US Army Corps of Engineers

Fuel Transportation Improvement Report

Prepared for: Alaska Energy Authority
Prepared by: U.S. Army Corps of Engineers, Alaska District

October 2016
Status: FINAL

Table of Contents

1.0 INTRODUCTION AND BACKGROUND

The distribution system that delivers fuel to communities in western and northern Alaska is complex and logistically challenging. Existing conditions within the system generate a great deal of inefficiency that can be reduced through a number of means. To that end, the Alaska Energy Authority (AEA) has contracted with the U.S. Army Corps of Engineers (Corps) to identify waterborne transportation-related inefficiencies and to produce recommendations to address those inefficiencies.

While there is some refining capacity in Alaska, most fuel enters the state via barge from Puget Sound.[1] Once in the state, fuel is delivered to communities via various modes of transportation. This study seeks to identify possible gains in efficiency in barged deliveries of fuel to coastal communities from the mouth of the Kuskokwim River to Demarcation Bay and to riverine communities on the Kobuk, Kuskokwim, and Yukon Rivers. In order to accomplish this effort, the team reviewed existing information on community fuel consumption, methods of delivery, consumer costs, and interviewed a number of fuel transportation companies to identify systematic inefficiencies and possible solutions.[2]

1.1 Scope of Study

The scope of this study includes an assessment of and recommendations for improving the fuel distribution systems along the Alaska coast from Kuskokwim Bay to Demarcation Bay and the Kobuk, Kuskokwim, and Yukon Rivers. The Lower Koyukuk River was also included in the Yukon River analysis. A great deal of effort went into establishing the existing and future without-action conditions in order to identify the largest transportation inefficiencies in the system. Once these conditions were determined, recommendations could be formulated to address these inefficiencies.

1.2 Data Sources

Information was gathered from a number of sources. AEA contributed much of the existing data on fuel usage and storage. A number of fuel transportation companies contributed field-level knowledge of fuel mixes and logistical challenges. Existing studies such as the Corps DeLong Mountain Terminal, Alaska Navigation Improvements Feasibility Report (2005) contributed information about current usage and potential improvements along the coast. In short, all reliable information sources were considered in order to produce the best recommendations possible within the scope and budget of the study.

1.3 Data Limitations, Uncertainty, and Mitigating Practices

There are several data and methodological limitations for this reconnaissance level study and therefore a number of conservative assumptions were made. The team did not have access to a comprehensive enumeration of fuel farm sizes at each community in the study area. While gross storage estimates were available for the majority of the communities, the number of tanks and

[1] http://www.eia.gov/dnav/pet/PET_PNP_CAPCHG_DCU_SAK_A.htm, 97,700 barrels per day for all fuel types, 11,500 barrels per day of diesel.

[2] Crowley, Delta Western, Vitus Marine, and Everts Air Fuel

their individual fuel mixes were not available.[3] Additionally, multi-year consumption and price data were not available.[4] While this information would have been beneficial, the lack of said information is not considered to be detrimental to the overall quality of analyses performed or the resulting recommendations.

While some data was available regarding consumption of diesel and modeled estimates on consumption of heating oil, there was no data available regarding consumption of aviation fuels or gasoline. To estimate the aggregate amount of aviation fuels and gasoline, a rule of thumb provided by barge operators was used. The barge operators consistently estimated the mix of fuels delivered at 70 percent diesel and heating oil and 30 percent aviation fuels and gasoline. This estimate placed a quality check on the analysis and allowed for estimation of total gallons of combined aviation fuels and gasoline consumed.

With regards to barge operations, service routes and timing were discussed with major barge operators, but these relatively short conversations did not yield a comprehensive account of barge operations at every community within the study area. Likewise the actual hourly costs of operating the barges, aircraft, and trucks were not available. To compensate for these limitations, generic costs and demand estimates were made based on existing knowledge, available data contained in existing studies, and other published resources. Additionally, when calculating the number of barge trips to each community, multiple conservative assumptions were made. It was assumed that barge companies work in concert and that barges arrived at a village with a full complement of fuel to deliver to multiple entities at the same time and returned to the hub afterward regardless of fuel remaining in the barge. This assumption is conservative in that it likely overestimates the efficiency of barge operations. Some of the reasons for this are discussed below.

Multiple barge lines might stop at multiple communities during a round trip and can make partial deliveries to a number of different customers since not all customers in a village coordinate their purchases and/or deliveries. Additionally, it is not certain that barges always depart a hub with a full load of fuel. However, without a full picture of each company's operations throughout all four study areas, this assumption is a conservative, but reasonable proxy for delivery costs and amounts that could be estimated. With regard to air deliveries, without confirmation from existing data sets that air fuel was being delivered to each of the communities, it was assumed that their full annual fuel need was delivered by barge and that there is a sufficient number of tugs and barges to complete all deliveries. This assumption adds to the conservative nature of the existing condition since it is known that a greater number of villages receive fuel via air than what the existing data set was able to provide.

Finally, best professional judgement was used in determining which communities were placed into which region. For the three riverine regions (Kobuk, Kuskokwim, Yukon) the communities were essentially the fuel hub and the dependent villages upriver that would benefit from the recommendations. For instance, while Deering and Buckland receive fuel from Kotzebue, the

[3] These estimates were based on best available data and may not be comprehensive for all communities.
[4] All Diesel prices are based on the latest information available from the Alaska Power Cost Equalization Program.

recommendation for the Kobuk River would not necessarily benefit Deering or Buckland so they were placed in the Coastal region. Similarly, while Selawik is not on the Kobuk River, it receives fuel via Hotham Inlet (see Figure 1).

These preceding assumptions were made to be conservative due to the great amount of uncertainty surrounding detailed systemic and site-specific operations. Were the recommendations in this report able to reduce the number of barge deliveries or displace more air deliveries than what is claimed, additional gains in efficiency may be realized. Conversely, it is possible that some of the benefits claimed may be overstated if the desired result in foregone transportation costs are not realized due to barge operator operational preference, order and delivery structures, or other unforeseen factors. It is recommended that further study be undertaken prior to construction of these recommendations to ensure viability and justification.

1.4 Problem Statement

Due to natural conditions and storage capacities, there are numerous inefficiencies in the fuel distribution system in Western Alaska. In riverine systems, fuel is generally distributed from the mouth of the river. Because spring thaw occurs on the rivers from upstream to downstream, the mouth of the river is the last to see open water. By the time the mouth of the river becomes ice-free, the spring high water levels have begun to drop on the upper reaches of the river, lowering available draft and forcing barges to light load into some communities. Other communities cannot receive barge service at all, often forcing them to receive fuel via air, which is far more costly in most situations.

Fuel distribution on the Yukon comes from both the mouth of the river and from Nenana, on the Tanana River, a tributary of the Yukon. The Tanana River has insufficient draft for barges to fully load, presenting additional inefficiencies.

Conditions at individual villages contribute additional inefficiencies in the form of insufficient storage and a lack of shoreside infrastructure in the form of mooring points, which would allow barges to power down during fuel transfers, lowering the cost of delivery.

Communities receive fuel based on multiple buyers (power generation plant, school, contractor(s), and local vendors) and there may be multiple buys during the year based on funds availability, available tank storage volume, and non-economic ties between buyer and vendor.

This study examines possible increases in efficiency as a result of:

- Increased utilization of periods and locations of increased draft to increase barge delivery into communities
- Increased storage at individual communities, both for local consumption and for regional distribution
- Increased shoreside infrastructure at individual communities

This study does not examine increases in efficiency as a result of coordination between buyers or between vendors to reduce the number of deliveries made to a single community.

2.0 EXISTING AND FUTURE WITHOUT-ACTION CONDITIONS

The following sections describe the study area, the different regions that were included in this study and the conditions as they exist on the ground today. These descriptions are based on the information available at the time of the study including various databases, studies, and interviews conducted with fuel distributors (barge operators).[5]

While the cost of fuel will fluctuate with the market price of crude oil, it is assumed that the amounts of fuel consumed by village will tend to remain relatively steady absent investment in alternative energy generation that offsets the need for diesel and/or heating oil. It is also assumed that the non-fuel cost to deliver fuel to the villages will tend to remain fairly steady, mostly due to the low likelihood of increased efficiency in delivery equipment. Specifically, there is no foreseeable change in tug and barge configurations that could deliver more fuel at existing available drafts. Additionally, this analysis assumes no large regulatory changes that would significantly change the fleet or reduce the usability of the existing storage.

2.1 Description of Study Area

Alaska's rural communities are generally isolated villages that are not connected to the continental road system, and with few exceptions, there are no navigation improvements such as dredged channels or breakwaters. Generally, village populations do not exceed 1,500 people and the majority of the population practices a mixed-subsistence way of life. Power generation for the communities is generally provided by diesel-fired generators and residential heat is provided by heating oil-fired stoves. Diesel and heating oil tend to equal approximately 70 percent of all fuel delivered to the communities in the study area with aviation fuels and gasoline comprising the remaining 30 percent.

There are four distinct study areas within the scope of this study. The areas and existing conditions are discussed briefly below.

2.1.1 Kobuk River

There are six communities on the 280-mile-long Kobuk River that receive fuel from the hub community of Kotzebue: Selawik, Noorvik, Kiana, Ambler, Shungnak, and Kobuk (see Figure 1). Combined, these villages have 8.6 million gallons of fuel storage with 6.1 million gallons of that storage lying within the hub community of Kotzebue. Kotzebue receives its fuel from a coastal barge but is included here as the hub community for the Kobuk River system.

A major inefficiency that exists in this area is related to channel conditions in Kotzebue Sound. Coastal barges must anchor offshore 15 miles and lighter fuel into Kotzebue via shallow-draft barge. Depending on delivery volumes, Kotzebue requires 15-20 lightering barge trips to complete a delivery.

Ice in Kotzebue Sound generally goes out two weeks after the mouth of the Kobuk River is ice-free. This two week delay in the start of summer fuel delivery often means that the high-water

[5] The total number of barge operators interviewed was less than ten so there was no need to conduct an OMB-approved survey.

from spring breakup has begun to wane in the upper villages by the time fuel deliveries begin. Because of this, there is often not sufficient draft available at the three farthest upriver communities (Ambler, Shungnak, and Kobuk) to allow for these villages' total fuel need to be delivered via barge.[6] This necessitates flying fuel in at a much greater cost. Even under conditions where a barge can access these communities, it is often under extreme light-loading conditions, decreasing the overall efficiency of the delivery process. According to barge operators, barges with a capacity of 120,000 gallons may carry as little as 30,000 gallons due to low water conditions.

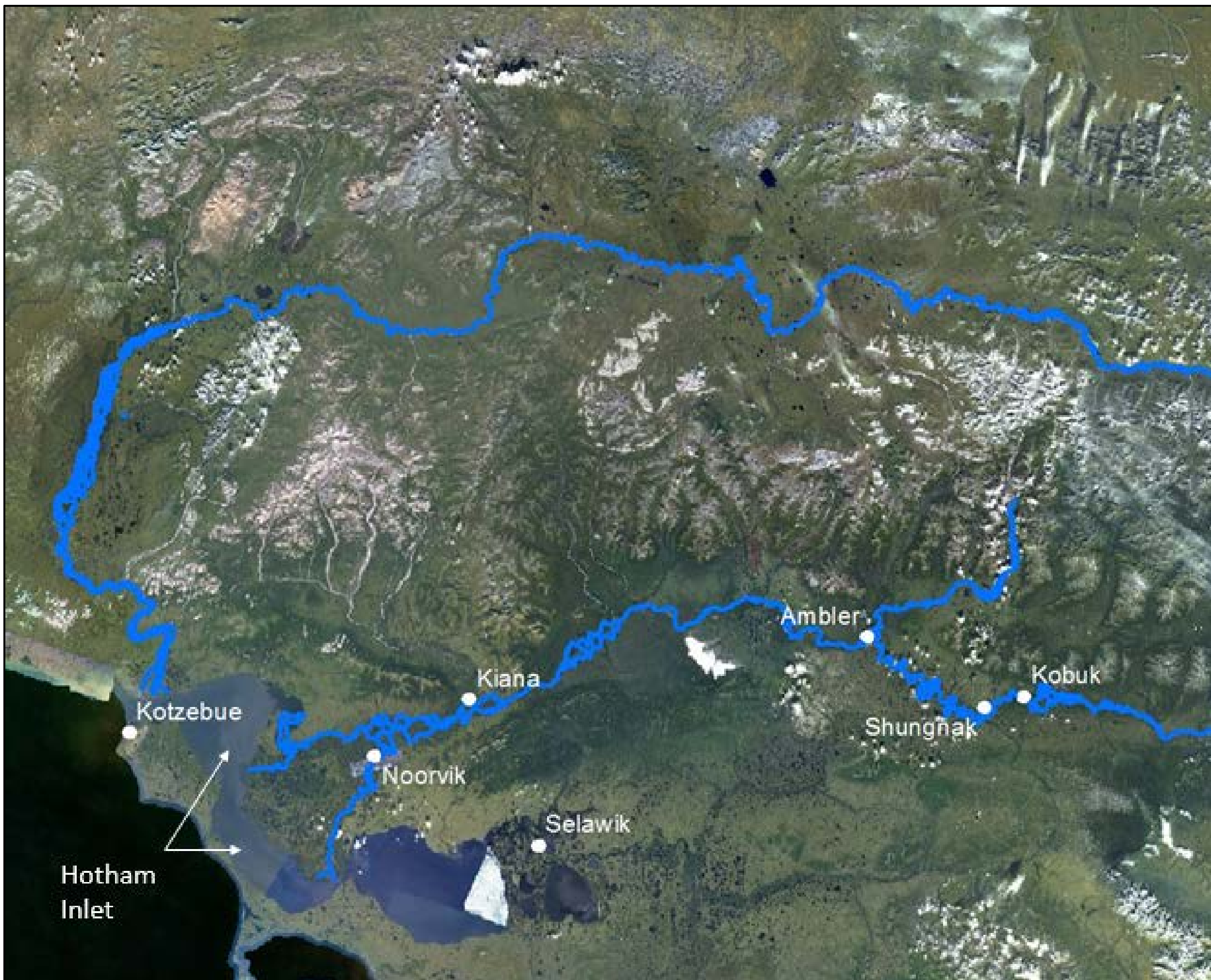

Figure 1: Kobuk River Study Area

As shown in Table 1, Kotzebue has by far the greatest amount of fuel storage of any location in the region. Outside of Kotzebue, storage averages approximately 416,000 gallons per village with the villages consuming between 137,000 and 1.3 million gallons of fuel per year. The

[6] AEA data shows that Ambler and Kobuk receive most of their fuel via air. Shungnak's delivery methods were shown as "unknown" and therefore deliveries are assumed to be via barge in an attempt to conservatively estimate benefits. This assumption is carried through the study in an attempt to be conservative with assumptions in the existing, future without-project, and future with-project conditions.

villages have fuel storage capacities of between 32 percent and 114 percent of their annual usage meaning some villages would require at least three separate barge deliveries to fill their annual need. In areas where there is not sufficient draft to support the required number of barge deliveries, the balance of the deliveries would be supplemented by air delivery, which is generally far more costly than barge delivery.

Table 1: Estimated Usage and Storage by Community, Kobuk River Villages[7]

Community	Fuel Storage (gallons)	Usage			Storage/ Usage
		Diesel	Heating Oil	Est. Annual Fuel Usage	
Kotzebue*	6,132,000	1,374,594	2,871,165	6,065,370	101%
Noorvik	755,200	155,919	308,011	662,757	114%
Selawik	629,500	225,172	661,838	1,267,157	50%
Kiana	419,700	118,408	238,605	510,019	82%
Ambler	410,400	92,858	170,665	376,461	109%
Shungnak	236,400	145,005	155,172	428,824	55%
Kobuk	44,100	**	96,065	137,236	32%
Total with Kotzebue:	**8,627,300**	**2,111,956**	**4,501,521**	**9,447,824**	
Total w/o Kotzebue:	**2,495,300**	**737,362**	**1,630,356**	**3,382,454**	
Avg. with Kotzebue:	**1,232,471**	**351,993**	**643,074**	**1,349,689**	**78%**
Avg. w/o Kotzebue:	**415,883**	**147,472**	**271,726**	**563,742**	**74%**

*-Kotzebue storage numbers were not available. Therefore, Crowley's Fuel Storage was used as proxy.
**-Kobuk diesel consumption data was not available. Kobuk receives electricity through an intertie with Shungnak.

Table 2 shows the cost of diesel in the Kobuk River villages. In total, the region uses 2.1 million gallons of diesel on an annual basis with 1.4 million gallons of that usage at Kotzebue. Outside of Kotzebue, the villages use an average of approximately 147,000 gallons of diesel. On average, the villages pay about $1.29/gallon more for diesel than Kotzebue.

Table 2: Diesel Prices in Kobuk River Communities[8]

Community	Diesel $/gal
Kotzebue	$3.45
Noorvik	$4.39
Selawik	$4.31
Kiana	$4.32
Ambler	$5.34
Shungnak[9]	$5.36
Average:	**$4.53**
Avg. w/o Kotzebue:	**$4.74**

An interesting pattern in the price of fuel in this region is that as one proceeds upriver, the price of fuel becomes more expensive. This stands to reason as the farthest upriver communities

[7] Storage is as reported by the PCE Program. Communities without PCE data or where storage data was supplemented by other available data are marked with an asterisk.
[8] Alaska Energy Authority Data
[9] Shungnak provides power to Kobuk through an intertie.

require severely light-loaded barges and also generally require some delivery of fuel via air. While this pattern is logical in nature, it is important to note.

Table 3 presents a picture of the amount of heating oil consumed in the Kobuk River communities. Analysis of heating oil consumption shows the villages (minus Kotzebue) consume an average of 272,000 gallons of heating oil at prices up to $3.50/gallon higher than the price in Kotzebue.

Table 3: Cost of Heating Oil, Kobuk River Communities

Community	Population[10]	Heating Oil Used (gal)[11]	$/gal[12]	Est. Cost per Village[13]	Est. Cost/ Person
Kotzebue	3,267	2,871,165	$6.16	$17,686,376	$5,414
Noorvik	638	308,011	$6.57	$2,023,632	$3,172
Selawik	873	661,838	$7.89	$5,221,902	$5,982
Kiana	425	238,605	$6.71	$1,601,040	$3,767
Ambler	277	170,665	$4.96	$846,498	$3,056
Shungnak	290	155,172	$9.19	$1,426,031	$4,917
Kobuk	148	96,065	$9.66	$927,988	$6,270
Average:	**845**	**643,074**	$7.31	$4,247,638	$4,654
Avg. w/o Kotzebue:	**442**	**271,726**	$7.50	$2,007,848	$4,527

Existing data, suggests that Ambler receives approximately one-third of its fuel by air and Kobuk receives all of its fuel by air. All other fuel deliveries in this region are assumed to be accomplished via barge.

2.1.2 Kuskokwim River

There are over 20 communities on the Kuskokwim River (Figure 2). The largest community, Bethel, is located near the mouth of the river and has 14 million gallons of fuel storage capacity. Bethel receives its fuel from a coastal barge but is included here as the hub community for the Kuskokwim River system. From Bethel, shallow-draft river barges resupply the river communities. As with the other rivers in this study, the Kuskokwim breaks up in the spring from upriver to downriver, sometimes taking a full month to become ice-free. As soon as the river is ice-free, fully-loaded river barges with loaded drafts of approximately 3 feet begin delivering upriver, stopping as they go.[14] This process allows the barges to lighten their draft as they progress upriver into shallower waters. However, this process also requires so much time that high water has passed on the far upriver villages by the time the barges reach them, restricting the amount of fuel that can be delivered by barge to the villages upriver of Lisky's Crossing (Figure 3), a relatively shallow and braided portion of channel upstream of Sleetmute.

[10] 2015 State of Alaska Department of Labor Estimates
[11] Alaska Energy Authority Modeled Estimates
[12] Alaska Housing Authority/Alaska Division of Community and Regional Affairs
[13] Estimated costs per village and per person assume equal consumption per capita across the region.
[14] A fully loaded barge on the Kuskokwim can hold 300,000 gallons but they are limited to 150,000 gallons above Lisky's Crossing.

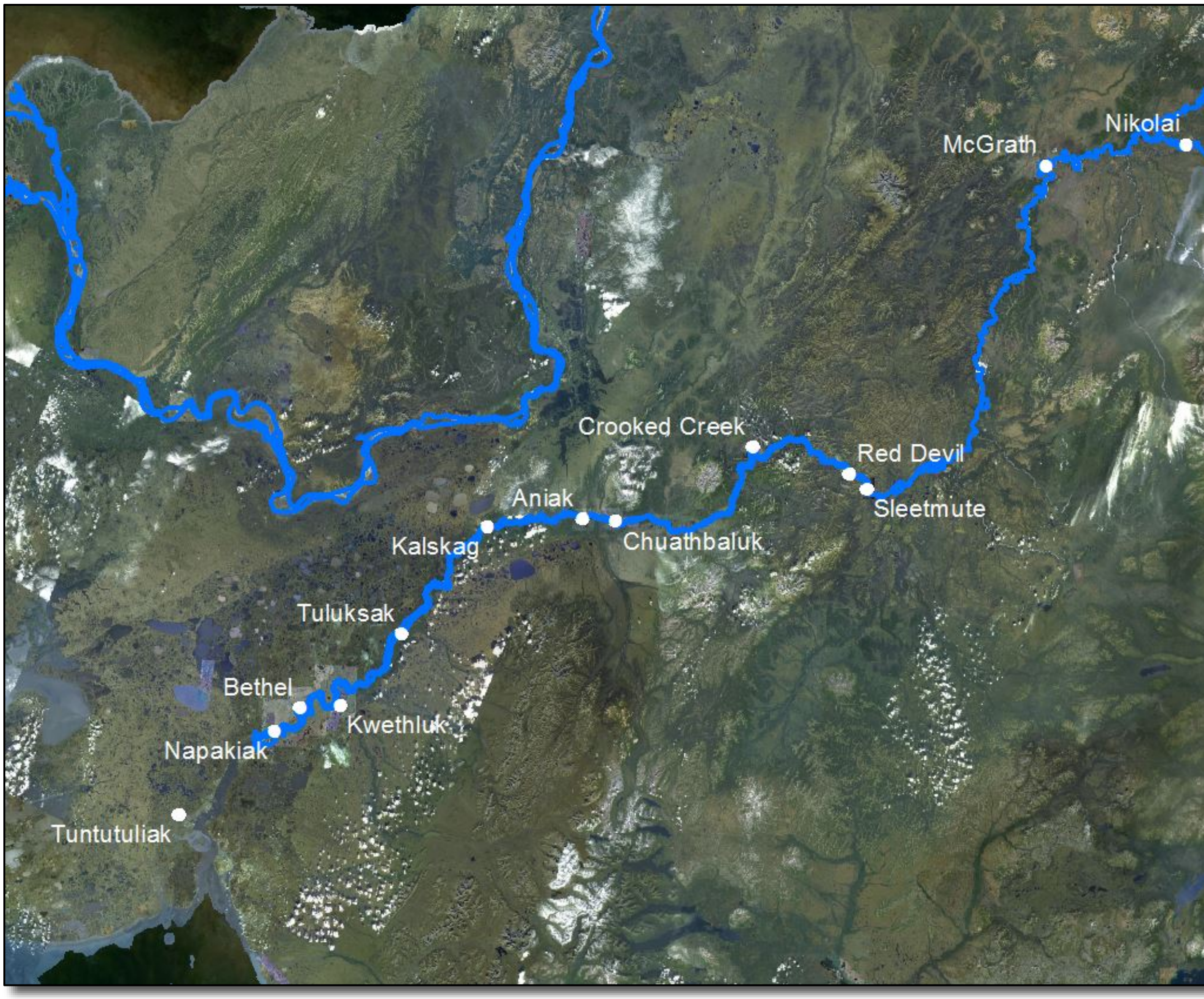

Figure 2: Kuskokwim River Study Area (Note: not all villages pictured)

Figure 3: Lisky's Crossing (courtesy: Google Earth)

As shown in Table 4, outside of Bethel, villages on the Kuskokwim generally have less than 1 million gallons of storage. The exception is Aniak, a sub-regional hub, which has approximately 1.1 million gallons of storage, likely owing to its status as a regional hub for air transportation which would require a greater ability to store aviation fuels and fuel for airport support equipment such as plows, fuel trucks, and other related ground service equipment for loading and unloading baggage and cargo.

Table 4: Estimated Usage and Storage by Community, Kuskokwim River[15]

Community	Fuel Storage (gallons)	Usage			Storage/ Usage
		Diesel	Heating Oil	Est. Annual Fuel Usage[16]	
Eek	210,893	66,411	86,376	218,267	97%
Tuntutuliak	233,000	87,777	141,854	328,044	71%
Kasigluk	624,000	188,651	264,519	647,386	96%
Nunapitchuk	250,550	**	243,336	347,623	72%
Atmautluak	183,250	51,429	136,579	268,583	68%
Napaskiak	151,086	71,591	150,180	316,816	48%
Bethel*	14,215,500	3,171,809	4,495,285	10,952,991	130%
Napakiak	151,086	**	169,198	241,711	63%
Oscarville	45,100	**	56,546	80,780	56%
Akiachak	605,000	151,531	260,785	589,023	103%
Akiak	417,750	83,601	223,537	438,769	95%
Kwethluk	439,500	101,286	267,941	527,467	83%

[15] Storage is as reported by the PCE Program. Communities without PCE data or where storage data was supplemented by other available data are marked with an asterisk. This may capture all storage in a community.
[16] Includes estimated aggregate usage of gasoline and aviation gas, rows do not sum.

Tuluksak	204,311	44,482	135,950	257,760	79%
Upper Kalskag	305,000	98,790	***	141,129	216%
Lower Kalskag	194,270	**	***	-	****
Aniak	1,144,730	188,472	373,842	803,306	143%
Chuathbaluk	85,500	35,617	74,319	157,051	54%
Crooked Creek	259,000	23,183	74,642	139,750	185%
Red Devil	102,600	10,348	33,332	62,400	164%
Sleetmute	91,800	24,170	52,243	109,161	84%
Stony River	75,600	16,044	88,462	149,294	51%
McGrath	282,100	190,327	232,207	603,620	47%
Nikolai	127,000	33,946	59,783	133,899	95%
Total with Bethel:	**20,398,626**	**4,639,465**	**7,620,916**	**17,514,830**	
Total w/o Bethel:	**6,183,126**	**1,467,656**	**3,125,631**	**6,561,839**	**95%**
Avg. with Bethel:	**886,897**	**244,182**	**362,901**	**761,514**	
Avg. w/o Bethel:	**281,051**	**81,536**	**156,282**	**298,265**	**94%**

*-PCE data did not include data for Bethel. Therefore Crowley's Fuel Storage was used as proxy.
**- Community receives its electricity from another community via intertie
***- Data was not available for this community
****- Without inputs, this figure could not be estimated

As shown above, absent Bethel, the Kuskokwim River villages consume between 62,000 and 803,000 gallons of fuel per year on average. The villages have fuel storage capacities of between 47 percent and 216 percent of their annual usage meaning some villages would require up to three separate barge deliveries to fill their annual need.[17] In areas where there is not sufficient draft to support the required number of barge deliveries, the balance of the deliveries would be supplemented by air delivery, which is generally far more costly than barge delivery.

Table 5 shows diesel costs and usage in the Kuskokwim River communities

Table 5: Diesel Prices in Kuskokwim River Communities[18]

Community	Diesel $/gal
Eek	$4.06
Tuntutuliak	$3.80
Kasigluk	$4.02
Nunapitchuk*	
Atmautluak	$3.92
Napaskiak	$4.04
Bethel	$4.54
Napakiak*	
Oscarville*	
Akiachak	$3.89
Akiak	$4.76
Kwethluk	$4.10
Tuluksak	$3.98
Upper Kalskag	$3.96
Lower Kalskag*	
Aniak	$3.88

[17] Assuming no air or truck deliveries and full barge loads per assumptions previously detailed
[18] Alaska Energy Authority Data

Chuathbaluk	$4.53
Crooked Creek	$4.53
Red Devil	$4.53
Sleetmute	$4.53
Stony River	$4.53
McGrath	$4.67
Nikolai	$5.74
Average:	**$4.32**
Avg. w/o Bethel	**$4.30**

*- Information about diesel usage not available.

The communities of Chuathbaluk, Crooked Creek, Red Devil, Sleetmute, and Stony River are all members of the Middle Kuskokwim Electrical Cooperative, which may explain the similarity in price paid for diesel since power generation makes up the bulk of diesel consumption in the region. Outside of the MKEC villages, there does not appear to be a pattern in fuel prices. Whereas the Kobuk River tended to become more expensive as one proceeded upriver, this does not appear to hold true for the Kuskokwim. Table 6 estimates the existing costs for heating oil in Kuskokwim River communities.

Table 6: Cost of Heating Oil, Kuskokwim River Communities

Community	Pop[19]	Heating Oil Used (gal)[20]	$/gal[21]	Est. Cost per Village[22]	Est. Cost per Person
Eek	348	86,376	$6.58	$568,354	$1,633
Tuntutuliak	438	141,854	$5.98	$848,287	$1,937
Kasigluk	621	264,519	$7.23	$1,912,472	$3,080
Nunapitchuk	588	243,336	$7.31	$1,778,786	$3,025
Atmautluak	320	136,579	$6.73	$919,177	$2,872
Napaskiak	444	150,180	$5.99	$899,578	$2,026
Bethel	6,205	4,495,285	$7.22	$32,455,958	$5,231
Napakiak	379	169,198	$6.77	$1,145,470	$3,022
Oscarville	59	56,546	$6.41	$362,460	$6,143
Akiachak	696	260,785	$6.99	$1,822,887	$2,619
Akiak	380	223,537	$6.86	$1,533,464	$4,035
Kwethluk	793	267,941	$7.20	$1,929,175	$2,433
Tuluksak	376	135,950	$6.86	$932,617	$2,480
Upper Kalskag	234	***	$6.26	$-	$-
Lower Kalskag	284	***	$6.26	$-	$-
Aniak	532	373,842	$7.43	$2,777,646	$5,221
Chuathbaluk	145	74,319	$7.50	$557,393	$3,844
Crooked Creek	95	74,642	$7.81	$582,954	$6,136
Red Devil*-	11	33,332	$3.31	$110,329	$10,030
Sleetmute	103	52,243	$6.76	$353,163	$3,429
Stony River	37	88,462	$7.16	$633,388	$17,119

[19] 2015 State of Alaska Department of Labor Estimates
[20] Alaska Energy Authority Modeled Estimates
[21] 8/2014 Fuel Price Survey Data. Alaska Housing Finance Corporation (AHFC); Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs.
[22] Estimated costs per village and per person assume equal consumption per capita across the region.

McGrath	327	232,207	$7.47	$1,734,586	$5,305
Nikolai	87	59,783	$8.01	$478,862	$5,504
Average:	**587**	**362,901**	**$6.79**	**$2,362,479**	**$4,223**
Avg. w/o Bethel	**332**	**156,282**	**$6.77**	**$994,593**	**$4,177**

*-Red Devil was excluded as an outlier with Bethel due to an unreasonably low reported price.

Excluding Bethel, the average village consumed approximately 156,000 gallons of heating oil per year.

Based on interviews with barge operators and existing knowledge of channel conditions and fuel delivery on the upper reaches of the river, it is assumed that McGrath and Nikolai receive a great deal of their fuel via air delivery. While it would have been reasonable to assume Nikolai receives all of its fuel via air, the assumption that they receive at least a portion via barge is conservative in that it is an assumed efficiency in the existing system that may not actually exist. All other fuel deliveries in this area are assumed to be accomplished via barge.

2.1.3 Yukon River System

The Yukon River system (including the Yukon, Koyukuk, and Tanana Rivers) is home to about 30 villages (Figure 4). The Yukon main stem flows approximately 2,000 miles from the Canadian border to the river's mouth near Emmonak, Alaska. Due to the river's length, it requires that fuel deliveries be made from two directions. Deliveries from the coast head upriver, generally as far as the mouth of the Koyukuk River, a tributary approximately 715 miles upstream of the river mouth. From there, fuel is generally delivered from Nenana, which lies on the Tanana River 160 miles upriver of the Yukon at the intersection of the Tanana River and the Parks Highway. The Tanana River is a tributary of the Yukon with less draft than the Yukon. Nenana is the site of a 1 million gallon tank farm owned by Crowley Marine that can be refilled on a continual basis via truck or train from Cook Inlet or the Kenai Peninsula.

Barges delivering out of Nenana are forced to light-load because of draft restrictions on the Tanana River.[23] Because barges must return to Nenana to refill their tanks, an additional 320 miles is added to any refueling operation on the Yukon River. This combined with draft limitations on the Tanana River add a great deal of inefficiency to fuel deliveries on the Yukon River.

[23] Barge capacity on the Yukon is 375,000 gallons but barges are limited to 275,000 gallons on the Tanana River.

Figure 4: Yukon River System Study Area (Note: not all villages pictured)

As shown in Table 7, the majority of villages along the Yukon have storage capacity of less than 1 million gallons. The only exceptions are at Emmonak (1.05 million gallons) and Galena (2.2 million gallons). Some communities on the river are estimated to have storage equal to 39 percent of annual usage, which would necessitate at least three separate barge deliveries to fill their annual need. In areas where there is not sufficient draft to support the required number of barge deliveries, the balance of the deliveries would be supplemented by air delivery, which is generally far more costly than barge delivery.

Table 7: Estimated Usage and Storage by Community, Yukon River[24]

Community	Fuel Storage (gallons)	Usage			Storage/ Usage
		Diesel	Heating Oil	Est. Annual Fuel Usage	
Emmonak	1,045,895	189,371	377,196	809,381	129%

[24] Storage is as reported by the PCE Program. Communities without PCE data or where storage data was supplemented by other available data are marked with an asterisk.

Alakanuk	417,029	418,318	240,869	941,696	44%
Nunam Iqua	198,000	71,910	80,524	217,763	91%
Kotlik	444,000	170,658	226,592	567,500	78%
Mountain Village	628,444	218,242	390,290	869,331	72%
St. Mary's	339,677	253,913	357,965	874,111	39%
Pilot Station	257,125	140,973	208,099	498,674	52%
Marshall	354,662	127,440	232,207	513,781	69%
Russian Mission	260,569	84,792	162,695	353,553	74%
Holy Cross	290,614	50,650	119,251	242,716	120%
Anvik	137,163	37,317	61,234	140,787	97%
Shageluk	122,997	33,080	76,923	157,147	78%
Grayling	222,361	49,602	79,717	184,741	120%
Kaltag	264,500	54,443	106,776	230,313	115%
Nulato	316,600	81,670	142,096	319,666	99%
Koyukuk	117,000	25,980	74,039	142,884	82%
Huslia	167,607	74,427	108,115	260,774	64%
Galena	2,216,250	374,518	795,238	1,671,080	133%
Ruby	276,410	49,441	188,403	339,777	81%
Tanana	260,000	88,539	118,011	295,071	88%
Beaver	92,350	28,978	53,721	118,141	78%
Fort Yukon*	908,600	212,988	480,189	990,253	92%
Total:	**9,337,853**	**2,837,250**	**4,680,150**	**10,739,143**	
Total w/o Galena:	**7,121,603**	**2,462,732**	**3,884,912**	**9,068,063**	
Average:	**424,448**	**128,966**	**212,734**	**488,143**	**86%**
Average w/o Galena:	**339,124**	**117,273**	**184,996**	**431,813**	**84%**

*-PCE data did not include data for Fort Yukon. Crowley's Fuel Storage was used as proxy.

Table 8 shows costs of diesel in the Yukon River villages. The table is organized from downriver to upriver.

Table 8: Diesel Prices in Yukon River Communities[25]

Community	Diesel $/gal
Emmonak	$3.99
Alakanuk	$4.02
Nunam Iqua	$3.96
Kotlik	$4.02
Mountain Village	$3.99
St. Mary's	$3.66
Pilot Station	$3.72
Marshall	$3.72
Russian Mission	$3.70
Holy Cross	$3.73
Anvik	$3.73
Shageluk	$3.77
Grayling	$3.75
Kaltag	$3.66

[25] Generation and Fuel usage data taken from State of Alaska PCE program (FY 2015 PCE data).

Nulato	$3.70
Koyukuk	$3.96
Huslia	$3.90
Galena	$3.89
Ruby	$4.36
Tanana	$3.79
Beaver	$4.61
Fort Yukon	$5.92
Average:	**$3.98**
Avg. w/o Galena:	**$3.98**

Table 9 estimates the existing costs for heating oil in Yukon River communities. The Yukon communities consume an average of 212,000 gallons of heating oil per year at an average cost of $1.4 million per village.

Table 9: Cost of Heating Oil, Yukon River Communities

Community	Pop[26]	Heating Oil Used (gal)[27]	$/gal[28]	Est. Cost per Village[29]	Est. Cost Per Person
Emmonak	827	377,196	$6.15	$2,319,755	$2,805
Alakanuk	708	240,869	$7.09	$1,707,761	$2,412
Nunam Iqua	190	80,524	$6.77	$545,147	$2,869
Kotlik	645	226,592	$5.41	$1,225,863	$1,901
Mountain Village	902	390,290	$6.86	$2,677,389	$2,968
St. Mary's	561	357,965	$7.18	$2,570,189	$4,581
Pilot Station	625	208,099	$7.33	$1,525,366	$2,441
Marshall	462	232,207	$6.66	$1,546,499	$3,347
Russian Mission	334	162,695	$5.81	$945,258	$2,830
Holy Cross	175	119,251	$7.16	$853,837	$4,879
Anvik	77	61,234	$6.01	$368,016	$4,779
Shageluk	71	76,923	$7.01	$539,230	$7,595
Grayling	176	79,717	$5.76	$459,170	$2,609
Kaltag	178	106,776	$5.76	$615,030	$3,455
Nulato	236	142,096	$5.66	$804,263	$3,408
Koyukuk	96	74,039	$6.51	$481,994	$5,021
Huslia	326	108,115	$7.01	$757,886	$2,325
Galena	484	795,238	$6.38	$5,073,618	$10,483
Ruby	191	188,403	$6.01	$1,132,302	$5,928
Tanana	217	118,011	$5.76	$679,743	$3,132
Beaver	72	53,721	$9.01	$484,026	$6,723
Fort Yukon	564	480,189	$6.58	$3,159,644	$5,602
Average:	**369**	**212,734**	**$6.54**	**$1,385,090**	**$4,186**
Avg. w/o Galena:	**363**	**184,996**	**$6.55**	**$1,209,446**	**$3,886**

[26] 2015 State of Alaska Department of Labor Estimates
[27] Alaska Energy Authority Modeled Estimates
[28] 8/2014 Fuel Price Survey Data. Alaska Housing Finance Corporation (AHFC); Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs.
[29] Estimated costs per village and per person assume equal consumption per capita across the region.

No data was available that confirmed air deliveries within this area. Therefore the conservative assumption was made that all fuel deliveries in this area are accomplished via barge.

2.1.1 Coastal Communities

The most complex system of the four examined as part of this study is the coast. The coast affects delivery for not only coastal communities, but for the majority of the riverine communities examined as well. Along the coast, fuel has historically been delivered via a two-barge system.[30] Barges were dispatched from Seattle and sail around the Alaska Peninsula into the Bering Sea (Figure 6). From there, deliveries begin taking place. A mainline barge drafting up to 25 feet was accompanied by a lightering barge with drafts of as little as 3 feet. There are no communities on the coast that provide 25 feet of draft. Therefore, the lightering barge takes on fuel from the mainline barge for delivery into the community. A number of communities have such shallow drafts that the lightering barge is forced to come to shore at high tide and deliver while beaching itself through low tide then departing once sufficient draft comes at the next high tide. Lightering barges are also used to deliver fuel to some Yukon River communities that are sufficiently near the coast (generally from Koyukuk downriver to the mouth).

More recently, coastal barges have been replaced, at least to some degree by deep draft tankers with larger capacities that deliver fuel to Dutch Harbor, then travel north where they meet lightering barges that complete deliveries in the same way that was previously accomplished with coastal barges.

[30] USACE, DeLong Mountain Terminal, Alaska Navigation Improvements Feasibility Study, September 2005

Figure 5: Coastal Study Area (Note: not all villages pictured)

Table 10 shows the amount of storage available by community along the coast. Storage as a percentage of annual consumption (usage) varies from 38 percent to 207 percent. Villages at the lower end of the spectrum require up to three separate barge deliveries to fill their annual need. In areas where there is not sufficient draft or open water season to support the required number of barge deliveries, the balance of the deliveries would be supplemented by air delivery, which is generally far more costly than barge delivery.

In the case of Tununak (207 percent), it is likely that this abundance of storage exists because of storage needs that existed prior to construction of an electrical intertie to Toksook Bay. The same holds true for Nightmute (114 percent) which also receives electricity from Toksook Bay via intertie. Similarly, this may explain why Toksook Bay only has 38 percent of usage.

Sums and averages are available at the bottom of the table both with and without Nome and North Slope Borough (NSB) communities. Nome was considered an outlier in the dataset given its fuel consumption and status as a regional hub. NSB communities were also outliers due to their large amounts of diesel consumed. It is also worth noting that these numbers would fluctuate if Kotzebue and Bethel were included as coastal communities rather than hub communities for their respective rivers.

Table 10: Estimated Usage and Storage by Village, Coast[31]

Community	Fuel Storage (gallons)	Usage			Storage/ Usage
		Diesel	Heating Oil	Est. Annual Fuel Usage	
Goodnews Bay	268,810	57,941	77,177	193,026	139%
Quinhagak	553,300	117,144	188,345	436,413	127%
Kongiganak	446,000	71,904	203,832	393,909	113%
Kwigillingok	283,700	19,302	168,284	267,980	106%
Kipnuk	559,800	126,566	211,187	482,504	116%
Chefornak	267,060	92,857	146,206	341,519	78%
Toksook Bay	787,000	209,432	339,510	784,203	100%
Nightmute	814,500	**	96,995	138,564	588%
Tununak	356,000	**	101,033	144,333	247%
Newtok	195,400	41,048	122,868	234,166	83%
Chevak	811,000	156,591	377,949	763,629	106%
Hooper Bay	562,222	235,531	537,417	1,104,211	51%
Scammon Bay	398,179	128,263	195,375	462,340	86%
Stebbins	788,000	112,304	274,608	552,731	143%
St. Michael	215,500	137,506	199,263	481,099	45%
Unalakleet	1,442,500	229,962	529,240	1,084,574	133%
Shaktoolik	327,100	63,652	154,315	311,381	105%
Koyuk	306,400	98,682	292,494	558,823	55%
Elim	346,320	90,313	287,017	539,043	64%
Golovin	203,600	62,015	164,931	324,209	63%
White Mountain	276,000	69,885	164,711	335,137	82%
Nome*	4,620,000	2,123,234	3,243,067	7,666,144	60%
Teller	374,700	69,865	202,620	389,264	96%
Brevig Mission	513,600	95,987	223,155	455,917	113%
Wales	222,478	42,809	118,588	230,567	96%
Savoonga	616,000	149,060	395,693	778,219	79%
Gambell	643,600	125,800	337,616	662,023	97%
Diomede	216,900	32,735	102,622	193,367	112%
Shishmaref	504,300	126,643	401,594	754,624	67%
Deering	252,000	53,850	64,233	168,690	149%
Buckland	451,000	132,983	218,394	501,967	90%
Kivalina	297,800	100,057	315,292	593,356	50%
Point Hope	1,285,000	347,207	421,657	1,098,377	117%
Point Lay	591,900	258,358	218,241	680,856	87%
Wainwright	1,498,100	449,284	474,725	1,320,013	113%
Nuiqsut	681,450	18,257	814,248	1,189,293	57%
Kaktovik	1,364,000	389,582	269,317	941,284	145%
Barrow***					
Total:	**24,341,219**	**6,636,609**	**12,653,819**	**27,557,754**	

[31] Storage is as reported by AEA. Communities without AEA data or where storage data was supplemented by other available data are marked with an asterisk.

Total w/o Nome/NSB:	**14,300,769**	**3,050,687**	**7,212,564**	**14,661,787**	
Avg.:	**657,871**	**189,617**	**341,995**	**744,804**	**112%**
Avg. w/o Nome/NSB:	**461,315**	**105,196**	**232,663**	**472,961**	**116%**

*-PCE data did not include Nome. Therefore, Crowley's storage was used.

**-Community receives electricity via intertie

***-PCE data was not available for Diomede or Barrow. Barrow uses natural gas for electricity and heating so it was not included in this analysis.

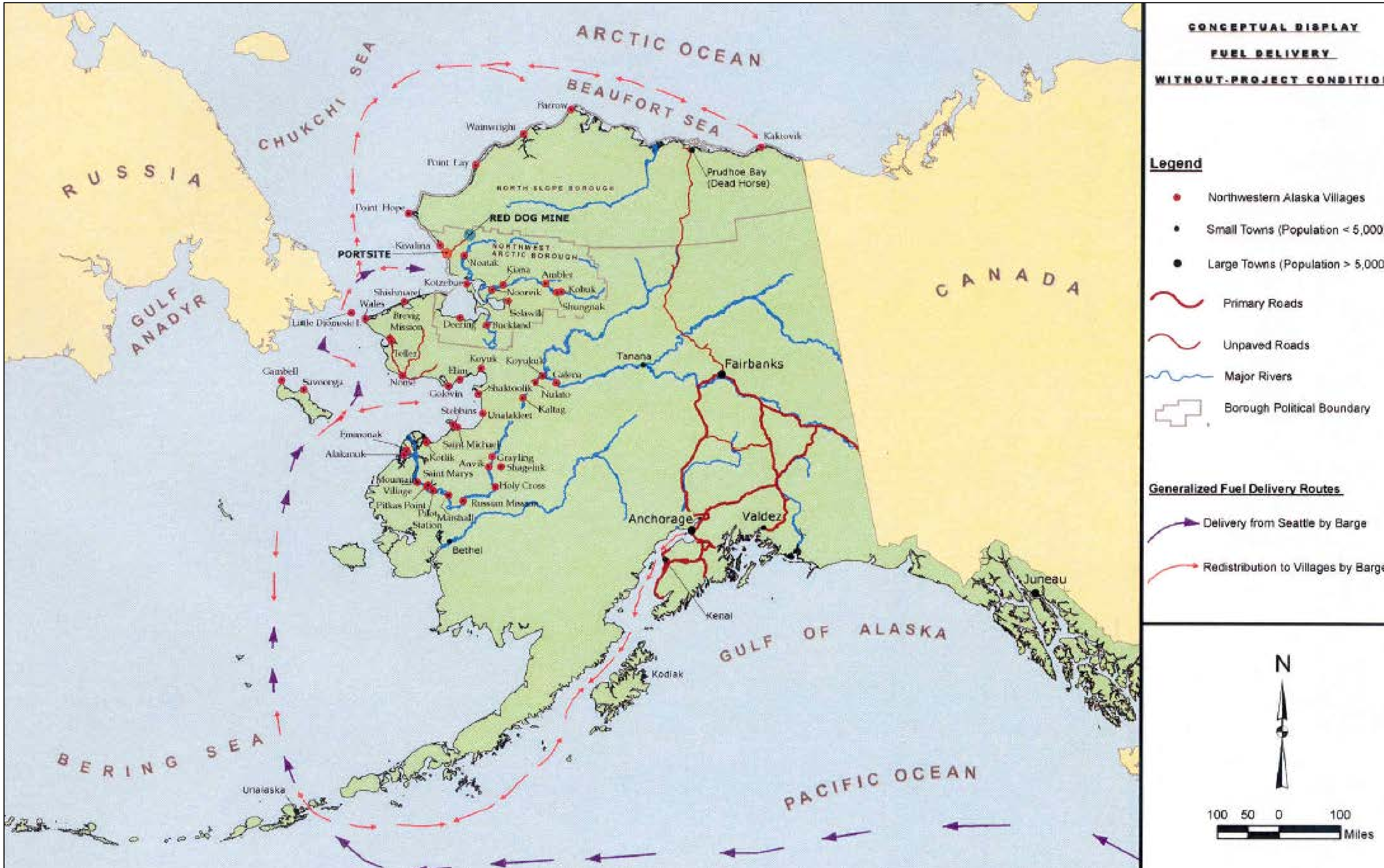

Figure 6: Current Coastal Fuel Delivery System

Table 11 shows the cost of diesel in coastal communities. As with the other regions, there are a number of villages that are part of AVEC. These villages include: Goodnews Bay, Quinhagak, Toksook Bay, Nightmute, Tununak, Chevak, Hooper Bay, Scammon Bay, Stebbins, St. Michael, Shaktoolik, Teller, Brevig Mission, Wales, Savoonga, Gambell, Shishmaref, and Kivalina. The minimum cost of diesel in this region is $3.38/gallon at Nome and the highest is $5.40/gallon at Nuiqsut. Given Nome's status as a regional hub, the fairly deep port, and the amount of fuel delivered, it is reasonable that fuel would be cheapest there.

Table 11: Diesel Prices in Coastal Communities[32]

Community	Diesel $/gal
Goodnews Bay	$3.97
Quinhagak	$4.12
Kongiganak	$3.84
Kwigillingok	$4.10
Kipnuk	$4.00
Chefornak	$4.55
Toksook Bay	$3.91
Nightmute**	
Tununak**	
Newtok	$3.89
Chevak	$3.88
Hooper Bay	$4.07
Scammon Bay	$4.01
Stebbins	$4.06
St. Michael	$4.09
Unalakleet	$3.78
Shaktoolik	$4.09
Koyuk	$4.10
Elim	$4.08
Golovin	$3.73
White Mountain	$3.68
Nome	$3.38
Teller	$4.04
Brevig Mission	$3.84
Wales	$4.31
Savoonga	$4.01
Gambell	$4.05
Diomede	No report
Shishmaref	$4.36
Deering	$4.15
Buckland	$4.56
Kivalina	$4.33
Point Hope	$4.64
Point Lay	$4.87
Wainwright	$4.15
Nuiqsut*	$5.40

[32] FY 2015 PCE data. Barrow was not included because it utilizes natural gas for power generation.

Kaktovik	$4.45
Barrow*	
Average:	**$4.13**
Avg. w/o Nome/NSB:	**$4.06**

*- Barrow and Nuiqsut use natural gas for all or a portion of electricity and heating. Nuiqsut is included here since it reported some diesel use.
**- Diesel consumption data not available.

Table 12 shows the cost and usage of heating oil in the coastal communities. An important note about this table is that the five villages of the North Slope Borough have markedly lower costs of heating oil due to a North Slope Borough program that subsidizes heating oil prices for consumers. In all, the coastal communities consume 28 million gallons of heating oil per year. The North Slope Borough communities consume significantly more per capita than non-North Slope Borough communities.

Table 12: Cost and Usage of Heating Oil, Coast

Community	Pop.[33]	Heating Oil Used (gal)[34]	$/gal[35]	Est. Cost per Village[36]	Est. Cost per Person
Goodnews Bay	267	77,177	$5.45	$420,615	$1,575
Quinhagak	745	188,345	$6.71	$1,263,795	$1,696
Kongiganak	503	203,832	$6.31	$1,286,180	$2,557
Kwigillingok	377	168,284	$6.03	$1,014,753	$2,692
Kipnuk	675	211,187	$6.32	$1,334,702	$1,977
Chefornak	433	146,206	$6.79	$992,739	$2,293
Toksook Bay	622	339,510	$7.68	$2,607,437	$4,192
Nightmute	285	96,995	$8.68	$841,917	$2,954
Tununak	395	101,033	$6.96	$703,190	$1,780
Newtok	396	122,868	$6.69	$821,987	$2,076
Chevak	1,023	377,949	$6.34	$2,396,197	$2,342
Hooper Bay	1,210	537,417	$6.91	$3,713,551	$3,069
Scammon Bay	561	195,375	$7.41	$1,447,729	$2,581
Stebbins	618	274,608	$7.23	$1,985,416	$3,213
St. Michael	428	199,263	$6.77	$1,349,011	$3,152
Unalakleet	745	529,240	$6.46	$3,418,890	$4,589
Shaktoolik	274	154,315	$5.83	$899,656	$3,283
Koyuk	333	292,494	$6.40	$1,871,962	$5,622
Elim	340	287,017	$5.37	$1,541,281	$4,533
Golovin	185	164,931	$6.01	$991,235	$5,358
White Mountain	187	164,711	$4.86	$800,495	$4,281
Nome	3,819	3,243,067	$6.29	$20,398,891	$5,341
Teller	261	202,620	$5.58	$1,130,620	$4,332
Brevig Mission	415	223,155	$5.36	$1,196,111	$2,882
Wales	171	118,588	$6.50	$770,822	$4,508

[33] 2015 State of Alaska Department of Labor Estimates
[34] Alaska Energy Authority Data
[35] 8/2014 Fuel Price Survey Data. Alaska Housing Finance Corporation (AHFC); Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs.
[36] Estimated costs per village and per person assume equal consumption per capita across the region.

Savoonga	723	395,693	$6.52	$2,579,918	$3,568
Gambell	698	337,616	$6.45	$2,177,623	$3,120
Diomede	94	102,622	$8.95	$918,467	$9,771
Shishmaref	574	401,594	$6.48	$2,602,329	$4,534
Deering	135	64,233	$6.71	$431,003	$3,193
Buckland	463	218,394	$6.90	$1,506,919	$3,255
Kivalina	412	315,292	$6.95	$2,191,279	$5,319
Point Hope	680	421,657	$1.99	$839,097	$1,234
Point Lay	211	218,241	$1.45	$316,449	$1,500
Wainwright	555	474,725	$1.50	$712,088	$1,283
Nuiqsut	450	814,248	$2.09	$1,701,778	$3,782
Kaktovik	244	269,317	$1.50	$403,976	$1,656
Barrow*					
Average:	**554**	**341,995**	**$5.90**	**$1,934,597**	**$3,381**
Avg. w/o Nome/NSB:	**469**	**232,663**	**$6.57**	**$1,522,833**	**$3,558**

*- Barrow and Nuiqsut use natural gas for all or a portion of electricity and propane for heating. Nuiqsut is included here since it still has some consumption reported.

2.1.2 Summary of Existing Conditions

Table 13 below shows some village averages by region. This data allows for a comparison of average village expenditures on fuel, their abilities to store fuel, and the differences in these by region. This may help to prioritize investments in alternatives that would reduce the price of fuel for the end consumer by determining which consumers are currently enduring the highest prices.

Table 13: Summary of Community Averages by Region

Region	Diesel		Heating Oil		Total	
	$/gal	Gal. Used	$/gal	Gal. Used	Usage (gal.)	Storage (gal.)
Kobuk	$4.53	351,993	$7.31	643,074	1,349,689	1,232,471
Kuskokwim	$4.32	244,182	$6.79	362,901	761,514	886,897
Yukon	$3.98	128,966	$6.54	212,734	488,143	424,448
Coast	$4.13	189,617	$5.90	341,995	744,804	657,871

Determining the exact causes of the differences in price and consumption by region with any certainty is beyond the scope of this study. However, some reasonable inferences can be drawn from the results of the analysis and existing knowledge about the regions themselves.

The Kobuk region is the highest consumer of fuel on a per-village basis, consuming approximately 1.4 million gallons of fuel per village, per year. The Kobuk region is completely off of the road system, does not have access to a port with sufficient draft to support ocean-going barges, and overall, has the shortest annual ice-free period of the four regions studied. Additionally, this region has relatively few villages and almost half of the villages lack sufficient draft to support a fully-loaded river fuel barge under existing distribution operations.

Conversely, the Yukon River has both sufficient draft for barges through much of its lower reaches for a majority of the open water period and also has road access via the Tanana River at

Nenana. While the Tanana River has some limiting draft conditions, road and rail access appears to play a role in reducing the delivery price of fuel.

3.0 ALTERNATIVES AND RECOMMENDATIONS

The overarching strategy for formulating alternatives is to reduce inefficiencies that currently exist in the system.[37] For the riverine systems, those inefficiencies were generally related to a lack of draft, an inability to utilize open water periods, and capital deficiencies that increased the number of deliveries and related delivery times. This formulation strategy took on two aspects.

First, analyses were conducted to determine the best locations for regional fuel depots that are located far enough upriver to take advantage of open water prior to the river mouth opening, but are also located far enough downriver to accept deliveries in the fall during low water periods. By doing this, barges are able to access upriver communities during periods of higher water, displacing air deliveries and increasing available draft for barges. The size of these depots was optimized to the level required to reasonably achieve anticipated benefits provided by these facilities given estimates about open water periods at the location of the depot as well as that at the river mouth. This informed assumptions about the availability of the depots to be resupplied and changes in operations given assumptions about available draft and delivery times.

Second, analyses were conducted to determine the best communities for fuel delivery system upgrades, generally consisting of mooring points and additional storage capacity.

The Denali Commission has previously partnered with the Corps of Engineers to identify communities that would benefit from installation of barge mooring points. Mooring points provide both economic and environmental benefits. At communities without moorings, barges keep their engines running during deliveries in order to maintain flush contact with the bank. This increases delivery costs by forcing the barges to burn fuel and also has environmental impacts in the form of increased carbon emissions and often times, induced scour and erosion on the opposite bank of the river. To date, three phases of mooring points have been installed throughout the State of Alaska with the fourth phase pending funding. The fuel-specific recommendations for Phase IV will be included throughout the recommendations provided in this section, as appropriate.[38,39]

Additional capacity is generally recommended at locations where marginal additional capacity could eliminate the need for a delivery or multiple deliveries. The recommendations take into account a community's storage capacity as a percentage of its annual usage.[40] For instance, a community with 40 percent of its annual usage requires at least three barge deliveries to fill the village's annual need.[41] However, if this community were at 55 percent of its annual usage, the number of deliveries may drop to two, depending on barge size. The number of additional tanks

[37] It is important to note that these recommendations are based on best available data and conservative assumptions about existing conditions and operational changes that would happen in the with-project condition.
[38] Stevens Village was eliminated as it was not a part of the fuel-related study and therefore benefits from mooring points could not be calculated on a common basis with other villages.
[39] The Denali Commission recommended mooring points for both freight and fuel barges. Only the moorings that would benefit fuel barges are included here since that is within the scope of this study.
[40] Existing storage is based on best data available at the time of the study and may not full account for a community's storage.
[41] Assuming no air deliveries and full barges delivering to all customers at time of delivery.

needed is based on a tank size of 46,600 gallons since this size of tank can easily be barged to a site.[42]

Each riverine system contains recommendations for improvements at specific local communities in order to eliminate the number of stops a barge would be required to make in order to fully accommodate a community's annual fuel need.[43]

In addition to these strategies, for the coastal communities, this study examined taking advantage of potential efficiency gains related to importing fuel via tanker from Asia instead of via barge from the Pacific Northwest. Fuel would be delivered to an existing fuel farm at DeLong Mountain Terminal for distribution to coastal villages.[44]

It is important to note that these recommendations only take into account construction and O&M costs and transportation cost savings benefits associated mostly with a reduction in barge miles traveled. Other factors that may affect recommendation viability that are not a part of this analysis include financing costs of holding the fuel as well as benefits that may arise from a change in price per gallon of delivered fuel based on more efficient operations. These issues would need to be addressed in a more detailed site-specific study prior to construction in order to reduce uncertainty surrounding the existing condition. All costs and benefits in this study are based on a 50-year project life and the Federal Fiscal Year 2016 Discount Rate of 3.125 percent.

3.1 Kobuk River

The alternatives for improving efficiency on the Kobuk River are twofold. The first is the construction of a Regional Fuel Depot that would allow for better utilization of the short open water period and high spring flows that provide sufficient draft for more efficient upriver deliveries. The second is related to increased capacity at Kobuk as well as installation of mooring points at Kiana and Noorvik. Construction costs for additional storage were assumed to be $12.50/gallon with annual O&M costs of $0.25/gallon.[45]

3.1.1 Kobuk River Regional Fuel Depot

This alternative considered the benefits associated with a new fuel hub located at Kiana. The Kobuk River Regional Fuel Depot (RFD) would consist of a fuel facility and a barge haul-out facility located at Kiana. Kiana is the most upstream community that can receive barge traffic into the fall low-water months and therefore maximizes use of the open water period on the higher reaches of the river while also ensuring fall deliveries are possible. In the fall, the expanded fuel facility would be filled and a river tug and barge would be hauled out for the winter. In the spring as the Kobuk River opened at Kiana, the tug and barge would be mobilized, filled, and make more fully-loaded deliveries upriver.

[42] This analysis does not necessarily account for construction considerations such as pre-staging of equipment, real estate acquisition, or utility relocation. It also assumes existing tankage could be reassigned to accommodate fuel mix and does not consider the financial ability of the communities to purchase additional fuel.
[43] While this may not completely accurately reflect barge operations in the field, it stands as a proxy for other times when a barge would stop at a community, making partial deliveries.
[44] Using recommendations from the DeLong Mountain Terminal, Alaska Feasibility Report, USACE, 2005
[45] All construction and O&M cost estimates provided by AEA Bulk Fuel Unit.

Optimization of RFD capacity at Kiana failed to identify any size of facility that would be justified.[46] Facilities ranging in size from 120,000 to 480,000 gallons were analyzed.[47] These facilities ranged from providing benefits to only Kobuk to providing benefits to Ambler, Shungnak, and Kobuk. However, after careful analysis of displaced air delivery costs and offsetting increases in barge delivery costs as well as the costs of construction, operation, and maintenance of the RFD itself, it was determined that there is no economically justified facility that could be placed at Kiana at this time. Average annual costs and benefits for the RFD varied depending on configuration and upstream storage. In the scenario where a 120,000-gallon RFD was constructed at Kiana with a single 46,600-gallon tank placed at Kobuk, average annual costs were $121,400 with average annual benefits of $103,000 for net average annual benefits of ($18,300) and a benefit-to-cost ratio of 0.85.

3.1.2 Kobuk River Local Improvements

There are improvements that could be made at multiple Kobuk River communities that could increase the efficiency of fuel deliveries.

3.1.2.1 Village of Kobuk Improvements

Kobuk is the most upriver community on the Kobuk River and as such, is the most difficult to access under current conditions. Therefore, it is important to make the delivery to Kobuk as efficient as possible. Kobuk's annual consumption is approximately 137,000 gallons. Kobuk has two separate tank farms with capacity totaling 44,100 gallons. The first is owned by the City of Kobuk, has a capacity of 16,900 gallons, and is approximately 300 feet from top of bank along a slough of the Kobuk River. It has capacity for 12,900 gallons of diesel and 4,000 gallons of gasoline. The second tank farm is owned by the Northwest Arctic Borough (NWAB) School District and has capacity for 27,200 gallons of diesel. Combined storage at these facilities is approximately 32 percent of Kobuk's annual fuel need. Because of the challenges of navigating to this reach of the river, there are years where fuel delivery barge is not possible. Kobuk currently receives a great deal of fuel via air, which is more expensive than receiving fuel via barge.

Kobuk was analyzed to see if additional barge deliveries and additional storage would be beneficial. However, without a RFD at Kiana, improvements at Kobuk would not provide any benefits as fully-loaded barges would still not be able to navigate to Kobuk. Additional analysis was performed to determine whether these two facilities (RFD plus tanks) would be justified when constructed in combination. That analysis was negative as well.

An additional piece of analysis was performed to gauge the relative benefits of constructing a 6.5-mile road from Shungnak to the Dahl Creek Road, which connects to Kobuk. Construction of new roads in rural Alaska vary depending on availability of buildings materials and local conditions but are generally estimated to cost $2 million per mile. At this cost, constructing the road from Shungnak to Kobuk would be estimated to cost $13.5 million assuming annual maintenance costs of $13,000, the present value of costs of the road are $12.9 million with

---

[46] All analyses assume a 50-year project life and the Federal Fiscal Year 2016 Discount Rate of 3.125%

[47] All estimated construction costs were $12.50/gallon with O&M costs of $0.25/gallon/year

average annual costs of $514,000. Conversely, the present value of reductions in barge operating costs associated with trucking fuel from Shungnak to Kobuk is $1.04 million, which means this road is not justified based on fuel transportation cost savings. There are many other non-fuel related savings that could be realized if the two communities were connected by road. However, analyses of those benefits are beyond the scope of this study.

3.1.2.2 Kobuk River Mooring Points

Mooring points were recommended for two communities on the Kobuk River including Kiana and Noorvik.

3.1.2.2.1 Kiana Mooring Points

The Denali Commission previously recommended installation of two fuel-related mooring points at Kiana. Kiana's fuel header is located at approximately 66°58'5.5"N, 160°26'23.24"W at the base of the bluff below the terminus of Schverch Street. The previous recommendation was for installation of two below-grade type mooring points 100 feet to either side (upstream and downstream) of the fuel header.[48]

Continuing the assumption that Kiana receives all of its fuel via barge, that barges servicing Kiana have an offload rate of 100 gallons per minute, and that their non-crew costs are reduced by 75 percent by running an offloading generator instead of their main engines, installation of the mooring points is expected to provide average annual barge operating cost savings of $7,200. Assuming installation costs of $78,500 and zero maintenance, this improvement is justified with net annual benefits of $4,200 and a benefit-to-cost ratio of 2.38.[49]

3.1.2.2.2 Noorvik Mooring Points

The Denali Commission previously recommended installation of two fuel-related mooring points near a fuel landing located at approximately 66°50'15.6"N, 161°2'42.1"W. The mooring points would be below grade and located approximately 75 feet back from top of bank and 200 feet apart.

Continuing the assumption that Noorvik receives all of its fuel via barge and that barges have an offload rate of 100 gallons per minute and that their non-crew costs are reduced by 75 percent by running an offloading generator instead of their main engines, installation of the mooring points is expected to provide average annual barge operating cost savings of $9,400. Assuming installation costs of $78,500 and zero maintenance, this improvement is justified with net annual benefits of $6,300 and a benefit-to-cost ratio of 3.09.

---

[48] The Denali Commission report contained recommendations for below-grade and above-grade mooring points depending on the needs and concerns of the various communities. Both mooring points at Kiana were to be below-grade.

[49] Installation of 21 mooring points on the Kuskokwim in Phase III cost $916,850, or approximately $44,000 per mooring point. When adjusted using the Civil Works Construction Cost Index, the cost dropped to $39,249.

3.1.1 Summary of Recommendations and Benefits, Kobuk River

The recommendations for the Kobuk River include installing mooring points at Kiana and Noorvik. These mooring points are estimated to provide a reduction in barge operating costs attributable to reduced barge operating costs during fuel transfers at Kiana and Noorvik.

Table 14: Cost Summary of Recommendations, Kobuk River

Place	Item	Construction Cost	Annual O&M Cost
Kiana	Moorings	$78,500	$0
Noorvik	Moorings	$78,500	$0

Note: Values rounded to nearest $00's.

Table 15: Economic Summary of Recommendations, Kobuk River

Place	Item	Avg. Annual Costs	Avg. Annual Benefits	Net Avg. Annual Benefits	BCR
Kiana	Moorings	$3,030	$7,200	$4,200	2.38
Noorvik	Moorings	$3,030	$9,400	$6,300	3.09

Note: Totals may not sum due to rounding.

3.2 Kuskokwim River

The following sections discuss actions that could be taken that would provide additional efficiencies to the fuel delivery system on the Kuskokwim River. The alternatives include: constructing moorings at McGrath, additional capacity at a number of communities, and the construction of a 300,000-gallon RFD at Aniak. Construction costs for additional storage were assumed to be $11.50/gallon with annual O&M costs of $0.25/gallon.

3.2.1 Kuskokwim River Regional Fuel Depot and Linked Storage Upgrades

This alternative considered the benefits associated with a new fuel hub located at Aniak with associated storage upgrades that are dependent upon the hub for their benefits to be realized. These associated storage facilities are located above Lisky's Crossing in the communities of Stony River, McGrath, and Nikolai.

These facilities are assumed to allow for two fully loaded barges to deliver to communities above Lisky's Crossing with two light-loaded deliveries to complete all required deliveries to these communities. This is an improvement over the assumed existing condition of two light-loaded barges with the balance being made up through air delivery. The facilities include a 300,000-gallon RFD (and barge haulout) at Aniak, which is equivalent to one fully-loaded barge on the Kuskokwim River. Aniak currently has storage capacity approximately 340,000 gallons greater than their annual fuel usage. When combined with the 300,000-gallon new facility, Aniak would have the ability to store up to 640,000 additional gallons of fuel, depending on Aniak's local use patterns. By fully taking advantage of current surplus storage and adding new storage, it is likely that barge would be able to take advantage of high water periods to deliver fuel to villages above Lisky's Crossing. To minimize the number of barge trips required across Lisky's Crossing, two 46,600-gallon tanks would be installed at Stony River with one additional tank at both McGrath and Nikolai. Given the above assumptions regarding fully loaded barge deliveries holds true, installation of these facilities is estimated to mostly eliminate the need for air deliveries to these communities.

Average annual transportation cost savings as a result of the RFD and additional storage at Stony River, McGrath, and Nikolai are attributable to a reduced number of barge trips and decreased air deliveries. The facilities are estimated to provide $913,900 in average annual benefits. Given construction costs of $5.6 million and annual O&M costs of $121,600, this alternative has average annual costs of $332,800. Therefore, it has net average annual benefits of $581,100 and a benefit to cost ratio of 2.75.[50]

3.2.2 Kuskokwim River Local Improvements

Additional efficiencies could be gained through increased capacity at a number of Kuskokwim River communities. As done with the Kobuk River villages, a village was recommended for additional capacity if installation additional capacity could eliminate a barge delivery to that community. This analysis assumed a 46,600-gallon tank size and a 300,000-gallon barge capacity. These recommendations are discussed below and are in order of downriver to upriver.

3.2.2.1 Eek

Eek is located approximately 101 miles downriver from Bethel on the Eek River. Eek currently consumes approximately 218,000 gallons of fuel per year and has storage of approximately 211,000 gallons. Given barge capacities of 300,000 gallons, with the addition of one 46,600-gallon tank, Eek could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increase efficiencies, therefore one tank is the recommendation. Considerations surrounding this recommendation are shown below in Table 16.

Table 16: Additional Storage Considerations, Eek

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	210,893	N/A
	Usage (gals)	218,267	
	% of Usage	97%	
100%	Total Gals. Needed	218,267	1
	Additional Gals. Needed	7,374	
	Additional Tanks Needed	1	
	With-Project Storage	257,493	

The installation of this additional tank is expected to cost $536,000 with average annual costs of $31,900.[51] Average annual transportation cost savings associated with this tank are $37,500. Therefore, the construction of this tank is justified with net annual benefits of $5,625 and a benefit-to-cost ratio of 1.18. The net benefits for the work could probably be increased by site-specific planning to customize tank sizes and product requirements.

[50] Does not include cost to construct a barge haulout, but surplus benefits should be sufficient to cover costs.
[51] Operation and Maintenance costs are assumed to be $0.25/gallon/year

3.2.2.2 Napaskiak

Napaskiak is located approximately 8 miles downriver of Bethel. In the winter, it receives fuel via truck driven on the frozen river. Because of this steady supply of fuel that is easily delivered for the majority of the winter months, Napaskiak currently has storage equal to 23 percent of its annual usage. Additionally, the current storage of approximately 88,200 gallons means that a barge would have to visit the community seven times to meet the community's annual fuel need of approximately 391,000 gallons. With the addition of one tank, capacity would increase to 134,800 gallons. With an assumed barge capacity of 300,000 gallons, the number of total deliveries required would decrease to three. The installation of additional tanks would not further reduce the number of deliveries required and therefore the addition of one tank is the most efficient solution.

There is a further consideration related to climate change. If the open water period around Bethel is extended, the window to receive fuel via truck may shrink considerably. The addition of a single tank would double their storage as a percentage of usage. This would increase the community's resilience to climate change and natural disasters.

Table 17: Additional Storage Considerations, Napaskiak

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	88,200	N/A
	Usage (gals)	390,934	
	% of Usage	23%	
33%	Total Gals. Needed	97,734	2
	Additional Gals. Needed	9,534	
	Additional Tanks Needed	1	
	With-Project Storage	134,800	
50%	Total Gals. Needed	195,467	1
	Additional Gals. Needed	107,267	
	Additional Tanks Needed	3	
	With-Project Storage	228,000	
100%	Total Gals. Needed	390,934	1
	Additional Gals. Needed	302,734	
	Additional Tanks Needed	7	
	With-Project Storage	414,400	

The installation of this additional tank is expected to cost $536,000 with average annual costs of $31,900. Transportation cost savings associated with this tank are $4,300. Therefore, the construction of this tank has net average annual benefits of ($27,500) with a benefit to cost ratio of 0.14 and is not justified.

3.2.2.3 Oscarville

Oscarville is located 7 miles from Bethel. Oscarville currently consumes approximately 81,000 gallons of fuel per year and has storage of approximately 45,100 gallons. Given barge capacities of 300,000 gallons, with the addition of one 46,600-gallon tank, Oscarville could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 18.

Table 18: Additional Storage Considerations, Oscarville

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	45,100	N/A
	Usage (gals)	80,780	
	% of Usage	56%	
100%	Total Gals. Needed	80,780	1
	Additional Gals. Needed	35,680	
	Additional Tanks Needed	1	
	With-Project Storage	91,700	

The installation of this additional tank is expected to cost $536,000 with average annual costs of $31,900. Transportation cost savings associated with this tank are $2,600. Therefore, the construction of this tank has net average annual benefits of ($29,300) with a benefit-to-cost ratio of 0.08 and is not justified.

3.2.2.4 Sleetmute

Sleetmute is located 247 miles upriver of Bethel or 112 miles upriver of Aniak. Sleetmute currently consumes approximately 109,161 gallons of fuel per year and has storage of approximately 91,800 gallons. Given barge capacities of 300,000 gallons, with the addition of one 46,600-gallon tank, Sleetmute could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 19.

Table 19: Additional Storage Considerations, Sleetmute

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	91,800	N/A
	Usage (gals)	109,161	
	% of Usage	84%	
100%	Total Gals. Needed	109,161	1
	Additional Gals. Needed	17,361	
	Additional Tanks Needed	1	
	With-Project Storage	138,400	

The installation of this additional tank is expected to cost $536,000 with average annual costs of $31,900. Transportation cost savings associated with this tank are $9,700. Therefore, the construction of this tank has net average annual benefits of $9,710 with a benefit-to-cost ratio of 1.30 and is justified.

3.2.2.5 Stony River

Stony River is located 142 miles upriver of Aniak, or 412 miles upriver of Bethel. Stony River currently consumes approximately 149,300 gallons of fuel per year and has storage of approximately 75,600 gallons. Stony River is the first village located upriver of Lisky's Crossing, a relatively shallow and braided portion of the Kuskokwim River that limits barges to loads of 150,000 gallons or less. Given the addition of two tanks, Stony River could receive its full annual fuel need in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore two tanks is the recommendation. Considerations surrounding this recommendation are shown below in

Additional Storage Considerations, Stony River

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	75,600	N/A
	Usage (gals)	149,294	
	% of Usage	51%	
100%	Total Gals. Needed	149,294	1
	Additional Gals. Needed	73,694	
	Additional Tanks Needed	2	
	With-Project Storage	168,800	

The installation of this tank was recommended as part of construction of the RFD at Aniak since the tanks upriver of Lisky's Crossing provide a great deal of the justification for the RFD.

3.2.2.6 McGrath

McGrath is located 277 miles upriver of Aniak or 412 miles upriver of Bethel and currently receives approximately 65 percent of its fuel via air. If all of McGrath's fuel deliveries were via barge, there would be a minimum of seven deliveries per year based on approximately 282,000 gallons of storage and approximately 921,000 gallons of usage. With the construction of a RFD and the addition of one tank, the number of deliveries required could be reduced. The addition of more than one tank would not necessarily provide a greater gain in efficiency since at that point, the system would be limited by barge capacity, and not storage capacity.

This gain in efficiency will only be possible with the construction of a RFD at Aniak since taking advantage of high water soon after breakup would be essential to having sufficient draft available to complete two deliveries.

Table 20: Additional Storage Considerations, McGrath

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	282,100	N/A
	Usage (gals)	921,189	
	% of Usage	31%	
33%	Total Gals. Needed	303,992	1
	Additional Gals. Needed	21,892	
	Additional Tanks Needed	1	
	With-Project Storage	328,700	
50%	Total Gals. Needed	460,594	1

	Additional Gals. Needed	178,494	
	Additional Tanks Needed	4	
	With-Project Storage	468,500	
100%	Total Gals. Needed	921,189	1
	Additional Gals. Needed	639,089	
	Additional Tanks Needed	14	
	With-Project Storage	934,500	

The installation of this tank was recommended as part of construction of the RFD at Aniak since the tanks upriver of Lisky's Crossing provide a great deal of the justification for the RFD.

In addition, the Denali Commission previously recommended that fuel-related mooring points be installed at McGrath at two different fuel landings. One below grade mooring point would be installed near a fuel landing located at approximately 62°57'01.5"N, 155°35'17.5"W. The mooring point would be located approximately 5 feet from the shoreward edge of the road. Two additional below grade moorings would be installed at a fuel landing located at approximately 62°57'24.7"N, 155°35'34.5"W. The mooring points would be located 10 feet from the top of bank and 275 feet apart.

Continuing the existing condition that McGrath receives a great deal of its fuel via air, that barges have an offload rate of 100 gallons per minute, and that their non-crew costs are reduced by 75 percent by running an offloading generator instead of their main engines, installation of the mooring points is expected to provide average annual barge operating cost savings of $3,260, or a net present value of $82,000. Assuming installation costs of $132,000 and zero maintenance, this improvement has net annual benefits of ($1,279) with a benefit-to-cost ratio of 0.72 and is not justified. However, if the RFD at Aniak were constructed and barge fuel deliveries to McGrath increased, these moorings would have net annual benefits of $3,975 with a benefit-to-cost ratio of 1.87 and would be justified. Therefore, these mooring points are only recommended for construction in conjunction with construction of an RFD at Aniak.

3.2.2.7 Nikolai

Nikolai is located 347 miles upriver of Aniak, or 482 miles upriver of Bethel and currently receives a great deal of fuel via air. If all of Nikolai's fuel deliveries were via barge, there would be a minimum of three deliveries per year based on storage of approximately 87,500 gallons of fuel and approximately 181,551 gallons of usage. With the construction of a RFD and the addition of one tank, the number of required deliveries could be reduced to two. This gain in efficiency will only be possible with the construction of a RFD at Aniak since taking advantage of high water soon after breakup would be essential to having sufficient draft available to complete two deliveries.

Table 21: Additional Storage Considerations, Nikolai

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	87,500	N/A
	Usage (gals)	181,551	
	% of Usage	48%	
	Total Gals. Needed	90,776	

50%	Additional Gals. Needed	3,276	1
	Additional Tanks Needed	1	
	With-Project Storage	134,100	
100%	Total Gals. Needed	181,551	1
	Additional Gals. Needed	94,051	
	Additional Tanks Needed	3	
	With-Project Storage	227,300	

The installation of this tank was recommended as part of construction of the RFD at Aniak since the tanks upriver of Lisky's Crossing provide a great deal of the justification for the RFD.

3.2.3 Summary of Recommendations, Kuskokwim River

The recommendations for the Kuskokwim River include constructing a RFD at Aniak with a capacity of 300,000 gallons, utilizing existing surplus storage at Aniak, installing one additional 46,600-gallon tank at the communities of: Eek, Sleetmute, McGrath, and Nikolai, installing two additional tanks at Stony River, and installing mooring points at McGrath.[52] It is estimated that construction of these recommendations could reduce barge from 8,400 to 7,200, a reduction of 1,200 miles, or 15 percent.

The following tables summarize the construction and O&M costs and economic justification for the recommendations along the Kuskokwim River

Table 22: Cost Summary of Recommendations, Kuskokwim River

Place	Item	Construction Cost	Annual O&M Cost
Aniak	RFD	$3,450,000	$75,000
Eek	1 Tank	$535,900	$11,650
Sleetmute	1 Tank	$535,900	$11,650
Stony River	2 Tanks	$1,071,800	$23,300
McGrath	1 Tank	$535,900	$11,650
	Moorings	$117,750	$0
Nikolai	1 Tank	$535,900	$11,650

Note: Values rounded to nearest $00's.

Table 23: Economic Summary of Recommendations, Kuskokwim River

Place	Item	Avg. Annual Costs	Avg. Annual Benefits	Net Avg. Annual Benefits	BCR
Aniak	RFD	$332,800	$913,800	$581,100	2.75
McGrath (RFD-Linked)	1 Tank				
Nikolai (RFD-Linked)	1 Tank				
Stony River (RFD- Linked)	2 Tanks				
Eek	1 Tank	$31,900	$37,500	$5,630	1.18
Sleetmute	1 Tank	$31,900	$108,400	$76,550	3.40
McGrath	Moorings	$4,500	$8,500	$3,900	1.87

Note: Totals may not sum due to rounding.

[52] Mooring points in McGrath are recommended because the RFD at Aniak is also being recommended.

3.3 Yukon River

This section examines alternatives and provides recommendations for improvements along the Yukon River.

3.3.1 Yukon River Regional Fuel Depot

This analysis examines two different location for a RFD that serves Yukon River villages. The proposal would include installation of a 375,000-gallon bulk fuel storage facility. This analysis considered two separate locations, discussed below. Construction costs for additional storage were assumed to be $10.50/gallon with annual O&M costs of $0.25/gallon.

The benefits for these RFDs are based on allowing barges to travel the river more fully loaded that what currently exists. Due to draft restrictions on the Tanana River, barges are forced to light load to approximately two-thirds of their capacity when traveling from Nenana.

3.3.1.1 Yukon River Depot Alternative 1: Tanana Confluence Depot

The first location analyzed for construction of an RFD was near the village of Tanana at the confluence of the Yukon and Tanana Rivers. The RFD would be sited in order to take advantage of the two weeks where the Tanana River is navigable but the Yukon River is not, due to outflowing ice.

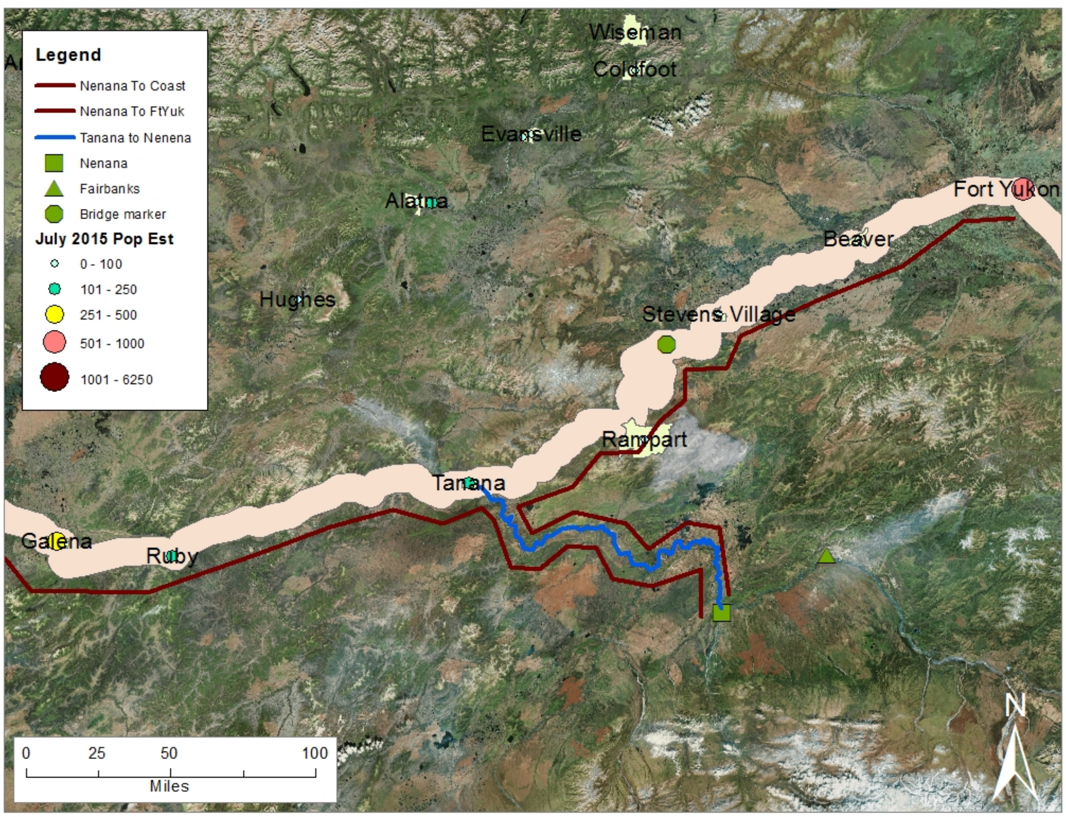

Figure 7: Yukon River near Tanana

Analysis of this alternative assumed that fuel would be delivered to the RFD via barge from Nenana and that once the Yukon was navigable, deliveries would begin taking place. The shuttling of fuel from Nenana to the RFD would reduce the total number of river miles traveled in a light-loaded condition as the only barges being forced to light load would be those shuttling fuel from Nenana. Barges traveling the main stem of the Yukon would be able to travel under fully-loaded conditions.

Because of the shuttling back and forth from Nenana to the RFD under light loaded conditions, this alternative only decreases the number of barge river miles traveled by 2,102 from 26,792 to 24,690 for total decreases in barge operating costs of $260,200. This decrease is addition to $15,000 in reductions in air transportation costs.

3.3.1.2 Yukon River Depot Alternative 2: Yukon River Crossing

A second alternative would be to place an RFD at the Yukon River Crossing of the North Slope Haul Road between Rampart and Stevens Village (see Figure 7 and Figure 8).

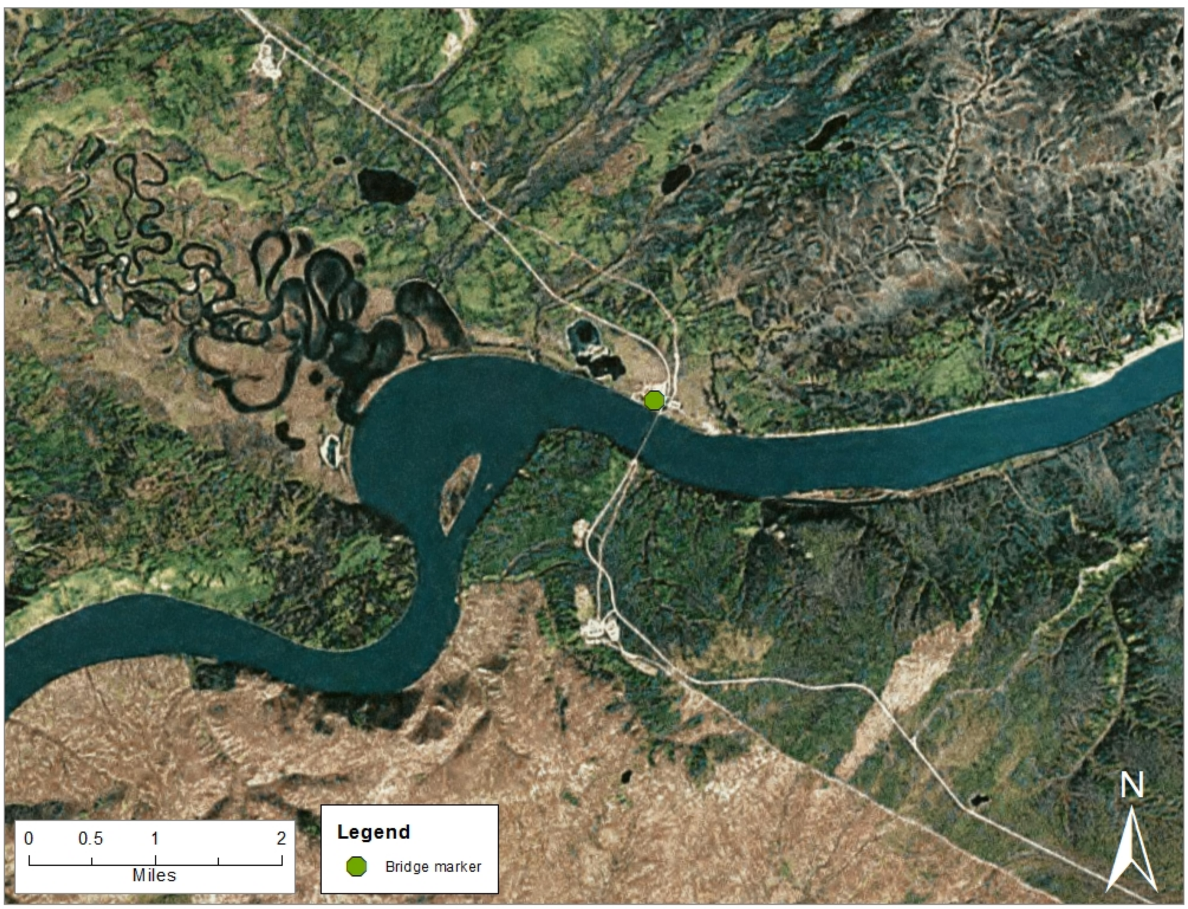

Figure 8: Location of Potential Yukon River Crossing RFD

The maximum possible estimated average annual transportation cost savings as a result of constructing the Yukon River Crossing RFD (including barge and air) are approximately

$446,500. This includes a $617,200 reduction in barge transportation costs offset by a $185,600 increase in truck transportation costs to move the fuel from Nenana to the Bridge RFD.[53, 54] This provides more potential benefits than an RFD at Tanana and given available road access of this site, construction costs are likely to be less than they would be at Tanana. Therefore, the Yukon River Crossing RFD is recommended over the Tanana RFD.

Benefits would accrue based on allowing Yukon River barges to operate fully loaded as opposed to being light loaded out of Nenana. By allowing the barges to carry up to 100,000 gallons more per trip, the number of trips needed to complete all required fuel deliveries is reduced. It is estimated that total barge miles traveled would decrease by approximately 5,000 miles per year.

Average annual costs of the RFD are estimated to be $247,900 including construction and O&M. This recommendation is estimated to product net average annual benefits of $198,600 and a benefit-to-cost ratio of 1.79. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2 Yukon River Local Improvements

Additional efficiencies could be gained through increased capacity at a number of Yukon River communities. As done previously, a village was recommended for additional capacity if installation additional capacity could eliminate a barge delivery to that community. These recommendations are discussed below and are in order of downriver to upriver.

3.3.2.1 Nunam Iqua

Nunam Iqua is located at the mouth of the Yukon River. The community currently consumes approximately 217,800 gallons of fuel per year and has storage of approximately 198,000 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of further tanks would not provide increased efficiencies, therefore one tank is the recommendation. Considerations surrounding this recommendation are shown below in Table 24.

Table 24: Additional Storage Considerations, Nunam Iqua

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	198,000	N/A
	Usage (gals)	217,763	
	% of Usage	31%	
100%	Total Gals. Needed	217,763	1
	Additional Gals. Needed	19,763	
	Additional Tanks Needed	1	
	With-Project Storage	244,600	

[53] Fuel is currently delivered to Nenana and is assumed to continue to be delivered to Nenana in the future without- and future with-project conditions. Since benefits are estimated by comparing future without- and future with-project conditions, this assumption is necessary in order to estimate potential benefits of the Bridge RFD.
[54] This analysis assumes trucks would be able to pull double tanks.

Benefits for this alternative vary greatly depending on barge operations. If fuel is lightered into Nunam Iqua from a deep-draft barge outside of the mouth of the Yukon, there are not sufficient benefits to justify this investment. However, if barges are dispatched from Nome, this investment would be justified with net annual benefits of $4,800 and a benefit-to-cost ratio of 1.16. Because of this uncertainty surrounding regular delivery patterns at this community, no recommendation is made for this alternative at this time.

3.3.2.2 Russian Mission

Russian Mission is located 218 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 354,000 gallons of fuel and has storage of approximately 261,000 gallons. Given barge capacities of 375,000 gallons, with the addition of two tanks, the community could receive its entire annual fuel needs in a single delivery. The addition of one tank would not eliminate a delivery and the addition of more than two tanks would not provide increased efficiencies. Considerations surrounding this alternative are shown below in Table 25.

Table 25: Additional Storage Considerations, Russian Mission

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	260,569	N/A
	Usage (gals)	353,553	
	% of Usage	74%	
100%	Total Gals. Needed	353,553	1
	Additional Gals. Needed	92,984	
	Additional Tanks Needed	2	
	With-Project Storage	353,769	

Installation of two additional tanks at Russian Mission (including O&M) has an average annual cost of $61,600 and provides $54,000 in average annual benefits. Therefore this alternative has net average annual benefits of ($7,600) and a benefit-to-cost ratio of 0.88. Because costs are greater than benefits, this alternative is not recommended for construction.

3.3.2.3 Anvik

Anvik is located 332 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 140,800 gallons of fuel per year and has storage of approximately 137,200 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation. Considerations surrounding this recommendation are shown below in Table 26.

Table 26: Additional Storage Considerations, Anvik

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	137,163	N/A
	Usage (gals)	140,787	
	% of Usage	97%	
	Total Gals. Needed	140,787	

100%	Additional Gals. Needed	3,624	1
	Additional Tanks Needed	1	
	With-Project Storage	183,763	

Installation of a single tank at Anvik (including O&M) has an average annual cost of $30,800 and provides $82,200 in average annual benefits for net average annual benefits of $51,400 and a benefit-to-cost ratio of 2.67. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.4 Shageluk

Shageluk is located 351 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 157,100 gallons of fuel per year and has storage of approximately 123,000 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 27.

Table 27: Additional Storage Considerations, Shageluk

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	122,997	N/A
	Usage (gals)	157,147	
	% of Usage	78%	
100%	Total Gals. Needed	157,147	1
	Additional Gals. Needed	34,150	
	Additional Tanks Needed	1	
	With-Project Storage	169,597	

Installation of a single tank at Shageluk (including O&M) bears an average annual cost of $30,800 and provides $86,900 in average annual benefits for net average annual benefits of $56,100 and a benefit-to-cost ratio of 2.82. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.5 Kaltag

Kaltag is located 470 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 230,300 gallons of fuel and has storage of approximately 264,500 gallons. The Denali Commission previously recommended that two fuel-related mooring points be installed at Kaltag near a fuel landing located at approximately 64°19’47.2”N, 158°43’28.0”W. The mooring points would be located 10 feet from the top of bank and 125 feet apart. The upstream mooring point would be above grade and the downstream mooring point would be below grade.

Installation of these mooring points has an average annual cost (including O&M) of $3,030 and average annual benefits of $3,250 for net average annual benefits of $221 and a benefit-to-cost ratio of 1.07. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.6 Nulato

Nulato is located 506 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 319,700 gallons of fuel per year and has storage of approximately 316,600 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 28.

Table 28: Additional Storage Considerations, Nulato

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	316,600	N/A
	Usage (gals)	319,666	
	% of Usage	99%	
100%	Total Gals. Needed	319,666	1
	Additional Gals. Needed	3,066	
	Additional Tanks Needed	1	
	With-Project Storage	363,200	

Installation of a single tank at Nulato (including O&M) has an average annual cost of $30,800 and provides $125,300 in average annual benefits for net average annual benefits of $94,500 and a benefit-to-cost ratio of 4.07. Because benefits are greater than costs, this alternative is recommended for construction.

The Denali Commission previously recommended that two fuel-related mooring points be installed at Nulato near a fuel landing located at approximately 64°43’7.3”N, 158°06’8.1”W. The mooring points would be located 20 feet shoreward of a revetment and 155 feet apart. The upstream mooring point would be above grade and the downstream mooring point would be below grade.

Installation of these mooring points has an average annual cost (including O&M) of $3,000 and average annual benefits of $4,500 for net average annual benefits of $1,500 and a benefit-to-cost ratio of 1.49. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.7 Koyukuk

Koyukuk is located at the confluence of the Yukon and Koykuk Rivers. The community currently consumes approximately 143,000 gallons of fuel per year and has storage of approximately 117,000 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 29.

Table 29: Additional Storage Considerations, Koyukuk

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	117,000	N/A
	Usage (gals)	142,884	
	% of Usage	82%	
100%	Total Gals. Needed	142,884	1
	Additional Gals. Needed	25,884	
	Additional Tanks Needed	1	
	With-Project Storage	163,600	

Installation of a single tank at Koyukuk (including O&M) has an average annual cost of $30,800 and provides $80,900 in average annual benefits for net average annual benefits of $50,100 and a benefit-to-cost ratio of 2.63. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.8 Huslia

Huslia is located on the Koyukuk River 713 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 260,800 gallons of fuel and has storage of approximately 167,700 gallons. Given barge capacities of 375,000 gallons, with the addition of two tanks, the community could receive its entire annual fuel needs in a single delivery. The addition of one tank would not eliminate a delivery and the addition of more than two tanks would not provide increased efficiencies. Considerations surrounding this alternative are shown below in Table 30.

Table 30: Additional Storage Considerations, Huslia

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	167,607	N/A
	Usage (gals)	260,774	
	% of Usage	64%	
100%	Total Gals. Needed	260,774	1
	Additional Gals. Needed	93,167	
	Additional Tanks Needed	2	
	With-Project Storage	260,807	

Installation of two additional tanks at Huslia (including O&M) has an average annual cost of $61,600 and provides $128,200 in average annual benefits. Therefore this alternative has net average annual benefits of $66,600 and a benefit-to-cost ratio of 2.08. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.9 Galena

The Denali Commission previously recommended that five fuel-related mooring points be installed at Galena in two locations. The first location is near a fuel landing located at approximately 64°44’02”N, 156°55’9.6”W. Two below grade mooring points would be located 23 feet from top of bank and 150 feet apart. The second location is near a fuel landing located at approximately 64°43’57”N, 156°56’9.5”W

Installation of these mooring points has an average annual cost (including O&M) of $7,600 and average annual benefits of $32,600 for net average annual benefits of $16,000 and a benefit-to-cost ratio of 3.11. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.10 Ruby

Ruby is located 609 miles upstream of the mouth of the Yukon River. The community currently consumes approximately 339,800 gallons of fuel and has storage of approximately 276,400 gallons. Given barge capacities of 375,000 gallons, with the addition of two tanks, the community could receive its entire annual fuel needs in a single delivery. The addition of one tank would not eliminate a delivery and the addition of more than two tanks would not provide increased efficiencies. Considerations surrounding this alternative are shown below in Table 30.

Table 31: Additional Storage Considerations, Ruby

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	276,410	N/A
	Usage (gals)	339,777	
	% of Usage	81%	
100%	Total Gals. Needed	339,777	1
	Additional Gals. Needed	63,369	
	Additional Tanks Needed	2	
	With-Project Storage	369,610	

Installation of two tanks at Ruby (including O&M) in the existing condition has positive net average annual benefits $180,500 and a benefit-to-cost ratio of 3.93. However, net average annual benefits fall to ($2,200) with a benefit-to-cost ratio of 0.96 with construction of a RFD at the Yukon River Bridge due to the benefits provided to Ruby by the RFD. Therefore, the installation of additional storage at Ruby is only recommended if the RFD at the Yukon River Bridge is not constructed.

The Denali Commission previously recommended that two fuel-related mooring points be installed at Ruby. Both mooring points would be above grade. The upstream mooring point would be located at approximately 64°44’29.1”N, 155°29’16.8”W. The downstream mooring point would be located at approximately 64°44’27.3”N, 155°29’26.8”W.

Installation of these mooring points has an average annual cost (including O&M) of $3,030 and average annual benefits of $4,800 for net average annual benefits of $1,500 and a benefit-to-cost ratio of 1.58. Because benefits are greater than costs, this alternative is recommended for construction.

3.3.2.11 Tanana

Tanana is located 725 miles upstream of the mouth of the Yukon River and 163 miles from Nenana. The community currently consumes approximately 295,071 gallons of fuel per year and has storage of approximately 260,000 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 32.

Table 32: Additional Storage Considerations, Tanana

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	260,000	N/A
	Usage (gals)	295,071	
	% of Usage	88%	
100%	Total Gals. Needed	295,074	1
	Additional Gals. Needed	35,071	
	Additional Tanks Needed	1	
	With-Project Storage	306,600	

Installation of an additional tank at Tanana (including O&M) in the existing condition has positive net average annual benefits $417,300 and a benefit-to-cost ratio of 10.7. However, net average annual benefits fall to ($100) with a benefit-to-cost ratio of 0.997 with construction of a RFD at the Yukon River Bridge due to the benefits provided to Tanana by the RFD. Therefore, if the RFD at the Yukon River Bridge is constructed, additional storage at Tanana may not be justified. Because of this uncertainty, no recommendation is made for this alternative at this time.

The Denali Commission previously recommended that five fuel-related mooring points be installed at Tanana at two locations. All mooring points would be below grade. The first location requires three mooring points near a fuel landing located at approximately 65°10’13.4”N, 152°04’49.1”W. The first mooring point would be located 75 feet upstream of the fuel header 3 feet from the edge of the road. The second mooring point would be located 85 feet downstream of the fuel header between the road and barge ramp. The third mooring point would be located 150 feet downstream of the fuel header 3 feet from the edge of the road.[55]

The second location requires two mooring points located at approximately 65°10’14.3”N, 152°05’7.4”W.

Installation of these mooring points has an average annual cost (including O&M) of $7,600 and average annual benefits of $4,200 for net average annual benefits of ($3,400) and a benefit-to-cost ratio of 0.55. Because costs are greater than benefits, this alternative is not recommended for construction.

[55] 6 feet downstream of the sewer cleanout

3.3.2.12 Beaver

Beaver is located 961 miles upstream of the mouth of the Yukon River and 399 miles from Nenana. The community currently consumes approximately 118,141 gallons of fuel per year and has storage of approximately 92,350 gallons. Given barge capacities of 375,000 gallons, with the addition of one 46,600-gallon tank, the community could receive its entire fuel needs in a single delivery. The installation of additional tanks would not provide increased efficiencies, therefore one tank is the recommendation.

Considerations surrounding this recommendation are shown below in Table 33.

Table 33: Additional Storage Considerations, Beaver

Breakpoint	Category	Amounts	Deliveries Eliminated
Current	Storage (gals)	92,350	N/A
	Usage (gals)	118,141	
	% of Usage	78%	
100%	Total Gals. Needed	118,141	1
	Additional Gals. Needed	25,791	
	Additional Tanks Needed	1	
	With-Project Storage	138,950	

Installation of an additional tank at Beaver (including O&M) in the existing condition has positive net average annual benefits $417,300 and a benefit-to-cost ratio of 14.6. However, net average annual benefits fall to ($3,080) with a benefit-to-cost ratio of 0.90 with construction of a RFD at the Yukon River Bridge due to the benefits provided to Beaver by the RFD. Therefore, the installation of additional storage at Beaver is only recommended if the RFD at the Yukon River Bridge is not constructed.

3.3.3 Summary of Yukon River Recommendations

In summary, the recommendations for the Yukon River include: a 375,000-gallon RFD at the Yukon River Crossing, one additional 46,600-gallon tank each at Anvik, Shageluk, Nulato, and Koyukuk, two additional 46,600-gallon tanks at Huslia, and various mooring points as previously discussed at Galena, Kaltag, Nulato, and Ruby. It is estimated that these improvements could reduce annual barge miles traveled by 9,000, or 34 percent.

The following tables summarize the construction and O&M costs as well as economic justification for the recommendations along the Yukon River.

Table 34: Cost Summary of Recommendations, Yukon River

Place	Item	Construction Cost	Annual O&M Cost
Yukon River Crossing	RFD	$8,176,500	$187,500
Anvik	1 Tank	$508,000	$11,700
Shageluk	1 Tank	$508,000	$11,700
Nulato	1 Tank	$508,000	$11,700
Koyukuk	1 Tank	$508,000	$11,700
Huslia	2 Tanks	$1,016,100	$23,300
Galena	Moorings	$39,300	$0
Kaltag	Moorings	$39,300	$0

Nulato	Moorings	$39,300	$0
Ruby	Moorings	$39,300	$0

Note: Values rounded to nearest $00's.

Table 35: Economic Summary of Recommendations, Yukon River

Place	Item	Avg. Annual Costs	Avg. Annual Benefits	Net Avg. Annual Benefits	BCR
Yukon River Crossing	RFD	$495,800	$2,414,700	$1,918,900	4.87
Anvik	1 Tank	$30,800	$82,200	$51,400	2.67
Shageluk	1 Tank	$30,800	$86,900	$56,100	2.82
Nulato	1 Tank	$30,800	$125,300	$94,500	4.07
Koyukuk	1 Tank	$30,800	$81,000	$50,100	2.63
Huslia	2 Tanks	$61,600	$128,200	$66,600	2.08
Galena	Moorings	$7,600	$23,600	$16,000	3.11
Kaltag	Moorings	$3,030	$3,250	$220	1.07
Nulato	Moorings	$3,030	$4,500	$1,480	1.49
Ruby	Moorings	$3,030	$4,800	$1,760	1.58

Note: Totals may not sum due to rounding.

3.4 Coastal Improvements

This section discusses recommendations for increasing efficiency of fuel deliveries on Alaska's western and northern coasts. This section does not make recommendations for additional storage at any one village as all villages have storage capacity that exceeds the amount of fuel that a lightering barge can deliver.

3.4.1 Portsite Improvements

Fuel delivery along Alaskan western and northern coasts is currently dominated by fuel originating from Seattle and/or Anchorage. Coastal barges deliver to various villages along the coast and must make occasional refueling journeys to the Anchorage area. These coastal barges are sometimes accompanied by lightering barges in order to reach villages with insufficient draft.

While there are a number of potential places where improvements may be beneficial such as Nome, Cape Blossom, and Port Clarence, a previous Corps study provided recommendations that utilized existing infrastructure to provide transportation cost savings related to fuel delivery and export of ore from the Red Dog Mine.[56]

In 2006, the Corps completed a study of fuel distribution along the western and northern coasts of Alaska. Estimates in that report suggest that fuel delivered from Singapore directly to the Alaska's west coast could provide savings on the delivered cost of fuel on the order of $0.15 per gallon.[57] Furthermore, there would be transportation cost savings in the form of reduced barge refueling trips to Anchorage or Seattle. Therefore, coastal and lightering barges could spend

[56] DeLong Mountain Terminal, Alaska Navigation Improvements Draft Interim Feasibility Report, September 2005
[57] Due to structural price differences available from Singapore.

more time actively delivering fuel to villages along the coast. There would also be a great deal of benefit to port operations at Portsite, which is the coastal port facility for Red Dog Mine.

Portsite is located approximately 15 marine miles south of Kivalina and 70 marine miles north of Kotzebue. Portsite's fuel storage capacity is such that it can store enough fuel to support the mine through the winter when the ocean is frozen and fuel barges are unable to deliver. Because of this built-in excess capacity, there is available storage during the summer months.

The recommended plan in the previous study was construction of a dredged channel to -53 feet Mean Lower Low Water (MLLW) and associated facilities in order to provide sufficient draft for a fuel tanker that drafts -40 feet MLLW to deliver to Portsite. The facility would then be used as a transshipment point for 30.1 million gallons of fuel per year to villages along the coast and in lower reaches of the rivers that were analyzed in previous sections (Figure 9). Additional transportation cost savings benefits would accrue to the mine through the use of larger bulk freighter vessels to offload ore from the mine.

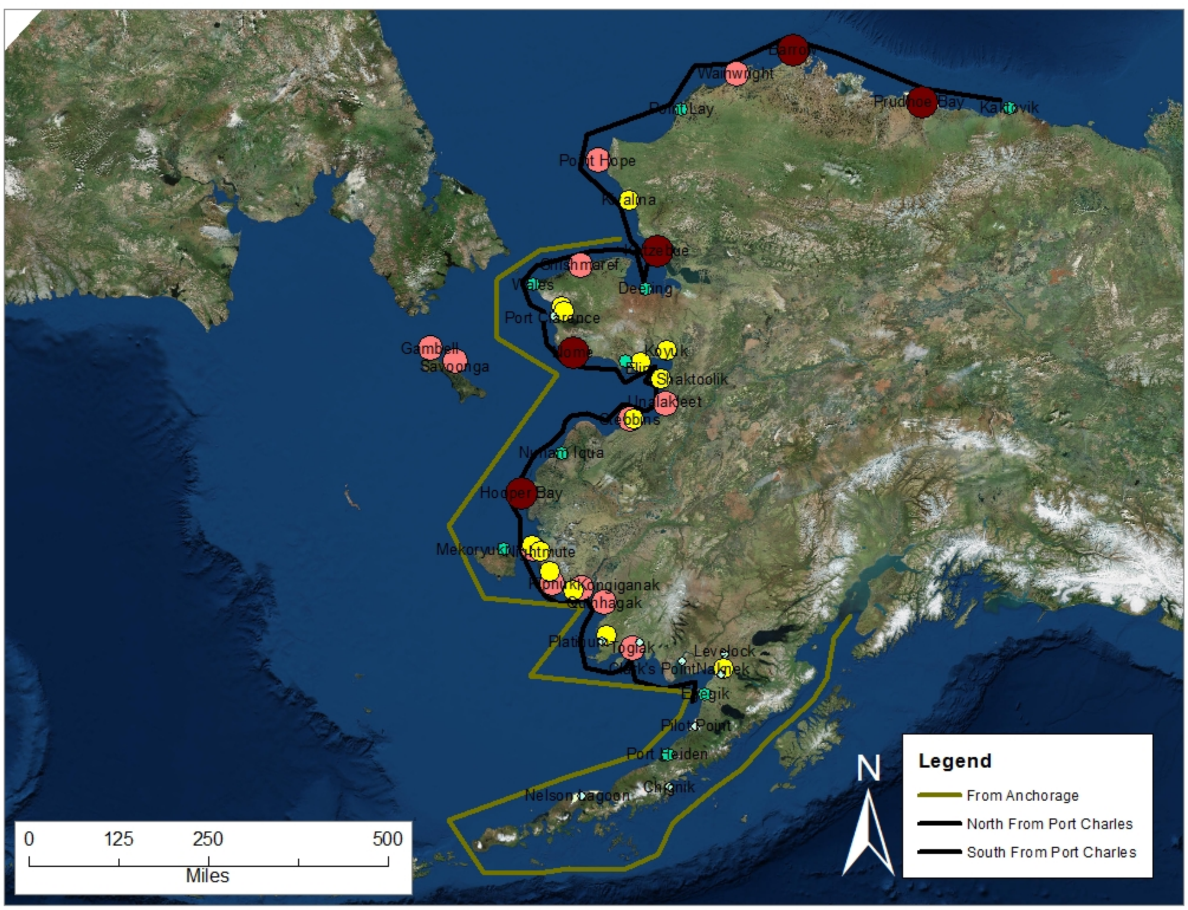

Figure 9: Coastal Study Area

There is some overlap in villages served by the previous sections' recommendations and this one. However, the benefits provided by this recommendation are expected to contain minimal double-counting. The recommendations in previous sections generally focused on increasing efficiencies of the existing delivery structure. The recommendation in this section decreases the delivered price of fuel to the hubs that service those villages. Therefore, double counting would only be present in village which were assumed in previous sections to not receive fuel from the coast that were assumed to receive benefits from this recommendation as well. The only villages that this applies to are Koyukuk and Galena. Average annual benefits from the Haul Road RFD for these villages were $91,000 for Koyukuk and $493,000 for Galena. Therefore that amount of average annual benefits has been subtracted from benefits expected to accrue as a result of improvements at Portsite.

Figure 10: Coastal Fuel Distribution (DeLong Alternative)

3.4.2 Summary of Previous Coastal Benefits

The 2006 Corps report that made recommendations for improvements at Portsite calculated average annual benefits of the improvements at $26.9 million with average annual costs of $22.3 million for net annual benefits of $4.6 million and a benefit to cost ratio of 1.20. These figures were updated to 2016 using the Corps of Engineers Civil Works Cost Index. Benefits accruing to Galena and Koyukuk due to recommendations for improvements on the Yukon River were subtracted from this total to eliminated double counting as much as possible. Table 36 shows a summary of these calculations.

Table 36: Summary of Benefits, Coast

Category	2005 Prices	2005 CCI	2016 CCI	2016 Prices	Galena/ Koyukuk	2016 Adjusted
Avg. Annual Costs	$22,340,000	612.13	868.52	$31,696,000		$31,696,000
Avg. Annual Benefits	$26,899,000	612.13	868.52	$38,165,000	($584,000)	$37,581,000
Net Annual Benefits	$4,559,000			$6,469,000		$5,885,000
BCR	1.20			1.20		1.19
Present Value	$114,578,000			$162,569,000		$147,889,000

3.4.3 Change in Existing and Future Without-Project Conditions

Between the time of the previous recommendations and the commencement of this effort, there was a change in the existing condition. Whereas existing conditions at the time of the previous report saw large coastal barges mobilize from Puget Sound to Alaska, at the time of this report, a tanker mobilizing from Vancouver has taken the place of the coastal barges, reducing the number of total vessel trips, and potentially reducing vessel operating costs in the new existing condition. Furthermore, while there may be very little change in price per gallon of fuel at the dock in Vancouver vis-à-vis Puget Sound, the tanker's voyage takes it from Vancouver to Japan. It is possible that the tanker is making return trips with fuel from Japan, which may or may not be cheaper than that in Puget Sound or Singapore.

A sensitivity analysis was conducted to anticipate what effect, if any, this change in condition may have on project viability. This analysis is shown in Table 37.

Table 37: Sensitivity Analysis

Benefit Category	Existing Benefits	Existing Percentage	Possible Reduction
Tug and Barge Cost	$10,788,300	40%	42%
Port & Queue	$3,333,200	12%	100%
Induced Tons	$1,707,900	6%	100%
Fuel	$11,002,400	41%	100%
Avoided Cost	$66,900	0%	41%
Avg. Annual Benefits	$26,898,700	100%	N/A
Avg. Annual Costs	$22,339,308		
Net Annual Benefits	$4,559,392		
BCR	1.20		

The Tug and Barge Cost benefit could be reduced by 42 percent before the project's BCR fell to 1.0 (all other categories being held equal). Similarly, the Fuel category (benefits from cheaper fuel from Singapore) could be reduced by 41 percent before the project's BCR fell to 1.0. All other categories could individually be reduced by 100 percent and the project would still be justified.

Because of the uncertainty surrounding this change in conditions, it is unclear at this time whether the recommendations contained in the DeLong Mountain Terminal feasibility report are still justified. Because of this, no recommendation is made in respect to the coastal alternative at this time.

3.5 Variance Analysis

Because of the highly uncertain nature of the existing and future without-project conditions, it is pertinent to discuss variances in assumptions about the existing condition that would lead to some of the preceding recommendations being rendered not cost effective. To test the resilience of the recommendations, an analysis was conducted in which the most efficient existing condition that could theoretically exist was constructed. This alternate existing condition assumes a single barge company, or all barge companies acting in a fully coordinated manner. Each barge would leave the hub fully loaded and deliver along the river at each community until it became empty, at which point it would return to the hub to refill.[58] Routings were optimized to the extent possible to approach the most optimally-efficient possible system. The recommendations were then re-examined against this more stringent baseline in order to determine if they were still justified.

The sections below discuss any changes that the recommendations would undergo as a result of this change in baseline assumption. It is important to note that the recommendations as stated above are still valid and supported as the existing condition that rendered those assumptions is

[58] The barge would fill a community's entire need, or to the barge's capacity, or to the community's storage limit, whichever came first. If a community could not fill its need in one delivery, the barge would return on a separate trips or trips until the community's need was filled.

itself conservative in nature. This analysis is meant to identify a set of recommendations that would still be justified under the most conservative assumptions about the existing condition.

3.5.1 Kobuk

There is no change to recommendations on the Kobuk River. The mooring points at both Noorvik and Kiana are still justified and saw no change in their net annual benefits.

3.5.2 Kuskokwim

Given the above-discussed change in baseline assumptions, the recommendation for the Kuskokwim changed. The net annual benefits for the standalone 300,000-gallon RFD at Aniak fell from $668,800 to $13,400 and the benefit-to-cost ratio fell from 4.26 to 1.07. However, this portion of the original Kuskokwim recommendations is still justified. Likewise, the mooring points at McGrath are still justified with no change to their net annual benefits. However, additional storage tanks at individual communities are no longer justified under this more conservative assumption.

Additionally, under this assumption, it is more cost effective to fly all of Nikolai's fuel in from Fairbanks rather than barge it from the RFD at Aniak. This is due not only to Nikolai's distance from Aniak (350 miles), but its incremental distance from McGrath (70 miles). It is estimated that delivery of all of Nikolai's fuel would cost $60,000 via air and would cost approximately $140,000 via barge in a scenario where a portion of Nikolai's fuel was delivered in conjunction with a delivery to McGrath and then filled the rest of the way with a dedicated light-loaded barge consistent with the change in baseline assumptions for barge operating patterns. This, of course, does not take into account the price differences between fuel delivered by air and that delivered by barge, which may negate all or a portion of the total cost savings. This finding would require additional study to be validated taking into account all factors of the delivered price of fuel to the end user.

3.5.3 Yukon

Given the change in baseline assumptions, only the mooring points at Galena, Kaltag, Nulato, and Ruby are still justified with no change to their net annual benefits. Net annual benefits for the Bridge RFD fell from $196,600 to ($179,600) and the benefit-to-cost ratio fell from 1.79 to 0.28. Likewise, all additional storage at individual communities would no longer be justified under this more conservative assumption.

3.5.4 Summary

Under the more conservative assumption for existing distribution operations, the recommendations that are still justified are a 300,000-gallon RFD at Aniak and mooring points at Noorvik, Kiana, McGrath, Galena, Kaltag, Nulato, and Ruby.

4.0 CONCLUSION AND FURTHER STUDIES

In summary, there appears to be a number of cost-effective measures that could be implemented throughout Alaska's riverine villages that would provide increased efficiency to fuel delivery operations. These measures range in cost from $40,000 mooring points to $4.1 million bulk fuel facilities, providing recommendations that are all economically justified at a range of costs and ease of implementation. Table 38 lists all recommendations.

Table 38: Ranking of all Recommendations by Net Average Annual Benefits (dollars)

Item	Avg. Annual Costs	Avg. Annual Benefits	Net Avg. Annual Benefits	BCR	Construction	O&M
Aniak RFD	$332,700	$874,000	$541,200	2.63	$5,593,600	$121,600
Stony River Tanks						
McGrath Tank						
Nikolai Tank						
Yukon River Crossing RFD	$247,900	$444,500	$196,600	1.79	$4,088,300	$93,750
Nulato Tank	$30,800	$125,300	$94,500	4.07	$508,000	$11,650
Huslia Tanks	$61,600	$128,200	$66,600	2.08	$508,000	$11,650
Shageluk Tank	$30,800	$86,900	$56,100	2.82	$508,000	$11,650
Anvik Tank	$30,800	$82,200	$51,400	2.67	$508,000	$11,650
Koyukuk Tank	$30,800	$81,000	$50,100	2.63	$508,000	$11,650
Galena Moorings	$7,600	$23,600	$16,000	3.11	$196,00	$0
Sleetmute Tank	$31,900	$41,600	$9,700	1.30	$535,900	$11,650
Noorvik Moorings	$3,000	$9,400	$6,300	3.09	$78,500	$0
Eek Tank	$31,900	$37,500	$5,600	1.18	$535,900	$11,650
Kiana Moorings	$3,000	$7,200	$4,200	2.38	$78,500	$0
Ruby Moorings	$3,000	$4,800	$1,800	1.58	$78,500	$0
Nulato Moorings	$3,000	$4,500	$1,500	1.49	$78,500	$0
Kaltag Moorings	$3,000	$3,300	$200	1.07	$78,500	$0

Note: Totals may not sum due to rounding

In addition to these recommendations, it appears that a great deal of efficiency could be gained by encouraging different buyers in communities to coordinate purchases and deliveries. The magnitude of those efficiencies is beyond the scope of this study, but could prove to be substantial.

There are a number of further studies that could either improve upon or lend further clarity to the information contained in this report. The first option is to conduct a series of site-specific studies. These studies could also attempt to gather details that were beyond the scope of this report such as detailed barge operations, multi-year data on fuel consumption, more accurate fuel storage levels, financing costs of holding fuel overwinter, etc.

A more robust analysis could be completed through partnering with the U.S. Army Corps of Engineering Inland Navigation Planning Center of Expertise (PCXIN). PCXIN has advanced modeling capability and experience in conducting feasibility-level analyses in the field of inland navigation.

Corps involvement in these studies would be under authority granted by Section 22 of Water Resources Development Act of 1974 (P.L. 93-251), as amended, commonly referred to as the Planning Assistance to States authority. This effort would allow for detailed analysis of single or smaller subsets of the recommendations.