker Cost Estimating Function Lead/Project Manager.

All reviews of the estimate, as well as all the review participants are documented below in the "Project Estimate Review Log".

PROJECT ESTIMATE REVIEW LOG			
Estimate Reviewed by	**Position/Role**	**Affiliation**	**Date**
Bill Olzack	QA	MBJ	1/24/12
Cory Wilder	QA	MBJ	1/24/12

REFERENCES & ATTACHMENTS

Many documents will be collected and referenced during the development of the estimate. Since these documents ultimately form the basis for the resulting estimated cost, the basis of estimate should contain a record of each of these documents. All project plans, technical documents, and drawings should be itemized and accurately described in the appropriate section of the basis of estimate.

The "Project References and Attachments Log" below includes all major documents associated with the estimate including, but not limited to: any design drawings or technical documents (e.g. P&IDs, Isometrics, etc.), project review meeting minutes, copies of important correspondences, etc.

PROJECT REFERENCES & ATTACHMENTS LOG	
Document Title or Description	**Date Issued**

Figure XXX Proposed Pipeline Layout	1/24/2012
Figure XXX High, Medium, and Low Demand Areas	1/24/2012

Summary	Total qty [LF]	Length (miles)	Construction cost	Materials	Engineering	Permitting	Total cost	Cost/foot	Cost/mile
High Demand Area									
Pipelines									
Transmission lines	*184,644*	*35*	*$ 29,232,000*	*$ 11,122,000*	*$ 2,018,000*	*$ 17,000*	*$ 42,389,000*	*$ 230*	*$ 1,212,000*
Distribution feeder lines	*275,435*	*52*	*$ 17,852,000*	*$ 3,840,000*	*$ 1,085,000*	*$ 25,000*	*$ 22,802,000*	*$ 83*	*$ 437,000*
Distribution lines	*1,996,112*	*378*	*$ 49,903,000*	*$ 13,631,000*	*$ 3,177,000*	*$ 182,000*	*$ 66,893,000*	*$ 34*	*$ 177,000*
Service lines	*840,091*	*159*	*$ 21,002,000*	*$ 11,989,000*	*$ 1,650,000*	*$ 76,000*	*$ 34,717,000*	*$ 41*	*$ 218,000*
Pig Launcher and Receiver				$ 600,000	$ 180,000		*$ 780,000*		
Unknown Costs							*$ 83,791,000*		
Subtotal	3,296,281	624	117,989,000	41,182,000	8,110,000	300,000	$ 251,372,000	$ 76	$ 403,000
Subtotal Cost Range (-30% to +50%)							**$176,000,000**	**$377,100,000**	
Medium Demand Area									
Pipelines									
Distribution feeder lines	*348,820*	*66*	*$ 17,441,000*	*$ 4,865,000*	*$ 1,115,000*	*$ 20,000*	*$ 23,441,000*	*$ 67*	*$ 355,000*
Distribution lines	*2,250,976*	*426*	*$ 56,274,000*	*$ 10,070,000*	*$ 3,317,000*	*$ 130,000*	*$ 69,791,000*	*$ 31*	*$ 164,000*
Service lines	*877,300*	*166*	*$ 21,933,000*	*$ 9,812,000*	*$ 1,587,000*	*$ 50,000*	*$ 33,382,000*	*$ 38*	*$ 201,000*
Unknown Costs							*$ 63,307,000*		
Subtotal	3,477,096	659	95,648,000	24,747,000	6,019,000	200,000	$ 189,921,000	$ 55	$ 288,000
Subtotal Cost Range (-30% to +50%)							**$132,900,000**	**$284,900,000**	
Combined High and Medium Demand Areas									
Total	6,773,377	1,283	213,637,000	65,929,000	14,129,000		$ 441,293,000	$ 65	$ 344,000
Combined Total Cost Range (-30% to +50%)							**$308,900,000**	**$661,900,000**	

Transmission lines- high pressure to commercial customers stepped down to residential users via regulation stations

Description	Class	Dia [in]	Quantity	unit	Cost	unit	Total cost
Construction							
Installation Fairbanks to Eielson	ANSI 600	10	168,494	LF	$ 90	LF	$ 15,164,000
Installation Fairbanks towards Fox	ANSI 300	8	16,149	LF	$ 90	LF	$ 1,453,000
Cathodic Protection			35	miles	$ 15,000	mile	$ 525,000
HDD Chena river	varies	varies	1,600	LF	$ 400	LF	$ 640,000
Gate Station	ANSI 600	10	9	EA	$ 1,250,000	EA	$ 11,250,000
Pigging connection	ANSI 600	10	2	EA	$ 50,000	EA	$ 100,000
Pigging connection	ANSI 300	8	2	EA	$ 50,000	EA	$ 100,000
Subtotal-construction							*$ 29,232,000*
Materials							
Materials- Steel pipe, FBE coated	ANSI 600	10	168,494	LF	$ 53	LF	$ 8,930,000
Materials- Steel pipe, FBE coated	ANSI 300	8	16,149	LF	$ 44	LF	$ 711,000
Materials- valves	ANSI 600	10	4	EA	$ 34,000	EA	$ 136,000
Materials- valves	ANSI 300	8	2	EA	$ 20,000	EA	$ 40,000
Materials- Design allowance	varies	10 & 8	5%	EA	$ 490,850	EA	$ 491,000
Materials- Misc. Freight			2%	EA	$ 196,340	EA	$ 196,000
Materials- Procurement			4%	EA	$ 412,320	EA	$ 412,000
Materials- SQS			2%	EA	$ 206,160	EA	$ 206,000
Subtotal-materials							*$ 11,122,000*
Launcher/Receiver							
Pig Barrels- mobile	ANSI 600	12	2	EA	$ 300,000	EA	$ 600,000
Subtotal- transmission lines			**184,644**	**LF**			**$ 40,954,000**

Distribution feeder lines- from transmission lines towards residential areas, along major roads, 60 psig

Description	Class	Dia [in]	Quantity	unit	Cost	unit	Total cost
Construction							
Installation	60psig	6	275,435	LF	$ 50	LF	$ 13,772,000
HDD Chena river	60psig	6	1600	LF	$ 300	LF	$ 480,000
Regulator stations	60psig	6	9	EA	$ 400,000	EA	$ 3,600,000
Subtotal-construction							*$ 17,852,000*
Materials							
Materials- plastic	60psig	6	275,435	LF	$ 12	LF	$ 3,305,000
Materials- valves	60psig	6	7	EA	$ 13,300	EA	$ 93,000
Materials- Design allowance	varies	varies	5%	EA	$ 169,900	EA	$ 170,000
Materials- Misc. Freight			2%	EA	$ 67,960	EA	$ 68,000
Materials- Procurement			4%	EA	$ 135,920	EA	$ 136,000
Materials- SQS			2%	EA	$ 67,960	EA	$ 68,000
Subtotal-materials							*$ 3,840,000*
Subtotal- distribution mains			**275,435**	**LF**			**$ 21,692,000**

Distribution lines- along CL of residential roads, 60 psig

Description	Class	Dia [in]	Quantity	unit	Cost	unit	Total cost
Construction							
Residential lines	60 psig	2	1,996,112	LF	$ 25	LF	$ 49,903,000
Subtotal-construction							*$ 49,903,000*
Materials							
Materials-Pipe HDPE	60 psig	2	1,996,112	LF	$ 6	LF	$ 11,977,000
Materials- valves	60 psig	2	48	EA	$ 6,200	EA	$ 298,000
Materials- Design allowance	varies	varies	5%	EA	$ 613,750	EA	$ 614,000
Materials- Misc. Freight			2%		$ 245,500		$ 246,000
Materials- Procurement			4%		$ 491,000		$ 491,000
Materials- SQS			2%	EA	$ 245,500	EA	$ 5,000
Subtotal-materials							*$ 13,631,000*
Subtotal- residential mains			**1,996,112**	**LF**			**$ 63,534,000**

Service lines- tie-in

Description	Class	Dia [in]	Quantity [houses]	Quantity [LF]	Cost	unit	Total cost
Construction							
Residential lines- high density	60 psig	0.625	12,466	807,116	$ 25	LF	$ 20,178,000
Commercial lines- high density	60 psig	1	761	32,975	$ 25	LF	$ 824,000
Subtotal-construction							*$ 21,002,000*
Materials							
Materials-Pipe HDPE	60 psig	0.625	12,466	807,116	$ 5	LF	$ 4,036,000
Materials-Pipe HDPE	60 psig	1	761	32,975	$ 5	LF	$ 4,000
Materials- valves	60 psig	0.625	12,466		$ 500	EA	$ 6,233,000
Materials- valves	60 psig	1	761		$ 500		$ 381,000
Materials- Design allowance			5%		$ 513,650	LF	$ 514,000
Materials- Misc. Freight			2%		$ 205,460	LF	$ 205,000
Materials- Procurement			4%		$ 410,920	LF	$ 411,000
Materials- SQS			2%		$ 205,460	LF	$ 205,000
Subtotal-materials							*$ 11,989,000*
Subtotal- residential mains			**840,091**	**LF**			**$ 32,991,000**

Distribution feeder lines- from transmission lines towards residential areas, along major roads, 60 psig

Description	Class	Dia [in]	Quantity	unit	Cost	unit	Total cost
Construction							
Installation	60psig	6	348,820	LF	$ 50	LF	$ 17,441,000
HDD Chena river	60psig	6	0	LF	$ 300	LF	$ -
Regulator stations	60psig	6	-	EA	$ 400,000	EA	$ -
Subtotal-construction							*$ 17,441,000*
Materials							
Materials- plastic	60psig	6	348,820	LF	$ 12	LF	$ 4,186,000
Materials- valves	60psig	6	9	EA	$ 13,300	EA	$ 120,000
Materials- Design allowance	varies	varies	5%	EA	$ 215,300	EA	$ 215,000
Materials- Misc. Freight			2%	EA	$ 86,120	EA	$ 86,000
Materials- Procurement			4%	EA	$ 172,240	EA	$ 172,000
Materials- SQS			2%	EA	$ 86,120	EA	$ 86,000
Subtotal-materials							*$ 4,865,000*
Subtotal- distribution mains			**348,820**	**LF**			**$ 22,306,000**

Distribution lines- along CL of residential roads, 60 psig

Description	Class	Dia [in]	Quantity	unit	Cost	unit	Total cost
Construction							
Residential lines	60 psig	2	2,250,976	LF	$ 25	LF	$ 56,274,000
Subtotal-construction							*$ 56,274,000*
Materials							
Materials-Pipe HDPE	60 psig	2	2,250,976	LF	$ 6	LF	$ 8,734,000
Materials- valves	60 psig	2	54	EA	$ 6,200	EA	$ 335,000
Materials- Design allowance	varies	varies	5%	EA	$ 453,450	EA	$ 453,000
Materials- Misc. Freight			2%		$ 181,380		$ 181,000
Materials- Procurement			4%		$ 362,760		$ 363,000
Materials- SQS			2%	EA	$ 181,380	EA	$ 4,000
Subtotal-materials							*$ 10,070,000*
Subtotal- residential mains			**2,250,976**	**LF**			**$ 66,344,000**

Service lines- tie-in

Description	Class	Dia [in]	Quantity [houses]	Quantity [LF]	Cost	unit	Total cost
Construction							
Residential lines- medium density	60 psig	0.625	8,610	861,000	$ 25	LF	$ 21,525,000
Commercial lines- medium density	60 psig	1	163	16,300	$ 25	LF	$ 408,000
Subtotal-construction							*$ 21,933,000*
Materials							
Materials-Pipe HDPE	60 psig	0.625	8,610	861,000	$ 5	LF	$ 4,305,000
Materials-Pipe HDPE	60 psig	1	163	16,300	$ 5	LF	$ 1,000
Materials- valves	60 psig	0.625	8,610		$ 500	EA	$ 4,305,000
Materials- valves	60 psig	1	163		$ 500		$ 82,000
Materials- Design allowance			5%		$ 430,550	LF	$ 431,000
Materials- Misc. Freight			2%		$ 172,220	LF	$ 172,000
Materials- Procurement			4%		$ 344,440	LF	$ 344,000
Materials- SQS			2%		$ 172,220	LF	$ 172,000
Subtotal-materials							*$ 9,812,000*
Subtotal- residential mains			**877,300**	**LF**			**$ 31,745,000**