Kivalina, Alaska

Evacuation / Relocation Road Feasibility Study

Submitted to:

Northwest Arctic Borough

October 2005

Submitted by:

ASCG
INCORPORATED
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EXECUTIVE SUMMARY

Kivalina is a traditional Inupiat Eskimo village located in northwest Alaska. Its precarious position on a low lying barrier island, between the Chukchi Sea and Kivalina Lagoon, and the severity of recent storms, have put the village at serious risk of being inundated by an ocean storm event.

Currently, there is no way for the villagers to escape the island by foot or wheeled vehicles; the only way to leave is by plane or boat. During a storm event both of these means of escape would be extremely dangerous, if not impossible. If a storm surge reaches a level where evacuation of the village is necessary, there is no way for people to evacuate.

The U.S. Army Corps of Engineers (USACE) is working with the village to identify a site on which to relocate the village. This process has been going on for approximately 10 years and the USACE estimates that it may take 15-20 more years to completely relocate the village. In the meantime, it is extremely important that an evacuation road be constructed that will allow the residents to escape from the barrier island, in the case of a severe storm event, and reach higher ground safely.

This Feasibility Study identifies various routes that will access a location that can be used as an Evacuation Destination Site. These routes were evaluated based on a set of criteria that includes:

1. The evacuation road must terminate at an elevation of at least 25 feet, which is thought to be an elevation safe from the effects of a realistic storm event;
2. The overall design and construction cost;
3. Other potential uses of the road, i.e. village relocation, gravel source, airport site, water source, etc.;
4. Maintenance requirements;
5. Right-of-way / property issues;
6. Environmental concerns; and
7. Length of time to construct.

Alternative Alignment 6, with the Alternative 8 Extension, has been recommended as the preferred alternative. This route begins in the village, crosses Kivalina Lagoon with a causeway and bridge, crosses the tundra, and terminates at Kisimigiuktuk Hill. This road will serve as a satisfactory evacuation route, while at the same time accessing a much needed gravel source. Depending on where the future village relocation site is located, it is likely that all or part of this road can be used in the relocation efforts. The road also accesses potential airport sites. The estimated cost of this alternative, in 2005 dollars, is $21,300,000.

Given the emergency nature of the project, it is recommended that all means to accelerate and streamline the funding, design, permitting, and construction processes be pursued.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Figures

Tables

Appendices

AASHTO	American Assoc. of State Highway and Transportation Officials
ADOT&PF	Alaska Department of Transportation and Public Facilities
ANCSA	Alaska Native Claims Settlement Act
ASCG	ASCG, Incorporated (A NANA Subsidiary Engineering Firm)
ATV	All-Terrain Vehicle
AVEC	Alaska Village Electric Co-operative
DNR	Alaska Department of Natural Resources
°F	Degrees Fahrenheit
FAA	Federal Aviation Administration
H	Horizontal
IRA	Indian Reorganization Act
M	Million
MSL	Mean Sea Level
Mph	Miles Per Hour
N	North
NANA	NANA Regional Corporation
NFS	Non-Frost Susceptible
NNW	North-Northwest
NAB	Northwest Arctic Borough
OHMP	Office of Habitat Management and Permitting
P.E.	Professional Engineer
ROM	Rough Order of Magnitude
ROW	Right-of-Way
SSE	South-Southeast
U.S.	United States
USACE	U.S. Army Corps of Engineers
V	Vertical
W	West
$	Dollars
%	Percent

1. INTRODUCTION

1.1 Purpose of Report

On August 23, 2005, ASCG, Incorporated (ASCG) contracted with the Northwest Arctic Borough (NAB) to perform an Evacuation / Relocation Road Feasibility Study in the Village of Kivalina, Alaska. The NAB is responsible for the protection and preservation of the safety and well being of borough residents. The NAB emergency management officials have determined that there exists a dire need for an evacuation route off the barrier island in order to protect Kivalina residents from severe storm inundation. The NAB has also been endorsed by the City of Kivalina to act as the lead entity for matters relating to the Kivalina Relocation.

The purpose of this study is to identify possible evacuation routes, evaluate the feasibility of each route, and provide recommendations for a preferred route. It is intended that this report be used to give funding agencies a clear and concise understanding of the need for an evacuation road in Kivalina and to obtain the necessary project funding to design and construct it.

This report provides general background information on Kivalina and its residents, outlines the design standards and criteria that should be used, describes various alternative route alignments and roadway sections, identifies environmental concerns and constraints, provides conceptual construction costs (in 2005 dollars) for the various alternatives, evaluates the various alternatives, and provides recommendations.

1.2 Need for Project

On September 29, 2005, the joint councils of the City of Kivalina and the Native Village of Kivalina passed Resolution 2005-02, declaring that a "Disaster and Continuing State of Emergency does exist [in Kivalina]...due to the fact that critical infrastructure such as the airport, power plant, and the school, which are all necessary components of the Evacuation Plan and Procedures for Kivalina and are all at risk of being damaged and/or lost." The following day, September 30, 2005, the mayor of the NAB also declared "that a disaster condition exists in the Borough community of Kivalina."

So far this 2005 fall storm season, two storms have caused considerable erosion damage to the community. Significant erosion also occurred in 2004. In some areas, especially near the Northwest Arctic Borough School District facilities and near the Alaska Village Electric Co-operative (AVEC) bulk fuel storage facility, as much as 69 feet of beach has eroded since 2004, leaving critical infrastructure at significant risk. One more similarly sized storm could undermine bulk fuel tanks, damage the runway, and/or wash away structures. Already, numerous power poles and a sanitary leachfield have been destroyed.

The storm on September 22-24, 2005, which caused significant erosion and loss of land, was estimated to have a storm surge height of 8.5 feet above mean sea level (MSL). The average elevation of the village is between 9 and 10 feet above MSL. The FAA states that the runway is at an elevation of 10 feet above MSL. The 100-year storm surge has been calculated by the US Army Corps of Engineers (USACE) to be 16.3 feet above MSL.

With the frequency of severe storm events apparently increasing, it is just a matter of time before "The Big One" hits. Because Kivalina is situated on a barrier island, with no road leaving the island, a storm event of only slightly greater magnitude than has occurred the last two years cold have catastrophic results if it occurs before an evacuation road is built or the village is relocated. With no way to evacuate off the island, the current Evacuation Plan states that the residents should assemble in the school building. While the school is the safest place in the village, it is by no means guaranteed to withstand a significant flood/storm surge event. If the school became damaged, the residents would have no alternative location to evacuate and would then be at the mercy of the storm. The likelihood of being washed away and drowning, and hypothermia would be great and significant loss of life could result, especially to the children and elderly. Survivors would also have difficulty after the storm, as it would be likely that the runway would be destroyed as well as all of the structures. Rescue would have to be by helicopter and boat from Kotzebue, which would take considerable time.

Understandably, the residents are becoming more and more anxious and concerned for their safety, especially for their children. The USACE is currently working with Kivalina to select a site in which to relocate the village. However, this will be a lengthy process. The USACE estimates that it may take between 15 and 20 years to complete the relocation effort. In the meantime, Kivalina is at great risk, as the recent storms have significantly reduced the buffer zone between the village and the Chukchi Sea. An evacuation road is desperately needed and needed quickly.

1.3 Support for the Project

On August 23, 2005, the NAB Assembly passed Resolution 05-51, authorizing the mayor to enter into a professional services contract with the engineering firm ASCG to complete a feasibility study of an evacuation / relocation road for the village of Kivalina, Alaska. The NAB fully realizes that Kivalina is extremely vulnerable to a severe storm event, not only to erosion and the resulting property damage, but also to the potential loss of life due to inundation of the ocean. The NAB, a partner in the Kivalina Relocation Planning effort, also recognizes that an evacuation road may be all or part of a road that will be needed during the village relocation effort. For these reasons, the NAB is aggressively pursuing federal funding to construct this evacuation road.

On September 29, 2005, the NAB held a meeting in Kivalina to present the recently completed Kivalina Emergency Evacuation Plan and to discuss the evacuation road. ASCG was present at this meeting, which was well attended by the community. All present understood the need for and fully supported an evacuation road.

2. BACKGROUND INFORMATION

2.1 Location and Access

Kivalina is located in northwestern Alaska, within the Northwest Arctic Borough. It is approximately 80 miles northwest of Kotzebue, 520 miles northwest of Fairbanks, 360 miles southwest of Barrow, and 83 miles north of the Arctic Circle. (See Figure 1 – Location Map, at the end of this section.) The village is situated on the southeast tip of a 5.5-mile long barrier island located between the Chukchi Sea (Arctic Ocean) and Kivalina Lagoon.

Kivalina is in the Kotzebue Recording District and the townsite is located in Section 21, Township 27 N, Range 26 W, of the Kateel River Meridian. The community's geographical coordinates are approximately 67° 43' North, 164° 32' West. Village lands lie within an approximately 20-mile radius (inland) of the townsite.

Access into and out of Kivalina is primarily by plane and barge. A 3,000-foot long, gravel airstrip, located just to the northwest of the village, accommodates regularly scheduled and charter air service from Kotzebue. Crowley Marine Services barges goods from Kotzebue during July and August. The Chukchi Sea is generally ice-free and open to boat traffic from mid-June to early November.

There are no roads to Kivalina. However, in the winter there are marked snow machine trails connecting to other villages and Kotzebue. There are also numerous subsistence trails within the area. Depending on the season, small boats, snow machines, all-terrain vehicles (ATVs), and/or full-sized vehicles are used for local transportation.

2.2 Population and Economy

At the time of the 2000 U.S. Census, the population of Kivalina was 377. Alaska Natives represented 96.6% of the population. The 2000 Census also revealed that the average household had approximately 4.83 persons in it. Between 1970 and 2000, Kivalina's population increased from 188 to 377, which is an annual increase of 2.3%. If this trend continues, Kivalina would have a population of 600 in the year 2020.

The people of Kivalina primarily depend on traditional subsistence practices, combined with a modern wage economy. Employment opportunities are limited, but there is some employment through the City, Village Council, school, Maniilaq Association, and local stores. The Red Dog Mine (zinc mine located approximately 53 miles northeast of the village) also offers some employment. Six residents hold commercial fishing permits. Native carvings and jewelry are produced from ivory and whale bone.

Subsistence hunting is the village's primary source of meat. Subsistence foods harvested include seal, walrus, whale, salmon, whitefish, and caribou. Kivalina is one of the ten whaling communities in the Alaska Eskimo Whaling Commission. In accordance with International Whaling Commission (IWC) rules, Alaska Native whalers can legally hunt an allocated number of bowhead whales each year for food, oil, and Native craft materials.

At the time of the 2000 Census, the median household income was $30,833. The official unemployment rate was 25.5% and there were an estimated 164 jobs in the community.

2.3 Government

Kivalina was incorporated as a second class city in 1969, and currently lies within the Northwest Arctic Borough. The Native Village of Kivalina, a federally recognized tribe, is located within the community. The Kivalina IRA Council governs Native affairs in the community.

Contact information is listed below.

City of Kivalina
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Kivalina, AK 99750
Phone: (907) 645-2137
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Mayor: Austin Swan

Northwest Arctic Borough
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Kotzebue, Alaska 99752
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Fax: (907) 442-2930
E-mail: tbolen@nwabor.org
Public Services Director: Thomas K. Bolen

Native Village of Kivalina
Kivalina IRA Council
P.O. Box 50051
Kivalina, AK 99750
Phone: (907) 645-2153
Fax: (907) 645-2193
E-mail: colleen.swan@kivaliniq.org
President: Jerry Norton
Tribal Administrator: Colleen Swan

While not governments, the NANA Regional Corporation and Maniilaq Association (a regional non-profit tribal consortium providing health, tribal, and social services) also serve the Native community.

Contact information is listed below.

NANA Regional Corporation
P.O. Box 49
Kotzebue, Alaska 99752
Phone: (907) 442-3301
Fax: (907) 442-2866
E-mail: marie.greene@nana.com
President: Marie Greene

Maniilaq Association
P.O. Box 256
Kotzebue, Alaska 99752
Phone: 1-800-478-3312
E-mail: hbolen@maniilaq.org
President / CEO: Helen Bolen

2.4 History and Culture

The northwest coastal region of Alaska has been inhabited for thousands of years by Inupiat Eskimos. Coastal Inupiat residents had established villages and trading routes long before European contact and exploration. The area around Kivalina was a traditional stopping-off point for travelers between Arctic coastal communities and Kotzebue Sound communities. In the mid-19th century, the people of Kivalina lived in small settlements along the Wulik, Kivalina, and upper Kukpuk Rivers. The Kivalina settlement was first recorded as "Kivualinagmut" in 1847 by the Russian Imperial Navy. At that time it was located at the northern end of Kivalina Lagoon. In 1885, the U.S. Navy recorded the village as "Kuveleek."

The community settled at their present village townsite in 1905 when the federal government built a school on the island. A post office was established in Kivalina in 1940, and an air airstrip was built in 1960. Kivalina was incorporated as a second class city in 1969. Construction of a new school, new houses, and an electric system followed in the 1970's.

Kivalina is a traditional Inupiat Eskimo village, whose traditional culture is based on subsistence hunting and gathering of whales, fish, caribou, moose, berries, and root plants. Today the people of Kivalina combine a subsistence lifestyle with a modern wage economy. Despite the geographic isolation of the village, the residents are served by daily air service from Kotzebue, satellite dishes, long-distance telephone service, and internet. However, the residents strive to preserve traditional ties to the land through hunting, whaling, fishing, gathering, and native craft activities, employing the skills and values that have been passed down for generations.

2.5 Infrastructure – Housing, Utilities, and Services

The 2000 U.S. Census reported 80 houses in Kivalina; 78 were occupied year-round, and 2 were vacant. There is currently a serious housing shortage in Kivalina, causing overcrowding in existing residences and forcing families to leave the village due to a lack of housing and expansion options.

There are no piped water services to the homes in Kivalina. Residents obtain treated water from the watering point at the washeteria (community laundry, restroom, and shower facility). They use small trailers towed by ATV's to transport the water to their homes. Approximately one-third of homes have water storage tanks to provide running water for the kitchen. The village water system consists of a raw water storage tank, a small water treatment plant, and a treated water storage tank. Water transmission lines extend from the treated water storage tank to the washeteria, clinic, and school.

There are also no piped sewer services to the homes. Residents use "honey-buckets" (5-gallon buckets, lined with plastic bags) for toilets in their homes. The honey-buckets are emptied into a containment bunker near the north end of the landfill, over a mile away. Residents dispose of their non-septic wastewater (grey water) outside of their houses. The washeteria, clinic, and school have septic systems.

The landfill is located a few hundred yards beyond the end of the runway, approximately one mile northwest of the village center, and extends for approximately 500 yards. Residents are responsible for transporting their waste to the landfill. The close proximity of the landfill to the runway is an FAA violation, and a serious safety concern due to bird interference with planes.

The Alaska Village Electric Cooperative (AVEC) owns and operates the electric service. All occupied homes are connected to the community's electrical distribution system. Telephone and internet services are provided by OTZ Telephone Cooperative, GCI, and Maniilaq. Most homes have satellite television. Fuel oil is the primary heat source.

Kivalina's school, McQueen School, includes grades pre-kindergarten through grade 12, and is administered by the Northwest Arctic Borough School District. In the fall of 2005 the school had 134 students and 10 teachers.

Local health care is provided by the Kivalina Health Clinic. Emergency service is provided by volunteers and a health aide. Auxiliary health care is obtained in Kotzebue and Fairbanks.

Other structures in the community include the following government, commercial, and public facilities: City Hall/IRA Office, Kivalina Native store and warehouse, community hall, post office, public safety/city jail, Alaska Army National Guard, Kivalina Friends Church, Epiphany Church (Episcopal), heavy equipment storage building, and ADOT&PF hangar.

2.6 Infrastructure – Transportation

2.6.1 Roads

There are approximately 1.5 miles of roads/streets/trails in Kivalina. These roads were not engineered or built to any standards, but have evolved into roads from use over time. The roads are not maintained or surfaced with crushed gravel and are in need of grading and surfacing. The traveled ways range from between 10 and 20 feet in width.

Most families in Kivalina own at least one ATV and one snowmachine. There are also a few full-sized vehicles in the community. The City of Kivalina owns a backhoe/loader and a small dump truck. ADOT&PF owns a grader, front-end loader, and small dozer, used for runway maintenance.

2.6.2 Bridges

There are no bridges in Kivalina.

2.6.3 Airports

The ADOT&PF owns and operates the airport located just northwest of, and adjacent to, the village. The gravel-surfaced runway is approximately 3,000 feet long by 60 feet wide, oriented in a NNW - SSE direction, and is lit by medium intensity runway edge lights. The airport is unattended, but is maintained by the ADOT&PF.

2.6.4 Barge Landings

Kivalina does not have a developed barge landing facility. Barges currently off-load on the beach along the ocean front.

2.7 Land Ownership and Right-of-Way

Under Section 12(a) of the Alaska Native Claims Settlement Act (ANCSA), the local Village Corporation was entitled to select the surface rights to 92,160 acres of land. The Village Corporation has since merged with NANA Regional Corporation. Village lands are now held and managed by NANA. The regional corporation, NANA, owns the subsurface rights. There have been no ANCSA 14(c)(3) actions in Kivalina. Village lands are located adjacent to Kivalina Lagoon and Chukchi Sea, within an approximately 20-mile radius of the townsite.

Street rights-of-way (ROW) were provided for in the Kivalina Townsite Survey (US Survey No. 5582). ROW varies from 20 to 40 feet; however there are numerous buildings and obstacles located within the ROW. In addition to the platted roadways, there are unplatted roads which have evolved from local traffic patterns.

There are numerous Native Allotments located throughout Kivalina and NANA lands surrounding the village, primarily along the Kivalina and Wulik Rivers. The known Native allotments are shown in Figure 2.

2.8 Topography and Soils

Kivalina is located at the southeastern tip of an approximately 5.5-mile long barrier island separating Kivalina Lagoon from the Chukchi Sea. The island is part of a 9.5-mile long barrier reef. Two tidal inlets define the island: Singauk Entrance, by the village, and Kivalik Inlet, 5.5 miles to the northwest.

Two rivers flow into Kivalina Lagoon: the Kivalina River at the northern end and the Wulik River at the southern end. The flood plains of both rivers are broad and braided.

Kivalina is located in a low-lying coastal area characterized by gently sloping hills and broad expanses of tundra. Vegetation consists of low growing shrubs and mosses.

Soils near the beach are gravel and sands, with ice-rich frozen silts further inland. The existing village site is situated on well-drained, noncohesive, non-frost susceptible (NFS) sands and gravels. Low-lying portions of land surrounding Kivalina are covered with unconsolidated Quaternary deposits of unknown thickness, ranging in grain size from clay to gravel.

Permafrost in the area is continuous and may be 600 feet deep. The active soil layer extends down 3 to 4 feet in well drained areas but may be only 18 inches in wetter soils. There is a potential for thaw bulbs in the vicinity of the Wulik and Kivalina Rivers.

2.9 Gravel Sources

There are no developed gravel sources in the Kivalina area. Gravel is available from the barrier island itself, but because of the narrowness of the island, this source will not be acceptable for large projects requiring significant amounts of fill. Both an evacuation road and the village relocation will require substantial amounts of gravel fill material. An economical source of gravel must be found nearby or else gravel will have to be barged from Kotzebue or Nome, at a considerable price. For these types of projects, gravel is the largest single cost item.

A gravel investigation performed by DOWL/BBFM in 1998 found sources of adequate granular borrow material located along the beach areas and the berms of the Wulik River. These sites, located on land controlled by NANA and on Native allotments, were estimated to contain more than 260,000 cubic yards of gravel. However, extraction of gravel from the Wulik River would disturb a large area and is not desired by the community, as it will likely negatively affect subsistence activities and the local ecology.

Other potential gravel sources include areas near Imnakuk Bluffs, Tatchim Isua, and Kisimigiuktik Hill. These sites have not been explored in detail, so the quality and quantity of any gravel reserves in these locations are not known at this time. There are no roads to any of these sites.

2.10 Climate

Kivalina is located within Alaska's Transitional Climatic Zone. Temperatures in July typically range from 43 °F to 54 °F, while in January temperatures range from -16 °F to -1 °F. The temperature extremes are from -54 °F to 85 °F. Prevailing winds are from the northeast, with the maximum wind speed recorded at 54 mph. The orientation of the barrier island perpendicular to the prevailing winter winds results in heavy snow drifting across the primary roads and the runway.

The following data were interpolated from the *Environmental Atlas of Alaska* and are applicable to the project area:

Mean Annual Precipitation .... 18 inches
Mean Annual Snowfall .... 40 inches
Mean Annual Temperature .... 19 °F
Thawing Index .... 1,400 °F - days
Design Thawing Index .... 2,250 °F - days
Freezing Index .... 6,200 °F - days
Design Freezing Index .... 6,550 °F - days

2.11 Natural Hazards

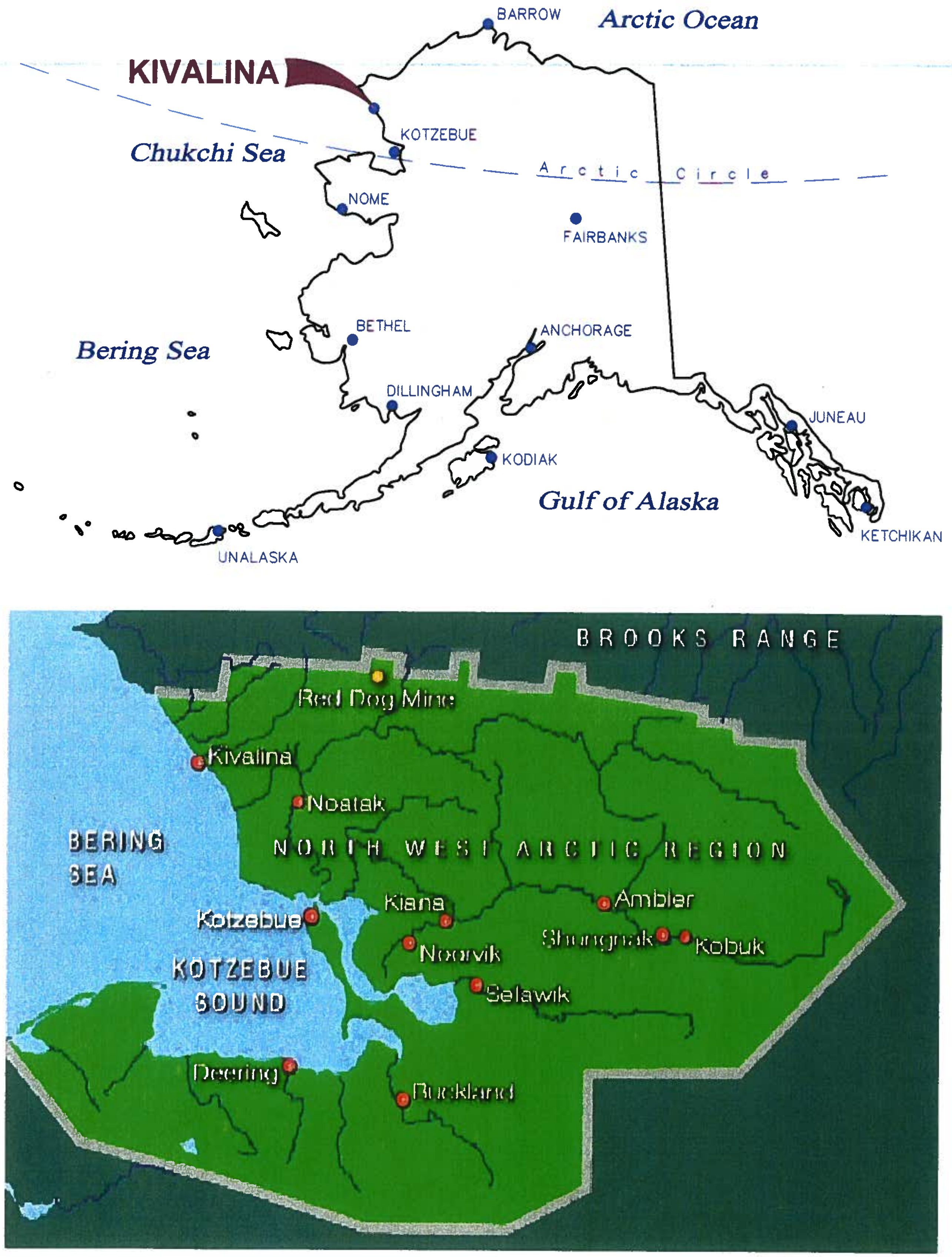
The precipitous location of Kivalina, on a narrow barrier island along the ocean, puts the village at significant risk of a storm surge washing over the village in a high-water event. The island has the overall appearance of a barrier island migrating shoreward, with a steep beach profile on the seaward shore, and sandy spit depositions on the lagoon side.

In the working draft of the Letter Report entitled, "*Reformulation of Water-Surface Elevation Frequency-of-Occurrence Relationships for Kivalina, Alaska,*" the USACE states that the 100-year water-surface elevation, due to storm surge, is 4.97 meters (16.3 feet) above MSL. The average elevation of the village is less than 10 feet above MSL. The threat of a storm surge that could inundate Kivalina is severe. When the 100-year storm surge event hits Kivalina, the entire village will be under approximately 6 feet of water.

The island is subject to severe erosion on three sides: along the ocean side, near Singauk Entrance at the south tip of the village, and on the lagoon side where the flow from the Wulik and Kivalina Rivers converge. Erosion has been occurring steadily for over two decades, with signs of acceleration in recent years. In 2004, over 40 feet of shoreline was lost during one storm event. Already, in the 2005 storm season, an additional 20 feet has been lost in places. There are many structures that are in danger of being damaged or destroyed by the effects of the beach erosion. Appendix B includes photos showing some of the problem areas.

Effects of global climate change are most significant in Arctic regions. Since the early 1980's, the time between spring break-up of sea ice and autumn freeze-up along Arctic shorelines has increased from barely three months to as much as five months. This substantially extends the time window for coastal erosion, as well as for significant damage from storm surges.

Kivalina is in seismic risk zone one (low risk).



NORTHWEST ARCTIC BOROUGH INCORPORATED JUNE 2, 1986

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Location Map
Evacuation / Relocation Road Feas. Study

Kivalina, Alaska
Northwest Arctic Borough

Job No.:	4837
Date:	Oct. 2005
Drawn By:	SEC
Checked By:	SEC
Figure No.	1

3. DESIGN STANDARDS AND CRITERIA

3.1 Design Standards

Because of the importance of this road, as the only evacuation route out of the village, and because this road will most likely also be used to relocate the village, it should be designed to the standards normally used for permanent roads. The following design standards should be used:

- Alaska Department of Transportation & Public Facilities' (ADOT&PF's) *Preconstruction Manual*;
- American Association of State Highway and Transportation Officials' (AASHTO's) *A Policy on Geometric Design of Highways and Streets*;
- AASHTO's Guidelines for Geometric Design of Very Low-Volume Local Roads, 2001 (GDVLVLR);
- ADOT&PF's Alaska Highway Drainage Manual (HDM); and
- AASHTO's Standard Specifications for Highway Bridges.

3.2 Roadway Classification

AASHTO and ADOT&PF would classify this evacuation road as a Rural Collector.

3.3 Design Controls and Criteria

3.3.1 Design Loads / Vehicles

The road and bridges should be designed to carry heavy truck traffic, as this road will eventually be used to relocate the village. The ADOT&PF Bridge Design Division will require that the design load be an HS-20 load rating, as defined by AASHTO.

The design vehicle should be a WB-40 Intermediate semi-trailer, as this type of vehicle will probably be used to relocate the buildings to the future village relocation site. Also, the barge landing will remain at the ocean beach, so all freight will have to be hauled to the new village site along this road.

3.3.2 Traffic Volume

The future traffic volume of the road is not known. Because of the tie to the ocean, considerable traffic will occur between the lagoon and the future village site. It is likely that boats and skiffs will be moored in the lagoon. As mentioned above, the barge landing will remain at the ocean beach. Also, it may be some time before a new airport is built near the new village site, necessitating the continued use of the existing airport.

3.4 Cross Section Elements

3.4.1 Surface Type

The new road should be designed as a gravel surfaced road. Crushed material, such as ADOT&PF aggregate gradation type D-1 or E-1, is recommended. This material will perform better, require less maintenance, and will be less dusty than a lower quality material.

It is likely that bridge decks will be surfaced with timber planks or steel grating.

3.4.2 Roadway Width

The road should be designed as a 24-foot wide road. This will allow for two 10-foot traffic lanes and 2-foot shoulders on each side.

3.4.3 Side Slopes and Cross Slopes

Side slopes should be kept as steep as possible for two reasons. First, steeper slopes require less gravel. Second, steep slopes better protect the permafrost from thawing. At the same time, it will be important to maintain a slope that will not slough and create a maintenance problem.

At this time, it is expected that roads over tundra will have side slopes of 2.5H:1V. If a causeway is built, the side slopes will likely be 4H:1V to maintain a manageable slope in the water.

4. ROAD ALIGNMENT ALTERNATIVES

4.1 Overview

Six road alignment alternatives are identified in this Feasibility Study. Each alternative is briefly described below. More detailed descriptions and discussions on each alternative are included in the following sections. Refer to Figure 2 for the locations of the evacuation road alternatives and termination points.

Alternative 1 connects the existing village to Evacuation Road Termination Point A, at the Tatchim Isua site. It generally follows the barrier island and spit to the northwest and then heads inland to the 25-foot elevation. Alternative 1 is approximately 10.6 miles long and includes a 475-foot bridge.

Alternative 2 connects the existing village to Evacuation Road Termination Point B, near the Igrugaivik site. It generally follows the barrier spit to the southeast and then heads inland to the 25-foot elevation. Alternative 2 is approximately 3.1 miles long and includes a 475-foot bridge and a 60-foot bridge.

Alternative 3 connects the existing village to Evacuation Road Termination Point C. It generally follows the barrier island to the northwest, heads northeast across the lagoon, and then continues inland to the 25-foot elevation. Alternative 3 is approximately 4.4 miles long and includes a 0.7-mile causeway and a 60-foot bridge.

Alternative 4 extends Alternative 3 to Evacuation Road Termination Point E, at the Simiq site. From Termination Point C, it continues east-northeast to a hill at elevation 80 feet. Alternative 4 is approximately 6.4 miles long and includes a 0.7-mile causeway and a 60-foot bridge.

Alternative 5 connects the existing village to Evacuation Road Termination Point D. From the village, it heads northeast across Kivalina Lagoon and then continues inland to the 25-foot elevation. Alternative 5 is approximately 2.9 miles long and includes a 0.5-mile causeway and a 60-foot bridge.

Alternative 6 extends Alternative 5 to Evacuation Road Termination Point E, at the Simiq site. From Termination Point D, it continues north to a hill at elevation 80 feet. Alternative 6 is approximately 4.5 miles long and includes a 0.5-mile causeway and a 60-foot bridge.

While Alternatives 7 and 8 are probably not feasible as routes to evacuation road termination points, they have been included in this study because they show possible routes to potential gravel sources. Both routes are possible extensions from Evacuation Road Termination Point E.

Alternative 7 is a route connecting Termination Point E to Termination Point F, near Imnakuk Bluff. From Termination Point E, it heads generally northwest to the Kivalina River, crosses the river, and then continues to the bluffs. This section of road is approximately 3.6 miles long and includes a 350-foot bridge.

Alternative 8 is a route connecting Termination Point E to Termination Point G, near Kisimigiuktuk Hill. From Termination Point E, it heads generally northeast to the base of the hill at elevation 100 feet. This section of road is approximately 2.9 miles long.

4.2 Alternative 1: Northwest Along the Barrier Island to the Tatchim Isua Site

Beginning at the northwest end of the village, near the southeast end of the runway, Alternative 1 heads northwest, paralleling the runway, and then continuing along the center of the island, over sandy gravel soils, for approximately 5.2 miles to Kivalik Inlet. A 475-foot bridge would cross the inlet opening. The road would continue northwest along the gravelly spit for another 3.0 miles, crossing two Native allotments. The elevation of most of the island and spit is approximately 10 feet above sea level. At the northwest end of the spit, the road would head across the tundra for 2.4 miles, generally north-northeast around the northwest end of the lagoon, to the 25-foot elevation, also crossing two Native allotments. The road would end at Termination Point A, between the lagoon and Asikpak Mountain, at the west side of the Tatchim Isua village relocation site.

The total length of Alternative 1 is approximately 10.6 miles, including a 475-foot long bridge, all of which will require right-of-way. The land along this route is controlled by the State of Alaska (airport), NANA, and private landholders (Native allotments).

4.3 Alternative 2: Southeast Along the Spit to the Igrugaivik Site

Beginning at the southeast end of the village, an approximately 375-foot bridge would cross Singauk Entrance to the southeast. The road would then continue to the southeast along the spit, over sandy gravel soils, for approximately 0.8 mile. The elevation of most of the spit is approximately 10 feet above sea level. Near Igrugaivik Creek, the road would head east across the tundra for 1.6 miles through the potential village relocation site of Kiniktuuraq to a creek crossing, requiring a 60-foot bridge. The road would then head northeast for 0.7 mile, through the potential village relocation site of Igrugaivik, to an elevation of 25 feet. The road would end at Termination Point B, just to the east of the Igrugaivik site.

The total length of Alternative 2 is approximately 3.1 miles, including 375-foot and 60-foot long bridges, all of which will require right-of-way. The land along this route is controlled by NANA. There are no known Native allotments along this route.

4.4 Alternative 3: Northwest Along the Island, Across Kivalina Lagoon, and then Northeast to the 25-Foot Elevation

Beginning at the northwest end of the village, near the southeast end of the runway, Alternative 3 heads northwest, paralleling the runway, and then continuing along the center of the island, over sandy gravel soils, for approximately 2.2 miles. The elevation of most of the island is approximately 10 feet above sea level. The road would then turn northeast and cross Kivalina Lagoon with a causeway and bridge. The causeway would be 0.7 mile long and have a 60-foot long bridge crossing the main channel of the lagoon. On the far side of the lagoon, the road would head northeast across the tundra for 1.6

miles, following a slightly elevated ridge, to the 25-foot elevation. The road would end at Termination Point C, just south of a large lake.

The total length of Alternative 3 is approximately 4.4 miles, including 3.7 miles of road, 0.7 mile of causeway, and a 60-foot long bridge, all of which will require right-of-way. The land along this route is controlled by the State of Alaska (airport) and NANA. There are no known native allotments along this route.

4.5 Alternative 4: Continue Alternative 3 to the Simiq Site

Alternative 4 would continue Alternative 3 to the east across the tundra for approximately 1.3 miles. It would then head northeast for 0.6 mile to Termination Point E, located on a hill at elevation 80 feet, just north of two medium sized lakes, and within the Simiq village relocation site.

The total length of Alternative 4 is approximately 6.4 miles, including 5.7 miles of road, 0.7 mile of causeway, and a 60-foot long bridge, all of which will require right-of-way. The land along this route is controlled by the State of Alaska (airport) and NANA. There are no known Native allotments along this route.

4.6 Alternative 5: Across Kivalina Lagoon and then Northeast to the 25-Foot Elevation

Beginning at the center of the village, Alternative 5 would head northeast across Kivalina Lagoon with a causeway and bridge. The causeway would be approximately 0.5 mile long and have a 60-foot long bridge crossing the main channel of the lagoon. On the far side of the lagoon, the road would head northeast across the wet tundra for 2.4 miles, meandering through the many small ponds and lakes, to the 25-foot elevation. The road would end at Termination Point D, just south of a medium sized lake.

The total length of Alternative 5 is approximately 2.9 miles, including 2.4 miles of road, 0.5 mile of causeway, and a 60-foot long bridge, all of which will require right-of-way. The land along this route is controlled by NANA. There are no known Native allotments along this route.

4.7 Alternative 6: Continue Alternative 5 to the Simiq Site

Alternative 6 would continue Alternative 5 to the north for approximately 1.2 miles, across wet tundra, again meandering through small ponds and lakes. It would then continue northeast for 0.4 mile and end at Termination Point E, located on a hill at elevation 80 feet, just north of two medium sized lakes, and within the Simiq village relocation site.

The total length of Alternative 6 is approximately 4.5 miles, including 4.0 miles of road, 0.5 mile of causeway, and a 60-foot long bridge, all of which will require right-of-way. The land along this route is controlled by NANA. There are no known Native allotments along this route.

4.8 Alternative 7: Extension From the Simiq Site to the Imnakuk Bluff Site

Alternative 7 would continue either Alternative 4 or 6 to the north-northwest for approximately 0.7 mile across relatively high and dry tundra. It would then head northwest across lower and wetter tundra for 1.9 miles to the Kivalina River. It would cross the river with a 350-foot bridge. The road would then follow the Kivalina River for 1.0 mile to the west. It would end at Termination Point F, located just to the north of the Kivalina River at the east end of the Imnakuk Bluff village relocation site.

The total length of Alternative 7 is approximately 3.6 miles, including a 350-foot bridge, all of which will require right-of-way. The land along this route is controlled by NANA. There are no known Native allotments along this route.

4.9 Alternative 8: Extension From the Simiq Site to the Kisimigiuktuk Hill Area

Alternative 8 would continue either Alternative 4 or 6 to the north for approximately 0.8 mile across relatively high and dry tundra. It would then head northeast across lower and wetter tundra for 2.1 miles to the western flank of Kisimigiuktuk Hill. It would end at Termination Point G, located between the Kivalina River and Kisimigiuktuk Hill.

The total length of Alternative 8 is approximately 2.9 miles, all of which will require right-of-way. The land along this route is controlled by NANA. There are no known Native allotments along this route.

5. ROADWAY SECTION ALTERNATIVES

5.1 General

Any roads constructed must be designed to protect the underlying permafrost from melting. Putting a dark heat sink (gravel) on the permafrost will definitely melt the underlying ice, if protective measures are not taken. If the road design is not adequate, the ice will begin melting from the top down. As this happens, the weight of the road pushes the water (ice) out leaving only a fraction of the original volume (soil) left. As a result, the road begins to sink. This process repeats itself, year after year, until the road is literally below the surrounding ground surface.

Needless to say, this is highly undesirable. Roads that fail in this manner require much maintenance. As a road sinks the embankment material will sit in more and more water, which is extremely detrimental for roads, especially in a freeze-thaw environment, such as in Alaska. Unless the entire road prism is constructed of very expensive non-frost susceptible (NFS) gravel, serious frost heaving will occur as the water in the road expands as it freezes. Saturated road bases also lead to extremely weak roads, causing rutting and pumping during the spring thaw, necessitating reduced load limits or limiting traffic all together.

Problems such as these can be eliminated or reduced if proper road designs are used. There are various methods of keeping the permafrost frozen. The simplest and most practical in Kivalina is to keep the new depth of thaw within the road prism and existing active layer. This is accomplished by providing a sufficient thickness of gravel or providing an insulation layer to slow the heat penetration.

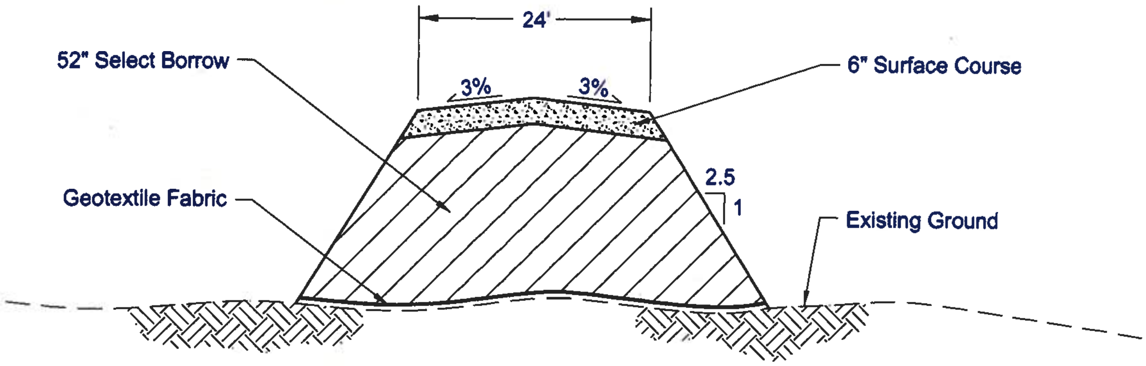
The decision to use an uninsulated or insulated road section is usually based on the cost and/or availability of gravel.

5.2 Uninsulated Section

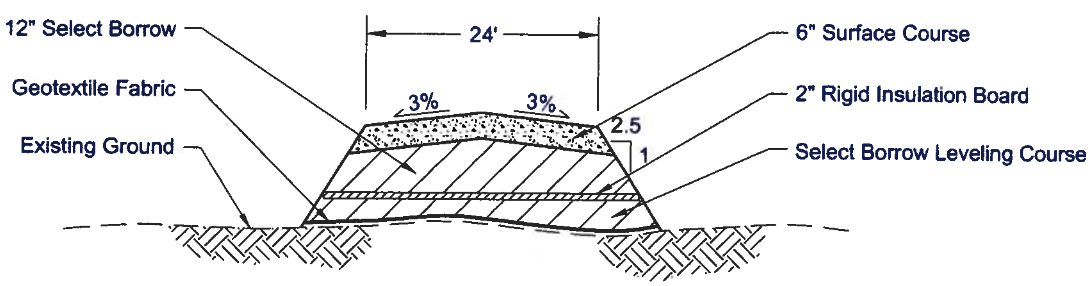
To accurately determine the thickness of gravel needed to limit the depth of thaw, so as not to melt the permafrost, a geotechnical investigation should be performed along the road alignment. For this analysis, a 5-foot thickness of gravel has been assumed, as it has proven to be adequate in similar locations. Typically, the existing tundra vegetation is left in place, as this further helps to insulate the frozen ground below. (See Figure 3.)

5.3 Insulated Section

Again, a geotechnical investigation should be performed along the road alignment to accurately determine an insulated road prism design. For this analysis, it has been assumed that 2 inches of boardstock insulation with 2 feet of gravel will perform similarly to a 5-foot uninsulated section. (See Figure 3.)



Typical Uninsulated Roadway Cross-Section



Typical Insulated Roadway Cross-Section

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Typical Overland Road Sections
Evacuation / Relocation Road Feas. Study

Kivalina, Alaska
Northwest Arctic Borough

Job No.:	4837
Date:	Oct. 2005
Drawn By:	
Checked By:	SEC
Figure No.	3

6. CAUSEWAY ALTERNATIVES

6.1 General

Because the lagoon is so shallow (less than 7 feet in most locations), it may be feasible to build an earthen causeway and bridge across it. The causeway would be a "tall" road through the water. A causeway could also be an elevated road constructed on piers, basically a long bridge. A full length causeway on piers has not been considered, in this analysis, as it would be extremely cost prohibitive.

If an alternative with a causeway segment was selected, a bathymetric survey of the lagoon bottom and a geotechnical investigation of the lagoon soils would be required. It would also be important to look at erosion protection to insure that the side slopes are stable and able to withstand the wave energy during a storm event. It is likely that large diameter culverts would be required to be placed periodically along the causeway to facilitate water flow and fish passage.

Two types of earthen causeway construction have been reviewed at for this analysis: earthen embankment and sheet pile retained embankment. (See Figure 4.) A 3-foot freeboard has been assumed. Freeboard is the height of the road surface above the normal water surface.

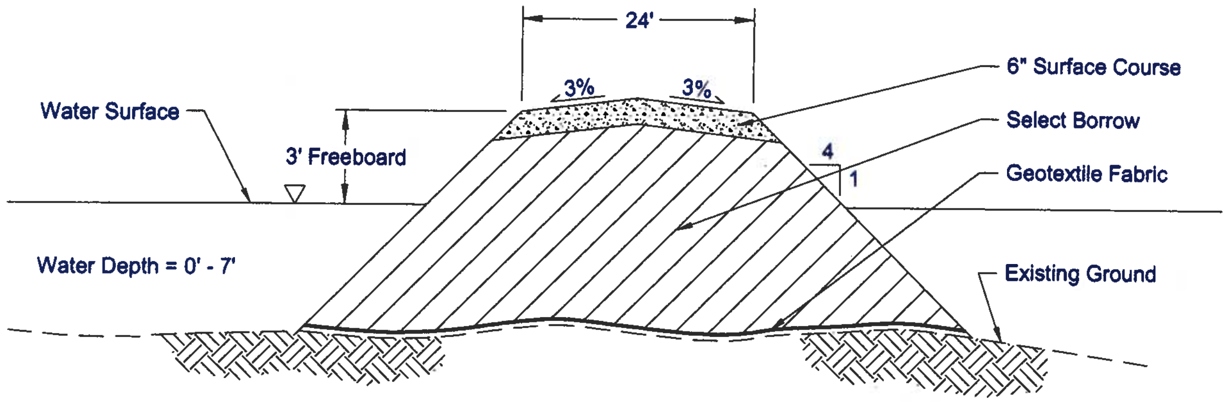
There will be significant environmental issues to address if an alternative that includes a causeway is selected. See Section 8 for a more detailed discussion of the environmental requirements.

6.2 Earthen Embankment

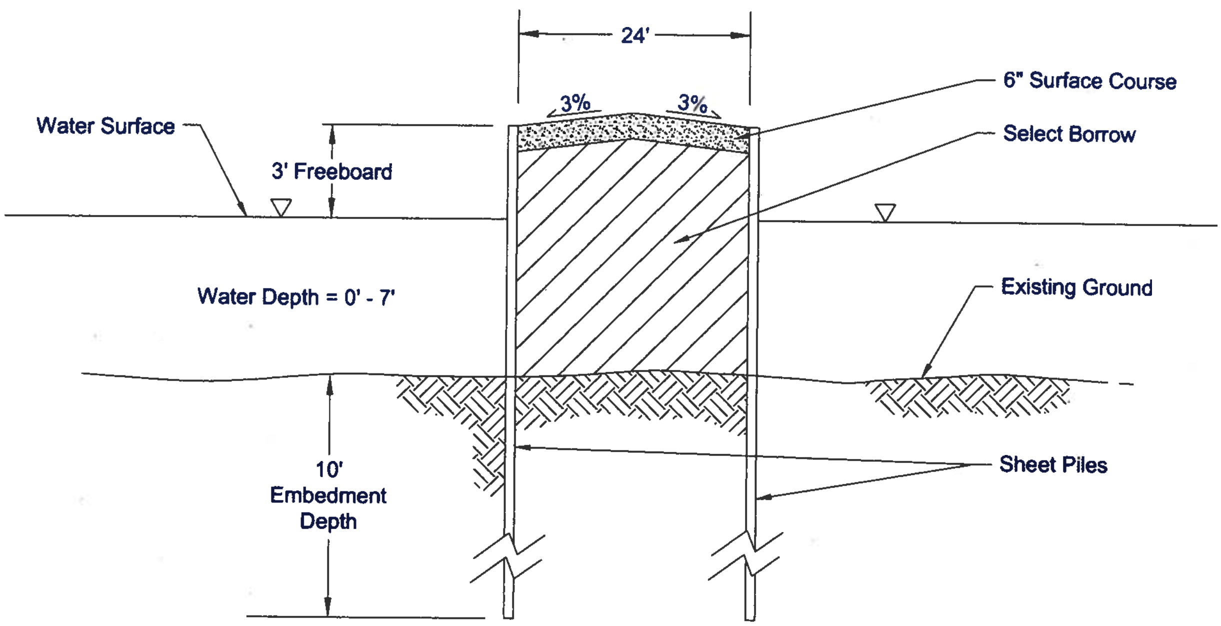
An earthen embankment would consist of placing borrow material under water and constructing a trapezoidal shaped embankment that is three feet higher than the water surface elevation. Depending on the water depth and side slope angle, the bottom width can become significant. For this analysis, a 4H:1V side slope has been assumed. This assumption will need to be confirmed during the design process. Construction could begin on either side of the lagoon. Borrow material would be end dumped into the lagoon until the embankment surface was above the water. Then compaction could begin. This sequence would be continued across the lagoon.

6.3 Sheet Pile Retained Embankment

Another method of constructing the causeway would be to drive sheet piles along both sides of the road alignment and then backfill between them with borrow material. This method would require less gravel, but would require a pile driver and a barge from which to drive the sheet piles.



Typical Causeway Cross-Section - Earthen Fill Construction



Typical Causway Cross-Section - Sheet Pile Construction

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Figure No.	4

7. BRIDGE ALTERNATIVES

All of the alternatives being considered will require at least one bridge. Alternatives 1 and 2 both require bridges 375 to 475 feet long. The causeway alternatives (Alternatives 3, 4, 5, and 6) can be constructed with shorter spans (approximately 60 feet) across the main channel.

Long span bridges across the barrier island inlets (Alternatives 1 and 2) would require intermediate piers, thus increasing the costs and environmental constraints. These bridges would also require significant erosion protection at the abutments.

The longer bridge options include steel, concrete, and/or timber construction. Designs have not been made at this conceptual level, but it is likely that the longer bridges would be constructed with steel beams, sit on concrete abutments, and have steel grating for decks.

The shorter bridges would also likely utilize steel beams. The abutments at the causeway may be able to rest on the gravel causeway, but may require a steel pile foundation. The abutments of inland bridges would probably require pile foundations. Decking could be either steel grating or timber planking.

8. ENVIRONMENTAL CONCERNS

8.1 General

The village of Kivalina is located on the southern end of a barrier island between Kivalina Lagoon and the Chukchi Sea. Barrier islands, by nature, are not static; their locations and inlets are constantly moving and shifting. Kivalina Lagoon has two inlets to the Chukchi Sea. Kivalik Inlet is located at the northwest end of the island, approximately 5.5 miles northwest of the village. Singauk Inlet is located directly southeast of the village. The inlets are approximately 450 feet and 350 feet across, respectively, although the normal water flow width is significantly less. Two rivers, the Kivalina River and the Wulik River, empty into the lagoon.

The area around Kivalina is a known Spectacled Eider nesting habitat. The lagoon and rivers also support various species of fish and other marine life.

8.2 National Environmental Protection Act (NEPA) Requirements

The National Environmental Protection Act (NEPA) requires that any proposed federal action, that will substantially affect the natural environment, must go through the NEPA process to ensure, to the maximum extent possible, that all possible alternatives are evaluated and given equal consideration.

Implementation of any of the alternatives being considered will require either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). The determination for an EA or an EIS will be made by the lead federal agency (i.e. U.S. Army Corps of Engineers, Environmental Protection Agency, etc.).

8.3 Permitting / Consultation / Study Requirements

The following permits, from various agencies, have been identified as being required for all of the proposed alternative routes.

- U.S. Army Corps of Engineers (USACE): A USACE permit is required for the filling, excavation, and/or dredging of wetlands and/or navigable waterways. A 401 Certification (Clean Water Certification) is part of the USACE process, and a separate application is not needed.
- United States Coast Guard (USCG): A USCG permit is required for the construction of causeways and bridges over navigable waters of the United States.
- Alaska Department of Natural Resources (ADNR) Office of Project Management and Permitting (OPMP): A Coastal Zone Consistency Determination will be required.
- ADNR Office of Habitat Management and Permitting (OHMP): A Title 41 Permit for work in or over fish habitat will be required.
- Northwest Arctic Borough (NAB): The NAB may require Development or Planning permits.

- If the evacuation road terminates at an evacuation staging area, permitting will be required for a drinking water source, domestic wastewater management, and fuel storage.
- National Pollution Discharge Elimination System (NPDES) permits will be required for construction. This will require a Storm Water Pollution Prevention Plan (SWPPP) and a permit for potential wastewater discharge.
- The USACE and/or the Environmental Protection Agency (EPA): The USACE and/or the EPA will require a permit for the marine disposal of dredge material for causeway construction.

Besides the permits listed above, the following consultations will be required.

- National Marine Fisheries Service (NMFS): The NMFS will be concerned with Marine Mammal Protection and Essential Fish Habitat.
- United States Fish and Wildlife Service (USFWS): USFWS will be concerned with Endangered Species. The proposed construction areas have been identified as Spectacled Eider nesting habitat. This may require a Formal Consultation which will result in a Biological Opinion.

Additionally, prior to permitting, the USACE may require studies of wildlife habitat, fish habitat, and Spectacled Eiders.

8.4 Schedule and Costs

If an EIS is required, it may take 2 to 5 years and 2 to 10 million dollars to complete. The length of time and costs are dependent on which studies are required to be performed.

If an EA is required, the time frame would be between 18 months and 3 years and could cost between 0.5 and 2 million dollars. Again, the length of time and costs are dependent on which studies are required to be performed.

Once the NEPA process is completed, it will take approximately 6 months to acquire the permits.

9. CONCEPTUAL CONSTRUCTION COSTS

Table 1, below, summarizes the construction cost estimates for the six alternatives described above. These estimates are rough order of magnitude (ROM), only, as detailed designs have not been performed. Alternatives 7 and 8 have also been included, but these costs are for the extensions only, and must be added to either Alternative 4 or 6 to get a total cost from the village. The costs shown in Table 1 are for the insulated roadway section and earthen embankment causeway options, which are the least expensive options. Table 2 shows the costs of all the alternatives and options reviewed.

Table 1. Summary of ROM Construction Costs

Alternative Description	Cost
No. 1: Northwest Along the Barrier Island to the Tatchim Isua Site	$20,200,000
No. 2: Southeast Along the Spit to the Igrugaivik Site	$13,500,000
No. 3: Northwest Along the Spit, Across Kivalina Lagoon, and then Northeast to the 25-Foot Elevation	$12,600,000
No. 4: Continue Alternative 3 to the Simiq Site	$16,600,000
No. 5: Across Kivalina Lagoon and then Northeast to the 25-Foot Elevation	$11,000,000
No. 6: Continue Alternative 5 to the Simiq Site	$14,400,000
No. 7: Extension From the Simiq Site to the Imnakuk Bluff Site	$12,500,000
No. 8: Extension From the Simiq Site to the Kisimigiuktuk Hill Area	$6,900,000

It should also be noted that these costs include Preconstruction Engineering activities (such as survey, geotechnical investigation, environmental and permitting work, and design), Construction Engineering, and a 20% contingency factor.

Appendix A contains a more detailed breakdown of these estimates.

Table 2. Summary of All Alternative Evacuation Route Costs

No.	Evacuation Road Alignment Alternative Route	Description	Length (mi.)	Estimated Cost Preconstr.	Estimated Cost Construction	Total
1a	Northwest Along the Barrier Island to the Tatchim Isua Site	Uninsulated Road Section	10.6	$ 2,900,000	$ 19,100,000	$ 22,000,000
1b	**Northwest Along the Barrier Island to the Tatchim Isua Site**	**Insulated Road Section**	**10.6**	**$ 2,600,000**	**$ 17,600,000**	**$ 20,200,000**
2a	Southeast Along the Spit to the Igrugaivik Site	Uninsulated Road Section	3.1	$ 2,000,000	$ 13,100,000	$ 15,100,000
2b	**Southeast Along the Spit to the Igrugaivik Site**	**Insulated Road Section**	**3.1**	**$ 1,800,000**	**$ 11,700,000**	**$ 13,500,000**
3a	Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Uninsulated Road Section, Embankment Causeway	4.4	$ 1,800,000	$ 11,800,000	$ 13,600,000
3b	**Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour**	**Insulated Road Section, Embankment Causeway**	**4.4**	**$ 1,600,000**	**$ 11,000,000**	**$ 12,600,000**
3c	Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Uninsulated Road Section, Sheet Pile Causeway	4.4	$ 2,600,000	$ 17,200,000	$ 19,800,000
3d	Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Insulated Road Section, Sheet Pile Causeway	4.4	$ 2,400,000	$ 16,100,000	$ 18,500,000
4a	Continue Alternative 3 to the Simiq Site	Uninsulated Road Section, Embankment Causeway	6.4	$ 2,500,000	$ 16,600,000	$ 19,100,000
4b	**Continue Alternative 3 to the Simiq Site**	**Insulated Road Section, Embankment Causeway**	**6.4**	**$ 2,100,000**	**$ 14,500,000**	**$ 16,600,000**
4c	Continue Alternative 3 to the Simiq Site	Uninsulated Road Section, Sheet Pile Causeway	6.4	$ 3,300,000	$ 21,800,000	$ 25,100,000
4d	Continue Alternative 3 to the Simiq Site	Insulated Road Section, Sheet Pile Causeway	6.4	$ 2,900,000	$ 19,600,000	$ 22,500,000
5a	Across Kivalina Lagoon and then Northeast to the 25-Foot Contour	Uninsulated Road Section, Embankment Causeway	2.9	$ 1,700,000	$ 11,100,000	$ 12,800,000
5b	**Across Kivalina Lagoon and then Northeast to the 25-Foot Contour**	**Insulated Road Section, Embankment Causeway**	**2.9**	**$ 1,400,000**	**$ 9,600,000**	**$ 11,000,000**
5c	Across Kivalina Lagoon and then Northeast to the 25-Foot Contour	Uninsulated Road Section, Sheet Pile Causeway	2.9	$ 2,200,000	$ 14,900,000	$ 17,100,000
5d	Across Kivalina Lagoon and then Northeast to the 25-Foot Contour	Insulated Road Section, Sheet Pile Causeway	2.9	$ 2,000,000	$ 13,400,000	$ 15,400,000
6a	Continue Alternative 5 to the Simiq Site	Uninsulated Road Section, Embankment Causeway	4.5	$ 2,300,000	$ 15,000,000	$ 17,300,000
6b	**Continue Alternative 5 to the Simiq Site**	**Insulated Road Section, Embankment Causeway**	**4.5**	**$ 1,900,000**	**$ 12,500,000**	**$ 14,400,000**
6c	Continue Alternative 5 to the Simiq Site	Uninsulated Road Section, Sheet Pile Causeway	4.5	$ 2,800,000	$ 18,600,000	$ 21,400,000
6d	Continue Alternative 5 to the Simiq Site	Insulated Road Section, Sheet Pile Causeway	4.5	$ 2,400,000	$ 16,300,000	$ 18,700,000
	Optional Road Extensions to Other Possible Destinations					
7a	Extension From the Simiq Site to the Imnakuk Bluff Site	Uninsulated Road Section	3.6	$ 1,400,000	$ 13,800,000	$ 15,200,000
7b	**Extension From the Simiq Site to the Imnakuk Bluff Site**	**Insulated Road Section**	**3.6**	**$ 1,100,000**	**$ 11,400,000**	**$ 12,500,000**
8a	Extension From the Simiq Site to the Kisimigluktuk Hill Area	Uninsulated Road Section	2.9	$ 800,000	$ 8,100,000	$ 8,900,000
8b	**Extension From the Simiq Site to the Kisimigluktuk Hill Area**	**Insulated Road Section**	**2.9**	**$ 600,000**	**$ 6,300,000**	**$ 6,900,000**

10. EVALUATIONS AND ANALYSES

10.1 Alignment Alternatives

10.1.1 General

The following criteria have been used to evaluate the various alternative evacuation road alignment alternatives:

1. The Evacuation Road Termination Point must be at an elevation of at least 25 feet;
2. The overall design and construction cost;
3. Other potential uses of the road, i.e. village relocation site, gravel borrow source, water source, airport site, etc.
4. Maintenance requirements;
5. Right-of-way / property issues;
6. Environmental concerns; and
7. Length of time to construct.

Table 3 outlines and summarizes the analyses of the alternative evacuation routes, based on the above criteria.

10.1.2 Alternative 1: Northwest Along the Barrier Island to the Tatchim Isua Site

Alternative 1 has the following positive aspects:

- Termination Point A is at an elevation of 25 feet;
- The route accesses a potential village relocation site (Tatchim Isua);
- This route will require moderate environmental difficulty;
- This route could be constructed within 3 to 6 years;
- Most of the route is over good subgrade soils (sands and gravels) on which to build roads on; and
- This route will require the least amount of gravel, per foot of road.

Alternative 1 has the following negative aspects:

- This is the most expensive route ($20.2 M);
- This is the longest route (10.6 miles);
- A long span bridge (475 feet) is required over Kivalik Inlet;
- This route will require the highest maintenance costs because the road and bridge will be prone to erosion from storms, as much of the route is at a 10-foot elevation;

- The Kivalik Inlet location could change over time causing problems at the bridge; and
- This route must cross the airport property and numerous Native allotments.

10.1.3 Alternative 2: Southeast Along the Spit to the Igrugaivik Site

Alternative 2 has the following positive aspects:

- Termination Point B is at an elevation of 25 feet;
- This is one of the least expensive routes ($13.5 M);
- The route accesses three potential village relocation sites (Kiniktuuraq, Igrugaivilk, and Kuugruaq);
- There are no property ownership issues;
- This route will require moderate environmental difficulty;
- This route could be constructed within 3 to 5 years;
- This is one of the shortest routes (3.1 miles); and
- 30% of the route is over good subgrade soils (sands and gravels) on which to build roads on.

Alternative 2 has the following negative aspects:

- This route will require moderate maintenance costs because the bridge and 30% of the road will be prone to erosion from storms, as this section of the route is at a 10-foot elevation;
- A long span bridge (375 feet) is required over Singauk Entrance;
- The Singauk Entrance location could change over time causing problems at the bridge; and
- Much of the route is over wet tundra.

10.1.4 Alternative 3: Northwest Along the Spit, Across Kivalina Lagoon, and then Northeast to the 25-Foot Elevation

Alternative 3 has the following positive aspects:

- Termination Point C is at an elevation of 25 feet;
- This is one of the least expensive routes ($12.6 M);
- This is a moderate length route (4.4 miles);
- 50% of the route is over good subgrade soils (sands and gravels) on which to build roads on;
- The tundra portion of this route is higher and drier than other tundra routes; and
- Only a short span bridge (60 feet) is required.

Alternative 3 has the following negative aspects:

- This route will require high maintenance costs because 50% of the road will be prone to erosion from storms, as this section of the route is at a 10-foot elevation;
- This route must cross the airport property;
- This route will require a high degree of environmental difficulty because of the causeway across Kivalina Lagoon; and
- This route will likely take 3.5 to 8 years to construct.

10.1.5 Alternative 4: Continue Alternative 3 to the Simiq Site

Alternative 4 has the following positive aspects:

- Termination Point E is at an elevation of 80 feet;
- This is a moderate cost route ($16.6 M);
- The route accesses a potential village relocation site (Simiq);
- 30% of the route is over good subgrade soils (sands and gravels) on which to build roads on;
- The tundra portion of this route is higher and drier than other tundra routes; and
- Only a short span bridge (60 feet) is required.

Alternative 4 has the following negative aspects:

- This route will have moderate maintenance costs because 50% of the road will be prone to erosion from storms, as this section of the route is at a 10-foot elevation;
- This route must cross the airport property;
- This route will require a high degree of environmental difficulty because of the causeway across Kivalina Lagoon;
- This is one of the longest routes (6.4 miles); and
- This route will likely take 3.5 to 8 years to construct.

10.1.6 Alternative 5: Across Kivalina Lagoon and then Northeast to the 25-Foot Elevation

Alternative 5 has the following positive aspects:

- Termination Point D is at an elevation of 25 feet;
- This is the least expensive route ($11.0 M);
- This is the shortest route (2.9 miles);
- This route will have a low maintenance cost because it is located inland and will not be prone to erosion from storms;

- There are no property ownership issues; and
- Only a short span bridge (60 feet) is required.

Alternative 5 has the following negative aspects:

- This route will require a high degree of environmental difficulty because of the causeway across Kivalina Lagoon;
- This route will likely take 3.5 to 8 years to construct; and
- Much of this route is over low, wet tundra.

10.1.7 Alternative 6: Continue Alternative 5 to the Simiq Site

Alternative 6 has the following positive aspects:

- Termination Point E is at an elevation of 80 feet;
- This is a moderate cost route ($14.4 M);
- The route accesses a potential village relocation site (Simiq);
- This is a moderate length route (4.5 miles);
- This route will have a low maintenance cost because it is located inland and will not be prone to erosion from storms;
- There are no property ownership issues; and
- Only a short span bridge (60 feet) is required.

Alternative 6 has the following negative aspects:

- This route will require a high degree of environmental difficulty because of the causeway across Kivalina Lagoon;
- This route will likely take 3.5 to 8 years to construct; and
- Much of this route is over low, wet tundra.

10.1.8 Alternative 7: Extension From the Simiq Site to the Imnakuk Bluff Site

Alternative 7 has the following positive aspects:

- Termination Point F is at an elevation above 50 feet;
- This route accesses a potential village relocation site (Imnakuk Bluff);
- This route accesses a potential gravel borrow source (Imnakuk Bluff);
- This route will have a low maintenance cost because it is located inland and will not be prone to erosion from storms; and
- There are no property ownership issues.

Alternative 7 has the following negative aspects:

- This is the most expensive of the extension routes (additional $12.5 M);
- The cost of the extension is in addition to the costs of Alternatives 4 or 6; and
- A 350-foot bridge is required over the Kivalina River.

10.1.9 Alternative 8: Extension From the Simiq Site to the Kisimigiuktuk Hill Area

Alternative 8 has the following positive aspects:

- Termination Point G is at an elevation above 100 feet;
- This is the least expensive of the extension routes (additional $6.9 M);
- This route accesses a potential gravel borrow source (Kisimigiuktuk Hill);
- This route will have a low maintenance cost because it is located inland and will not be prone to erosion from storms;
- There are no property ownership issues; and
- No additional bridges are required.

Alternative 8 has the following negative aspects:

- The cost of the extension is in addition to the costs of Alternatives 4 or 6.

10.2 Roadway Section Alternatives

10.2.1 Uninsulated

An uninsulated roadway section has the following positive aspects:

- An uninsulated section will have a finished road surface elevation that is approximately 2.5 feet higher than an insulated section;
- It is easier to construct, requiring a gravel layer and then a surface course layer;
- There are less construction materials to transport to the project site; and
- Road construction could occur during summer or winter.

An uninsulated roadway section has the following negative aspects:

- An uninsulated section is more expensive to construct in areas where gravel costs are high; and
- Because more gravel is required, there will be more haul time and the total time to construct will be longer.

10.2.2 Insulated

An insulated roadway section has the following positive aspects:

- An uninsulated section is less expensive to construct in areas where gravel costs are high; and
- Because less gravel is required, there will be less haul time and the overall time to construct will be shorter.

An insulated roadway section has the following negative aspects:

- An insulated road section is more difficult to construct, requiring a gravel layer, an insulation layer, another gravel layer, and then a surface course layer;
- There are more construction materials (insulation) to transport to the project site; and
- Construction can occur during the summer, only, as an embankment placed frozen in the winter will settle and break up the insulation when it thaws in the summer.

10.3 Causeway Alternatives

10.3.1 General

A causeway has the following positive aspects:

- Causeways will be less expensive than long bridges;
- They will be simpler to construct than bridges, allowing more local labor to be employed; and
- Less bridge construction materials will need to be transported to the project site.

A causeway has the following negative aspects:

- A causeway across the lagoon will require significantly more environmental permitting effort, due to fish habitat and sediment transport concerns, than a bridge;
- Because of the additional environmental effort required, the time to construct will be longer; and
- A causeway partially blocks the lagoon.

10.3.2 Earthen Embankment

An earthen embankment causeway has the following positive aspects:

- An earthen embankment causeway will be significantly less expensive than a sheet pile retained causeway;

- This construction method is simpler, allowing more local labor to be employed; and
- Less equipment (barge, pile driver) and construction material (steel sheet pile) will need to be transported to the project site.

An earthen embankment causeway has the following negative aspects:

- A trapezoidal shaped earthen embankment causeway will require more gravel than a sheet pile retained causeway; and
- The side slopes will need to be protected from erosion.

10.3.3 Sheet Pile Retained

A sheet pile retained causeway has the following positive aspects:

- A sheet pile retained causeway will require less gravel than a trapezoidal shaped earthen embankment causeway; and
- Steel sheet piles will not require additional erosion protection.

A sheet pile retained causeway has the following negative aspects:

- A sheet pile retained causeway will be significantly more expensive than an earthen embankment causeway;
- Sheet pile construction is more complicated and will require a specialized crew;
- Sheet pile construction will require additional construction equipment (barge, pile driver); and
- More construction materials (sheet piles) will need to be transported to the project site.

10.4 Bridge Alternatives

10.4.1 Bridge Locations

The longer bridges required to span the inlets (Alternatives 1 and 2) have the following positive aspects, when compared to the shorter bridges that can be used with a causeway to cross the lagoon (Alternative 3 through 6):

- A bridge crossing an inlet will require significantly less environmental permitting effort, than a bridge/causeway crossing the lagoon; and
- Because of the lesser environmental effort required, the environmental costs will be less expensive and the time to construct will be shorter.

The longer bridges required to span the inlets (Alternatives 1 and 2) have the following negative aspects, when compared to the shorter bridges that can be used with a causeway to cross the lagoon (Alternative 3 through 6):

- Long bridges are more expensive to construct and maintain;
- Long bridges require intermediate piers;
- The abutments for the bridges across the inlets will be subjected to severe erosion from storm events; and
- The inlet locations are prone to changing their locations.

10.4.2 Bridge Construction Type

The bridge construction type, i.e. steel, concrete, timber, etc. has not been evaluated in this study. The span distances will dictate, somewhat, which materials are feasible. This analysis will best be performed during the design stage.

Table 3. Analysis Summary of Alternative Evacuation Routes

Evacuation Road Alignment Alternative			25-Foot Elevation	Cost (million $)	Access to Other Uses			Environmental		Possible Water Source Nearby	Maintenance Requirements	Distance from Village (miles)	Time to Construct (years)
No.	Route	Description			Relocation Site	Gravel Source	River	Difficulty	Time (Yrs)				
1a	Northwest Along the Barrier Island to the Tatchim Isua Site	Uninsulated Road Section	✓	22.0	✓			Moderate	1.5 - 3		High	10.6	3 - 6
1b	Northwest Along the Barrier Island to the Tatchim Isua Site	Insulated Road Section	✓	20.2	✓			Moderate	1.5 - 3		High	10.6	3 - 6
2a	Southeast Along the Spit to the Igrugaivik Site	Uninsulated Road Section	✓	15.1	✓			Moderate	1.5 - 3	✓	Moderate	3.1	3 - 5
2b	Southeast Along the Spit to the Igrugaivik Site	Insulated Road Section	✓	13.5	✓			Moderate	1.5 - 3	✓	Moderate	3.1	3 - 5
3a	Northwest Along the Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Uninsulated Road Section, Embankment Causeway	✓	13.6				High	2 - 5	✓	Moderate	4.4	3.5 - 6
3b	Northwest Along the Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Insulated Road Section, Embankment Causeway	✓	12.6				High	2 - 5	✓	Moderate	4.4	3.5 - 6
3c	Northwest Along the Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Uninsulated Road Section, Sheet Pile Causeway	✓	19.7				High	2 - 5	✓	Moderate	4.4	3.5 - 6
3d	Northwest Along the Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Insulated Road Section, Sheet Pile Causeway	✓	16.5				High	2 - 5	✓	Moderate	4.4	3.5 - 6
4a	Continue Alternative 3 to the Simiq Site	Uninsulated Road Section, Embankment Causeway	✓	19.1	✓			High	2 - 5	✓	Moderate	6.3	3.5 - 6
4b	Continue Alternative 3 to the Simiq Site	Insulated Road Section, Embankment Causeway	✓	16.6	✓			High	2 - 5	✓	Moderate	6.3	3.5 - 6
4c	Continue Alternative 3 to the Simiq Site	Uninsulated Road Section, Sheet Pile Causeway	✓	25.1	✓			High	2 - 5	✓	Moderate	6.3	3.5 - 6
4d	Continue Alternative 3 to the Simiq Site	Insulated Road Section, Sheet Pile Causeway	✓	22.5	✓			High	2 - 5	✓	Moderate	6.3	3.5 - 6
5a	Across Kivalina Lagoon and the Northeast to 25-Foot Contour	Uninsulated Road Section, Embankment Causeway	✓	12.8				High	2 - 5	✓	Low	2.9	3.5 - 6
5b	Across Kivalina Lagoon and the Northeast to 25-Foot Contour	Insulated Road Section, Embankment Causeway	✓	11.0				High	2 - 5	✓	Low	2.9	3.5 - 6
5c	Across Kivalina Lagoon and the Northeast to 25-Foot Contour	Uninsulated Road Section, Sheet Pile Causeway	✓	17.1				High	2 - 5	✓	Low	2.9	3.5 - 6
5d	Across Kivalina Lagoon and the Northeast to 25-Foot Contour	Insulated Road Section, Sheet Pile Causeway	✓	15.4				High	2 - 5	✓	Low	2.9	3.5 - 6
6a	Continue Alternative 5 to the Simiq Site	Uninsulated Road Section, Embankment Causeway	✓	17.3	✓			High	2 - 5	✓	Low	4.5	3.5 - 6
6b	Continue Alternative 5 to the Simiq Site	Insulated Road Section, Embankment Causeway	✓	14.4	✓			High	2 - 5	✓	Low	4.5	3.5 - 6
6c	Continue Alternative 5 to the Simiq Site	Uninsulated Road Section, Sheet Pile Causeway	✓	21.4	✓			High	2 - 5	✓	Low	4.5	3.5 - 6
6d	Continue Alternative 5 to the Simiq Site	Insulated Road Section, Sheet Pile Causeway	✓	18.7	✓			High	2 - 5	✓	Low	4.5	3.5 - 6
Optional Road Extensions to Other Possible Destinations													
7a	Extension from the Simiq Site to the Imnakuk Bluff Site	Uninsulated Road Section	✓	15.2	✓	✓	✓	Low	1 - 2	✓	Low	8.2 - 10.0	2.5 - 5
7b	Extension from the Simiq Site to the Imnakuk Bluff Site	Insulated Road Section	✓	12.5	✓	✓	✓	Low	1 - 2	✓	Low	8.2 - 10.0	2.5 - 5
8a	Extension from the Simiq Site to the Kisimigluktuk Hill Area	Uninsulated Road Section	✓	8.9		✓		Low	1 - 2	✓	Low	7.5 - 9.3	2.5 - 4
8b	Additional Road from Simiq Site to Kisimigluktuk Hill	Insulated Road Section	✓	6.9		✓		Low	1 - 2	✓	Low	7.5 - 9.3	2.5 - 4

11. RECOMMENDATIONS AND CONCLUSIONS

11.1 Recommended Options

11.1.1 Alignment

The recommended alignment for an evacuation route is Evacuation Road Alternative 6. Because of the need to develop a local gravel borrow source, it is also recommended that the Alternative 8 extension also be constructed. The following factors were considered in this decision:

- Termination Point E will provide for a good evacuation site, as it is relatively high and dry;
- Alternative 6 is less expensive than Alternative 4, which also accesses Termination Point E;
- The Alternative 6 route begins within the village and will be easily accessible to the evacuees;
- Alternative 6 provides the shortest route across Kivalina Lagoon;
- Alternative 6 avoids building a road on the barrier island or spit, which would require a high degree of maintenance;
- The Alternative 8 extension route provides access to a much needed borrow source at Kisimigiuktuk Hill;
- The Alternative 8 extension is shorter and less expensive than the Alternative 7 extension;
- The Alternative 8 extension does not require a bridge;
- Only one 60-foot bridge will be required; and
- There are no ROW issues.

Because the environmental permitting effort is significant with Alternative 6, and will extend the time to construct the project, it may be possible to accelerate the schedule by constructing the road portions first. While the environmental work is being completed on the causeway/bridge portion, a hover craft of shallow draft landing craft could be used to transport evacuees across the lagoon. When the permitting for the causeway was completed, that portion of the project could be constructed.

11.1.2 Roadway Section

It is recommended that the least expensive road section be used for this project. Based on the costs of gravel and insulation assumed in this analysis, it appears that the insulated section is least expensive. If, however, it is determined later that the uninsulated section is less expensive, then that section should be used.

11.1.3 Causeway Construction Type

The earthen embankment is recommended over the sheet pile retained embankment for two reasons. First, it is the least expensive option, and second, it will be easier to construct with local labor.

11.1.4 Bridge Construction Type

Bridge construction type will be determined during the design stage.

11.2 Summary of Recommendations

Alignment:	Alternative 6, with the Alternative 8 extension (Kivalina to Kisimigiuktuk Hill, via Simiq site)
Roadway Section:	Insulated (if least expensive)
Causeway Construction Type:	Earthen embankment w/ a 60-foot bridge across the main channel of Kivalina Lagoon
Bridge Construction Type:	To be determined during the design

Given the emergency nature of the project, it is recommended that all means to streamline the funding, design, permitting, and construction processes be pursued.

11.3 Recommended Alternative Cost

The estimated cost to construct the recommended alternative is $21,300,000, which includes $14,400,000 for Alternative 6b and $6,900,000 for Alternative 8b.

Appendix A

Construction Cost Estimate Details

Summary of All Alternative Evacuation Route Costs

No.	Evacuation Road Alignment Alternative Route	Description	Length (mi.)	Estimated Cost Preconstr.	Construction	Total
1a	Northwest Along the Barrier Island to the Tatchim Isua Site	Uninsulated Road Section	10.6	$ 2,900,000	$ 19,100,000	$ 22,000,000
1b	**Northwest Along the Barrier Island to the Tatchim Isua Site**	**Insulated Road Section**	**10.6**	**$ 2,600,000**	**$ 17,600,000**	**$ 20,200,000**
2a	Southeast Along the Spit to the Igrugaivik Site	Uninsulated Road Section	3.1	$ 2,000,000	$ 13,100,000	$ 15,100,000
2b	**Southeast Along the Spit to the Igrugaivik Site**	**Insulated Road Section**	**3.1**	**$ 1,800,000**	**$ 11,700,000**	**$ 13,500,000**
3a	Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Uninsulated Road Section, Embankment Causeway	4.4	$ 1,800,000	$ 11,800,000	$ 13,600,000
3b	**Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour**	**Insulated Road Section, Embankment Causeway**	**4.4**	**$ 1,600,000**	**$ 11,000,000**	**$ 12,600,000**
3c	Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Uninsulated Road Section, Sheet Pile Causeway	4.4	$ 2,600,000	$ 17,200,000	$ 19,800,000
3d	Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour	Insulated Road Section, Sheet Pile Causeway	4.4	$ 2,400,000	$ 16,100,000	$ 18,500,000
4a	Continue Alternative 3 to the Simiq Site	Uninsulated Road Section, Embankment Causeway	6.4	$ 2,500,000	$ 16,600,000	$ 19,100,000
4b	**Continue Alternative 3 to the Simiq Site**	**Insulated Road Section, Embankment Causeway**	**6.4**	**$ 2,100,000**	**$ 14,500,000**	**$ 16,600,000**
4c	Continue Alternative 3 to the Simiq Site	Uninsulated Road Section, Sheet Pile Causeway	6.4	$ 3,300,000	$ 21,800,000	$ 25,100,000
4d	Continue Alternative 3 to the Simiq Site	Insulated Road Section, Sheet Pile Causeway	6.4	$ 2,900,000	$ 19,600,000	$ 22,500,000
5a	Across Kivalina Lagoon and then Northeast to the 25-Foot Contour	Uninsulated Road Section, Embankment Causeway	2.9	$ 1,700,000	$ 11,100,000	$ 12,800,000
5b	**Across Kivalina Lagoon and then Northeast to the 25-Foot Contour**	**Insulated Road Section, Embankment Causeway**	**2.9**	**$ 1,400,000**	**$ 9,600,000**	**$ 11,000,000**
5c	Across Kivalina Lagoon and then Northeast to the 25-Foot Contour	Uninsulated Road Section, Sheet Pile Causeway	2.9	$ 2,200,000	$ 14,900,000	$ 17,100,000
5d	Across Kivalina Lagoon and then Northeast to the 25-Foot Contour	Insulated Road Section, Sheet Pile Causeway	2.9	$ 2,000,000	$ 13,400,000	$ 15,400,000
6a	Continue Alternative 5 to the Simiq Site	Uninsulated Road Section, Embankment Causeway	4.5	$ 2,300,000	$ 15,000,000	$ 17,300,000
6b	**Continue Alternative 5 to the Simiq Site**	**Insulated Road Section, Embankment Causeway**	**4.5**	**$ 1,900,000**	**$ 12,500,000**	**$ 14,400,000**
6c	Continue Alternative 5 to the Simiq Site	Uninsulated Road Section, Sheet Pile Causeway	4.5	$ 2,800,000	$ 18,600,000	$ 21,400,000
6d	Continue Alternative 5 to the Simiq Site	Insulated Road Section, Sheet Pile Causeway	4.5	$ 2,400,000	$ 16,300,000	$ 18,700,000
	Optional Road Extensions to Other Possible Destinations					
7a	Extension From the Simiq Site to the Imnakuk Bluff Site	Uninsulated Road Section	3.6	$ 1,400,000	$ 13,800,000	$ 15,200,000
7b	**Extension From the Simiq Site to the Imnakuk Bluff Site**	**Insulated Road Section**	**3.6**	**$ 1,100,000**	**$ 11,400,000**	**$ 12,500,000**
8a	Extension From the Simiq Site to the Kisimigluktuk Hill Area	Uninsulated Road Section	2.9	$ 800,000	$ 8,100,000	$ 8,900,000
8b	**Extension From the Simiq Site to the Kisimigluktuk Hill Area**	**Insulated Road Section**	**2.9**	**$ 600,000**	**$ 6,300,000**	**$ 6,900,000**

Alternative 1a

Northwest Along the Barrier Island to the Tatchim Isua Site
Uninsulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	224,276	$ 5,606,900
301(2): Surface Course, Grading E-1	Ton	$60	46,612	$ 2,796,690
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	11,160	$ 4,464,000
630(1): Geotextile, Separation	SY	$3	218,097	$ 654,290
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 13,521,880**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,352,188
Construction Work Subtotal				**$ 14,874,068**
640: Mob/Demob (@ 4% of Constr. Work)	LS	4%		$ 594,963
Subtotal w/ Mob/Demob				**$ 15,469,031**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 464,071
Subtotal w/ Construction Engr. / Survey				**$ 15,933,102**
Contingency (@ 20% of Above)	LS	20%		$ 3,186,620
Total Estimated Construction Cost				**$ 19,119,722**

Alternative 1b

Northwest Along the Barrier Island to the Tatchim Isua Site

Insulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	135,356	$ 3,383,900
301(2): Surface Course, Grading E-1	Ton	$60	46,612	$ 2,796,690
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	11,160	$ 4,464,000
630(1): Geotextile, Separation	SY	$3	200,763	$ 602,290
635(1): Insulation Board	SF	$3	393,120	$ 1,179,360
Earthwork Subtotal				**$ 12,426,240**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,242,624
Construction Work Subtotal				**$ 13,668,864**
640: Mob/Demob (@ 4% of Constr. Work)	LS	4%		$ 546,755
Subtotal w/ Mob/Demob				**$ 14,215,619**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 426,469
Subtotal w/ Construction Engr. / Survey				**$ 14,642,087**
Contingency (@ 20% of Above)	LS	20%		$ 2,928,417
Total Estimated Construction Cost				**$ 17,570,505**

Alternative 2a

Southeast Along the Spit to the Igrugaivik Site

Uninsulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	144,653	$ 3,616,315
301(2): Surface Course, Grading E-1	Ton	$60	13,542	$ 812,545
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	11,280	$ 4,512,000
630(1): Geotextile, Separation	SY	$3	79,823	$ 239,470
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 9,180,330**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 918,033
Construction Work Subtotal				**$ 10,098,363**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 504,918
Subtotal w/ Mob/Demob				**$ 10,603,281**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 318,098
Subtotal w/ Construction Engr. / Survey				**$ 10,921,379**
Contingency (@ 20% of Above)	LS	20%		$ 2,184,276
Total Estimated Construction Cost				**$ 13,105,655**

Alternative 2b
Southeast Along the Spit to the Igrugaivik Site
Insulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	58,511	$ 1,462,783
301(2): Surface Course, Grading E-1	Ton	$60	13,542	$ 812,545
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	11,280	$ 4,512,000
630(1): Geotextile, Separation	SY	$3	63,032	$ 189,095
635(1): Insulation Board	SF	$3	380,835	$ 1,142,505
Earthwork Subtotal				**$ 8,118,928**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 811,893
Construction Work Subtotal				**$ 8,930,821**
640: Mob/Demob (@ 6% of Constr. Work)	LS	6%		$ 535,849
Subtotal w/ Mob/Demob				**$ 9,466,670**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 284,000
Subtotal w/ Construction Engr. / Survey				**$ 9,750,671**
Contingency (@ 20% of Above)	LS	20%		$ 1,950,134
Total Estimated Construction Cost				**$ 11,700,805**

Alternative 3a

Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour
Uninsulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	227,294	$ 5,682,360
301(2): Surface Course, Grading E-1	Ton	$60	19,740	$ 1,184,425
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	121,178	$ 363,533
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 8,190,319**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 819,032
Construction Work Subtotal				**$ 9,009,351**
640: Mob/Demob (@ 6% of Constr. Work)	LS	6%		$ 540,561
Subtotal w/ Mob/Demob				**$ 9,549,912**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 286,497
Subtotal w/ Construction Engr. / Survey				**$ 9,836,409**
Contingency (@ 20% of Above)	LS	20%		$ 1,967,282
Total Estimated Construction Cost				**$ 11,803,691**

Alternative 3b

Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour
Insulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	168,941	$ 4,223,517
301(2): Surface Course, Grading E-1	Ton	$60	19,740	$ 1,184,425
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	109,803	$ 329,408
635(1): Insulation Board	SF	$3	257,985	$ 773,955
Earthwork Subtotal				**$ 7,471,305**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 747,131
Construction Work Subtotal				**$ 8,218,436**
640: Mob/Demob (@ 7% of Constr. Work)	LS	7%		$ 575,290
Subtotal w/ Mob/Demob				**$ 8,793,726**
642: Constr. Engr. / Survey (@ 4% of Above)	LS	4%		$ 351,749
Subtotal w/ Construction Engr. / Survey				**$ 9,145,475**
Contingency (@ 20% of Above)	LS	20%		$ 1,829,095
Total Estimated Construction Cost				**$ 10,974,570**

Alternative 3c

Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour
Uninsulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	160,094	$ 4,002,360
301(2): Surface Course, Grading E-1	Ton	$60	19,507	$ 1,170,425
505(9): Steel Sheet Piles	SF	$40	140,000	$ 5,600,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	94,733	$ 284,200
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 12,016,985**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,201,699
Construction Work Subtotal				**$ 13,218,684**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 660,934
Subtotal w/ Mob/Demob				**$ 13,879,618**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 416,389
Subtotal w/ Construction Engr. / Survey				**$ 14,296,007**
Contingency (@ 20% of Above)	LS	20%		$ 2,859,201
Total Estimated Construction Cost				**$ 17,155,208**

Alternative 3d

Northwest Along Island, Across Kivalina Lagoon, Northeast to 25-Foot Contour
Insulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	101,741	$ 2,543,517
301(2): Surface Course, Grading E-1	Ton	$60	19,507	$ 1,170,425
505(9): Steel Sheet Piles	SF	$40	140,000	$ 5,600,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	83,358	$ 250,075
635(1): Insulation Board	SF	$3	257,985	$ 773,955
Earthwork Subtotal				**$ 11,297,972**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,129,797
Construction Work Subtotal				**$ 12,427,769**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 621,388
Subtotal w/ Mob/Demob				**$ 13,049,157**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 391,475
Subtotal w/ Construction Engr. / Survey				**$ 13,440,632**
Contingency (@ 20% of Above)	LS	20%		$ 2,688,126
Total Estimated Construction Cost				**$ 16,128,758**

Alternative 4a

Continue Alternative 3 to the Simiq Site

Uninsulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	342,583	$ 8,564,573
301(2): Surface Course, Grading E-1	Ton	$60	28,309	$ 1,698,515
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	176,602	$ 529,807
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 11,752,895**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,175,289
Construction Work Subtotal				**$ 12,928,184**
640: Mob/Demob (@ 4% of Constr. Work)	LS	4%		$ 517,127
Subtotal w/ Mob/Demob				**$ 13,445,311**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 403,359
Subtotal w/ Construction Engr. / Survey				**$ 13,848,671**
Contingency (@ 20% of Above)	LS	20%		$ 2,769,734
Total Estimated Construction Cost				**$ 16,618,405**

Alternative 4b

Continue Alternative 3 to the Simiq Site
Insulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	211,697	$ 5,292,417
301(2): Surface Course, Grading E-1	Ton	$60	28,309	$ 1,698,515
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	151,088	$ 453,265
635(1): Insulation Board	SF	$3	578,655	$ 1,735,965
Earthwork Subtotal				**$ 10,140,162**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,014,016
Construction Work Subtotal				**$ 11,154,178**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 557,709
Subtotal w/ Mob/Demob				**$ 11,711,887**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 351,357
Subtotal w/ Construction Engr. / Survey				**$ 12,063,243**
Contingency (@ 20% of Above)	LS	20%		$ 2,412,649
Total Estimated Construction Cost				**$ 14,475,892**

Alternative 4c

Continue Alternative 3 to the Simiq Site

Uninsulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	275,383	$ 6,884,573
301(2): Surface Course, Grading E-1	Ton	$60	28,075	$ 1,684,515
505(9): Steel Sheet Piles	SF	$40	140,000	$ 5,600,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	150,158	$ 450,473
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 15,579,561**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,557,956
Construction Work Subtotal				**$ 17,137,517**
640: Mob/Demob (@ 4% of Constr. Work)	LS	4%		$ 685,501
Subtotal w/ Mob/Demob				**$ 17,823,018**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	2%		$ 356,460
Subtotal w/ Construction Engr. / Survey				**$ 18,179,478**
Contingency (@ 20% of Above)	LS	20%		$ 3,635,896
Total Estimated Construction Cost				**$ 21,815,374**

Alternative 4d

Continue Alternative 3 to the Simiq Site
Insulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	144,497	$ 3,612,417
301(2): Surface Course, Grading E-1	Ton	$60	28,075	$ 1,684,515
505(9): Steel Sheet Piles	SF	$40	140,000	$ 5,600,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	124,644	$ 373,932
635(1): Insulation Board	SF	$3	578,655	$ 1,735,965
Earthwork Subtotal				**$ 13,966,828**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,396,683
Construction Work Subtotal				**$ 15,363,511**
640: Mob/Demob (@ 4% of Constr. Work)	LS	4%		$ 614,540
Subtotal w/ Mob/Demob				**$ 15,978,052**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	2%		$ 319,561
Subtotal w/ Construction Engr. / Survey				**$ 16,297,613**
Contingency (@ 20% of Above)	LS	20%		$ 3,259,523
Total Estimated Construction Cost				**$ 19,557,135**

Alternative 5a

Across Kivalina Lagoon and then Northeast to the 25-Foot Contour
Uninsulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	224,815	$ 5,620,363
301(2): Surface Course, Grading E-1	Ton	$60	12,861	$ 771,670
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	94,942	$ 284,827
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 7,636,859**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 763,686
Construction Work Subtotal				**$ 8,400,545**
640: Mob/Demob (@ 6% of Constr. Work)	LS	6%		$ 504,033
Subtotal w/ Mob/Demob				**$ 8,904,578**
642: Constr. Engr. / Survey (@ 4% of Above)	LS	4%		$ 356,183
Subtotal w/ Construction Engr. / Survey				**$ 9,260,761**
Contingency (@ 20% of Above)	LS	20%		$ 1,852,152
Total Estimated Construction Cost				**$ 11,112,913**

Alternative 5b

Across Kivalina Lagoon and then Northeast to the 25-Foot Contour
Insulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	134,612	$ 3,365,300
301(2): Surface Course, Grading E-1	Ton	$60	12,861	$ 771,670
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	77,359	$ 232,077
635(1): Insulation Board	SF	$3	398,790	$ 1,196,370
Earthwork Subtotal				**$ 6,525,417**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 652,542
Construction Work Subtotal				**$ 7,177,958**
640: Mob/Demob (@ 7% of Constr. Work)	LS	7%		$ 502,457
Subtotal w/ Mob/Demob				**$ 7,680,415**
642: Constr. Engr. / Survey (@ 4% of Above)	LS	4%		$ 307,217
Subtotal w/ Construction Engr. / Survey				**$ 7,987,632**
Contingency (@ 20% of Above)	LS	20%		$ 1,597,526
Total Estimated Construction Cost				**$ 9,585,158**

Alternative 5c

Across Kivalina Lagoon and then Northeast to the 25-Foot Contour
Uninsulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	175,951	$ 4,398,763
301(2): Surface Course, Grading E-1	Ton	$60	12,692	$ 761,490
505(9): Steel Sheet Piles	SF	$40	101,800	$ 4,072,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	75,713	$ 227,140
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 10,419,393**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,041,939
Construction Work Subtotal				**$ 11,461,332**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 573,067
Subtotal w/ Mob/Demob				**$ 12,034,398**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 361,032
Subtotal w/ Construction Engr. / Survey				**$ 12,395,430**
Contingency (@ 20% of Above)	LS	20%		$ 2,479,086
Total Estimated Construction Cost				**$ 14,874,516**

Alternative 5d

Across Kivalina Lagoon and then Northeast to the 25-Foot Contour
Insulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	85,748	$ 2,143,700
301(2): Surface Course, Grading E-1	Ton	$60	12,692	$ 761,490
505(9): Steel Sheet Piles	SF	$40	101,800	$ 4,072,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	58,130	$ 174,390
635(1): Insulation Board	SF	$3	398,790	$ 1,196,370
Earthwork Subtotal				**$ 9,307,950**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 930,795
Construction Work Subtotal				**$ 10,238,745**
640: Mob/Demob (@ 6% of Constr. Work)	LS	6%		$ 614,325
Subtotal w/ Mob/Demob				**$ 10,853,070**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 325,592
Subtotal w/ Construction Engr. / Survey				**$ 11,178,662**
Contingency (@ 20% of Above)	LS	20%		$ 2,235,732
Total Estimated Construction Cost				**$ 13,414,394**

Alternative 6a

Continue Alternative 5 to the Simiq Site

Uninsulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	318,246	$ 7,956,144
301(2): Surface Course, Grading E-1	Ton	$60	19,805	$ 1,188,295
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	139,859	$ 419,577
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 10,524,015**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,052,402
Construction Work Subtotal				**$ 11,576,417**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 578,821
Subtotal w/ Mob/Demob				**$ 12,155,238**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 364,657
Subtotal w/ Construction Engr. / Survey				**$ 12,519,895**
Contingency (@ 20% of Above)	LS	20%		$ 2,503,979
Total Estimated Construction Cost				**$ 15,023,874**

Alternative 6b

Continue Alternative 5 to the Simiq Site

Insulated Road Section, Embankment Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	169,262	$ 4,231,550
301(2): Surface Course, Grading E-1	Ton	$60	19,805	$ 1,188,295
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	110,817	$ 332,452
635(1): Insulation Board	SF	$3	658,665	$ 1,975,995
Earthwork Subtotal				**$ 8,688,292**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 868,829
Construction Work Subtotal				**$ 9,557,121**
640: Mob/Demob (@6% of Constr. Work)	LS	6%		$ 573,427
Subtotal w/ Mob/Demob				**$ 10,130,548**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 303,916
Subtotal w/ Construction Engr. / Survey				**$ 10,434,465**
Contingency (@ 20% of Above)	LS	20%		$ 2,086,893
Total Estimated Construction Cost				**$ 12,521,357**

Alternative 6c

Continue Alternative 5 to the Simiq Site

Uninsulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	269,382	$ 6,734,544
301(2): Surface Course, Grading E-1	Ton	$60	19,635	$ 1,178,115
505(9): Steel Sheet Piles	SF	$40	101,800	$ 4,072,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	120,630	$ 361,890
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 13,306,549**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,330,655
Construction Work Subtotal				**$ 14,637,204**
640: Mob/Demob (@ 4% of Constr. Work)	LS	4%		$ 585,488
Subtotal w/ Mob/Demob				**$ 15,222,692**
642: Constr. Engr. / Survey (@ 2% of Above)	LS	2%		$ 304,454
Subtotal w/ Construction Engr. / Survey				**$ 15,527,146**
Contingency (@ 20% of Above)	LS	20%		$ 3,105,429
Total Estimated Construction Cost				**$ 18,632,575**

Alternative 6d

Continue Alternative 5 to the Simiq Site

Insulated Road Section, Sheet Pile Causeway

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	120,398	$ 3,009,950
301(2): Surface Course, Grading E-1	Ton	$60	19,635	$ 1,178,115
505(9): Steel Sheet Piles	SF	$40	101,800	$ 4,072,000
509(X): Bridge	SF	$400	2,400	$ 960,000
630(1): Geotextile, Separation	SY	$3	91,588	$ 274,765
635(1): Insulation Board	SF	$3	658,665	$ 1,975,995
Earthwork Subtotal				**$ 11,470,825**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 1,147,083
Construction Work Subtotal				**$ 12,617,908**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 630,895
Subtotal w/ Mob/Demob				**$ 13,248,803**
642: Constr. Engr. / Survey (@ 2.5% of Above)	LS	2.5%		$ 331,220
Subtotal w/ Construction Engr. / Survey				**$ 13,580,023**
Contingency (@ 20% of Above)	LS	20%		$ 2,716,005
Total Estimated Construction Cost				**$ 16,296,028**

Alternative 7a
Extension From the Simiq Site to the Imnakuk Bluff Site
Uninsulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	213,929	$ 5,348,231
301(2): Surface Course, Grading E-1	Ton	$60	15,899	$ 953,945
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	7,680	$ 3,072,000
630(1): Geotextile, Separation	SY	$3	102,846	$ 308,537
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 9,682,713**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 968,271
Construction Work Subtotal				**$ 10,650,984**
640: Mob/Demob (@ 5% of Constr. Work)	LS	5%		$ 532,549
Subtotal w/ Mob/Demob				**$ 11,183,533**
642: Constr. Engr. / Survey (@ 3% of Above)	LS	3%		$ 335,506
Subtotal w/ Construction Engr. / Survey				**$ 11,519,039**
Contingency (@ 20% of Above)	LS	20%		$ 2,303,808
Total Estimated Construction Cost				**$ 13,822,847**

Alternative 7b

Extension From the Simiq Site to the Imnakuk Bluff Site

Insulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	71,099	$ 1,777,468
301(2): Surface Course, Grading E-1	Ton	$60	15,899	$ 953,945
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	7,680	$ 3,072,000
630(1): Geotextile, Separation	SY	$3	74,696	$ 224,087
635(1): Insulation Board	SF	$3	595,035	$ 1,785,105
Earthwork Subtotal				**$ 7,812,604**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 781,260
Construction Work Subtotal				**$ 8,593,865**
640: Mob/Demob (@ 6% of Constr. Work)	LS	6%		$ 515,632
Subtotal w/ Mob/Demob				**$ 9,109,497**
642: Constr. Engr. / Survey (@ 4% of Above)	LS	4%		$ 364,380
Subtotal w/ Construction Engr. / Survey				**$ 9,473,877**
Contingency (@ 20% of Above)	LS	20%		$ 1,894,775
Total Estimated Construction Cost				**$ 11,368,652**

Alternative 8a

Extension From the Simiq Site to the Kisimigiuktuk Hill Area

Uninsulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	174,745	$ 4,368,619
301(2): Surface Course, Grading E-1	Ton	$60	12,987	$ 779,215
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	0	$ -
630(1): Geotextile, Separation	SY	$3	84,008	$ 252,023
635(1): Insulation Board	SF	$3	0	$ -
Earthwork Subtotal				**$ 5,399,857**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 539,986
Construction Work Subtotal				**$ 5,939,843**
640: Mob/Demob (@ 8% of Constr. Work)	LS	8%		$ 475,187
Subtotal w/ Mob/Demob				**$ 6,415,030**
642: Constr. Engr. / Survey (@ 5% of Above)	LS	5%		$ 320,752
Subtotal w/ Construction Engr. / Survey				**$ 6,735,782**
Contingency (@ 20% of Above)	LS	20%		$ 1,347,156
Total Estimated Construction Cost				**$ 8,082,938**

Alternative 8b
Extension From the Simiq Site to the Kisimigiuktuk Hill Area
Insulated Road Section

Item Description	Unit	Unit Cost	Quantity	Extended Cost
203(6): Borrow, Type A	Ton	$25	64,806	$ 1,620,150
301(2): Surface Course, Grading E-1	Ton	$60	12,987	$ 779,215
505(9): Steel Sheet Piles	SF	$40	0	$ -
509(X): Bridge	SF	$400	0	$ -
630(1): Geotextile, Separation	SY	$3	62,577	$ 187,732
635(1): Insulation Board	SF	$3	486,045	$ 1,458,135
Earthwork Subtotal				**$ 4,045,232**
Incidental Work Items (@10% of Earthwork)	LS	10%		$ 404,523
Construction Work Subtotal				**$ 4,449,755**
640: Mob/Demob (@ 10% of Constr. Work)	LS	10%		$ 444,975
Subtotal w/ Mob/Demob				**$ 4,894,730**
642: Constr. Engr. / Survey (@ 7% of Above)	LS	7%		$ 342,631
Subtotal w/ Construction Engr. / Survey				**$ 5,237,361**
Contingency (@ 20% of Above)	LS	20%		$ 1,047,472
Total Estimated Construction Cost				**$ 6,284,834**

Alternative 1a - Northwest Along the Barrier Island to the Tatchim Isua Site (Uninsulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	27,310	24	2.5	6	26.50	12	32	0	32	12,770	29,333	22,986	52,799	95,585	0	0	0	0	0
Section 2 - Bridge (across Kivalik Inlet)	465	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	11,160	0	0
Section 3 - Road (on spit)	15,590	24	2.5	6	26.50	12	32	0	32	7,290	16,745	13,122	30,141	54,565	0	0	0	0	0
Section 4 - Road (on tundra)	12,480	24	2.5	6	26.50	54	49	0	49	5,836	78,520	10,504	141,336	67,947	0	0	0	0	0
	55,845	ft.								**25,895**	**124,598**	**46,612**	**224,276**	**218,097**	**0**		**11,160**		**0**
	10.58	mi.																	

Alternative 1b - Northwest Along the Barrier Island to the Tatchim Isua Site (Insulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	27,310	24	2.5	6	26.50	12	32	0	32	12,770	29,333	22,986	52,799	95,585	0	0	0	0	0
Section 2 - Bridge (across Kivalik Inlet)	465	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	11,160	0	0
Section 3 - Road (on spit)	15,590	24	2.5	6	26.50	12	32	0	32	7,290	16,745	13,122	30,141	54,565	0	0	0	0	0
Section 4 - Road (on tundra)	12,480	24	2.5	6	26.50	12	32	12	37	5,836	29,120	10,504	52,416	50,613	393,120	0	0	0	0
	55,845	ft.								**25,895**	**75,198**	**46,612**	**135,356**	**200,763**	**393,120**		**11,160**		**0**
	10.58	mi.																	

Alternative 2a - Southeast Along the Barrier Island to near the Igrugaivik Site (Uninsulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Bridge (across Singauk Entrance)	370	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	8,880	0	0
Section 2 - Road (on spit)	4,000	24	2.5	6	26.50	12	32	0	32	1,870	4,296	3,367	7,733	14,000	0	0	0	0	0
Section 3 - Road (on tundra)	8,470	24	2.5	6	26.50	54	49	0	49	3,961	53,290	7,129	95,923	46,114	0	0	0	0	0
Section 4 - Bridge (across river slough)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 5 - Road (on tundra)	3,620	24	2.5	6	26.50	54	49	0	49	1,693	22,776	3,047	40,997	19,709	0	0	0	0	0
	16,560	ft.								**7,524**	**80,363**	**13,542**	**144,653**	**79,823**	**0**		**11,280**		**0**
	3.14	mi.																	

Alternative 2b - Southeast Along the Barrier Island to Near the Igrugaivik Site (Insulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Bridge (across Singauk Entrance)	370	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	8,880	0	0
Section 2 - Road (on spit)	4,000	24	2.5	6	26.50	12	32	0	32	1,870	4,296	3,367	7,733	14,000	0	0	0	0	0
Section 3 - Road (on tundra)	8,470	24	2.5	6	26.50	12	32	12	37	3,961	19,763	7,129	35,574	34,351	266,805	0	0	0	0
Section 4 - Bridge (across river slough)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 5 - Road (on tundra)	3,620	24	2.5	6	26.50	12	32	12	37	1,693	8,447	3,047	15,204	14,681	114,030	0	0	0	0
	16,560	ft.								**7,524**	**32,506**	**13,542**	**58,511**	**63,032**	**380,835**		**11,280**		**0**
	3.14	mi.																	

Alternative 3a - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to 25-Foot Contour (Uninsulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 5 - Road (on tundra)	8,190	24	2.5	6	26.50	54	49	0	49	3,830	51,529	6,893	92,752	44,590	0	0	0	0	0
	23,450	ft.								10,967	126,275	19,740	227,294	121,178	0		2,400		0
	4.44	mi.																	

Alternative 3b - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to 25-Foot Contour (Insulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 5 - Road (on tundra)	8,190	24	2.5	6	26.50	12	32	12	37	3,630	19,110	6,893	34,398	33,215	257,985	0	0	0	0
	23,450	ft.								10,967	93,856	19,740	168,941	109,803	257,985		2,400		0
	4.44	mi.																	

Alternative 3c - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to 25-Foot Contour (Uninsulated Road Section, Sheet Pile Causeway)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 5 - Road (on tundra)	8,190	24	2.5	6	26.50	54	49	0	49	3,830	51,529	6,893	92,752	44,590	0	0	0	0	0
	23,450	ft.								10,837	88,941	19,507	160,094	94,733	0		2,400		140,000
	4.44	mi.																	

Alternative 3d - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to 25-Foot Contour (Insulated Road Section, Sheet Pile Causeway)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 5 - Road (on tundra)	8,190	24	2.5	6	26.50	12	32	12	37	3,830	19,110	6,893	34,398	33,215	257,985	0	0	0	0
	23,450	ft.								10,837	56,523	19,507	101,741	83,358	257,985		2,400		140,000
	4.44	mi.																	

Alternative 4a - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to Simiq Site (Uninsulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 5 - Road (on tundra)	18,370	24	2.5	6	26.50	54	49	0	49	8,590	115,578	15,461	208,040	100,014	0	0	0	0	0
	33,630	ft.								15,727	190,324	28,309	342,583	176,602	0		2,400		0
	6.37	mi.																	

Alternative 4b - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to Simiq Site (Insulated Road Section)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	4	6	28.00	96	92	0	92	843	31,111	1,517	56,000	17,889	0	0	0	0	0
Section 5 - Road (on tundra)	18,370	24	2.5	6	26.50	12	32	12	37	8,590	42,863	15,461	77,154	74,501	578,655	0	0	0	0
	33,630	ft.								15,727	117,609	28,309	211,697	151,088	578,655		2,400		0
	6.37	mi.																	

Alternative 4c - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to Simiq Site (Uninsulated Road Section, Sheet Pile Causeway)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 5 - Road (on tundra)	18,370	24	2.5	6	26.50	54	49	0	49	8,590	115,578	15,461	208,040	100,014	0	0	0	0	0
	33,630	ft.								15,597	152,991	28,075	275,383	150,158	0		2,400		140,000
	6.37	mi.																	

Alternative 4d - Northwest Along the Barrier Island, Causeway Across Lagoon, Road to Simiq Site (Insulated Road Section, Sheet Pile Causeway)

Street	Road Segment		Side	Surfacing, E-1		Borrow-1, Type A		Borrow-2, Type A		Volumes		Weights		Geotex.	Insul.	Bridge		Sheet Pile	
	Length (ft)	Width (ft)	Slope (H:1)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	Depth (in)	Width (ft)	E-1 (cy)	Type A (cy)	E-1 (Ton)	Type A (Ton)	Area (sy)	Area (sf)	Width (ft)	Area (sf)	Depth (ft)	Area (sf)
Section 1 - Road (on barrier island)	11,660	24	2.5	6	26.50	12	32	0	32	5,452	12,524	9,814	22,543	40,810	0	0	0	0	0
Section 2 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 3 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 4 - Causeway (across Kivalina Lagoon)	1,750	24	0	6	24.00	96	24	0	24	778	12,444	1,400	22,400	4,667	0	0	0	20	70,000
Section 5 - Road (on tundra)	18,370	24	2.5	6	26.50	12	32	12	37	8,590	42,863	15,461	77,154	74,501	578,655	0	0	0	0
	33,630	ft.								15,597	80,276	28,075	144,497	124,644	578,655		2,400		140,000
	6.37	mi.																	

Alternative 5a - Causeway Across Lagoon, Road to 25-Foot Contour (Uninsulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	4	6	28.00	96	92	0	92	758	28,000	1,365	50,400	16,100	0	0	0	0	0
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	4	6	28.00	96	92	0	92	467	17,244	841	31,040	9,916	0	0	0	0	0
Section 4 - Road (on tundra)	12,660	24	2.5	6	26.50	54	49	0	49	5,920	79,653	10,656	143,375	68,927	0	0	0	0	0
	15,305	ft.								**7,145**	**124,897**	**12,861**	**224,815**	**94,942**	**0**		**2,400**		**0**
	2.90	mi.																	

Alternative 5b - Causeway Across Lagoon, Road to 25-Foot Contour (Insulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	4	6	28.00	96	92	0	92	758	28,000	1,365	50,400	16,100	0	0	0	0	0
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	4	6	28.00	96	92	0	92	467	17,244	841	31,040	9,916	0	0	0	0	0
Section 4 - Road (on tundra)	12,660	24	2.5	6	26.50	12	32	12	37	5,920	29,540	10,656	53,172	51,343	398,790	0	0	0	0
	15,305	ft.								**7,145**	**74,784**	**12,861**	**134,612**	**77,359**	**398,790**		**2,400**		**0**
	2.90	mi.																	

Alternative 5c - Causeway Across Lagoon, Road to 25-Foot (Uninsulated Road Section, Sheet Pile Causeway)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	0	6	24.00	96	24	0	24	700	11,200	1,260	20,160	4,200	0	0	0	20	63,000
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	0	6	24.00	96	24	0	24	431	6,898	776	12,416	2,587	0	0	0	20	38,800
Section 4 - Road (on tundra)	12,660	24	2.5	6	26.50	54	49	0	49	5,920	79,653	10,656	143,375	68,927	0	0	0	0	0
	15,305	ft.								**7,051**	**97,750**	**12,692**	**175,951**	**75,713**	**0**		**2,400**		**101,800**
	2.90	mi.																	

Alternative 5d - Causeway Across Lagoon, Road to 25-Foot (Insulated Road Section, Sheet Pile Causeway)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	0	6	24.00	96	24	0	24	700	11,200	1,260	20,160	4,200	0	0	0	20	63,000
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	0	6	24.00	96	24	0	24	431	6,898	776	12,416	2,587	0	0	0	20	38,800
Section 4 - Road (on tundra)	12,660	24	2.5	6	26.50	12	32	12	37	5,920	29,540	10,656	53,172	51,343	398,790	0	0	0	0
	15,305	ft.								**7,051**	**47,638**	**12,692**	**85,748**	**58,130**	**398,790**		**2,400**		**101,800**
	2.90	mi.																	

Alternative 6a - Causeway Across Lagoon, Road to Simiq Site (Uninsulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	4	6	28.00	96	92	0	92	758	28,000	1,365	50,400	16,100	0	0	0	0	0
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	4	6	28.00	96	92	0	92	467	17,244	841	31,040	9,916	0	0	0	0	0
Section 4 - Road (on tundra)	20,910	24	2.5	6	26.50	54	49	0	49	9,777	131,559	17,599	236,806	113,843	0	0	0	0	0
	23,555	ft.								11,003	176,803	19,805	318,246	139,859	0		2,400		0
	4.46	mi.																	

Alternative 6b - Causeway Across Lagoon, Road to Simiq Site (Insulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	4	6	28.00	96	92	0	92	758	28,000	1,365	50,400	16,100	0	0	0	0	0
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	4	6	28.00	96	92	0	92	467	17,244	841	31,040	9,916	0	0	0	0	0
Section 4 - Road (on tundra)	20,910	24	2.5	6	26.50	12	32	12	37	9,777	48,790	17,599	87,822	84,802	658,665	0	0	0	0
	23,555	ft.								11,003	94,034	19,805	169,262	110,817	658,665		2,400		0
	4.46	mi.																	

Alternative 6c - Causeway Across Lagoon, Road to Simiq Site (Uninsulated Road Section, Sheet Pile Causeway)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	0	6	24.00	96	24	0	24	700	11,200	1,260	20,160	4,200	0	0	0	20	63,000
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	0	6	24.00	96	24	0	24	431	6,898	776	12,416	2,587	0	0	0	20	38,800
Section 4 - Road (on tundra)	20,910	24	2.5	6	26.50	54	49	0	49	9,777	131,559	17,599	236,806	113,843	0	0	0	0	0
	23,555	ft.								10,908	149,657	19,635	269,382	120,630	0		2,400		101,800
	4.46	mi.																	

Alternative 6d - Causeway Across Lagoon, Road to Simiq Site (Insulated Road Section, Sheet Pile Causeway)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Causeway (across Kivalina Lagoon)	1,575	24	0	6	24.00	96	24	0	24	700	11,200	1,260	20,160	4,200	0	0	0	20	63,000
Section 2 - Bridge (across Kivalina Lagoon)	100	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	2,400	0	0
Section 3 - Causeway (across Kivalina Lagoon)	970	24	0	6	24.00	96	24	0	24	431	6,898	776	12,416	2,587	0	0	0	20	38,800
Section 4 - Road (on tundra)	20,910	24	2.5	6	26.50	12	32	12	37	9,777	48,790	17,599	87,822	84,802	658,665	0	0	0	0
	23,555	ft.								10,908	66,888	19,635	120,398	91,588	658,665		2,400		101,800
	4.46	mi.																	

Alternative 7a - Additional Road from Simiq Site to Imnakuk Bluff Site (Uninsulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Road (on tundra)	13,780	24	2.5	6	26.50	54	49	0	49	6,443	86,699	11,598	156,059	75,024	0	0	0	0	0
Section 2 - Bridge (across Kivalina River)	320	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	7,680	0	0
Section 3 - Road (on tundra)	5,110	24	2.5	6	26.50	54	49	0	49	2,389	32,150	4,301	57,871	27,821	0	0	0	0	0
	19,210	**ft.**								**8,833**	**118,850**	**15,899**	**213,929**	**102,846**	**0**		**7,680**		**0**
	3.64	**mi.**																	

Alternative 7b - Additional Road from Simiq Site to Imnakuk Bluff Site (Insulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Road (on tundra)	13,780	24	2.5	6	26.50	12	32	9	35	6,443	27,576	11,598	49,637	53,972	434,070	0	0	0	0
Section 2 - Bridge (across Kivalina River)	320	24	0	0	24.00	0	24	0	24	0	0	0	0	0	0	24	7,680	0	0
Section 3 - Road (on tundra)	5,110	24	2.5	6	26.50	12	32	12	37	2,389	11,923	4,301	21,462	20,724	160,965	0	0	0	0
	19,210	**ft.**								**8,833**	**39,499**	**15,899**	**71,099**	**74,696**	**595,035**		**7,680**		**0**
	3.64	**mi.**																	

Alternative 8a - Additional Road from Simiq Site to Kisimigiuktuk Site (Uninsulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Road (on tundra)	15,430	24	2.5	6	26.50	54	49	0	49	7,215	97,080	12,987	174,745	84,008	0	0	0	0	0
	15,430	**ft.**								**7,215**	**97,080**	**12,987**	**174,745**	**84,008**	**0**		**0**		**0**
	2.92	**mi.**																	

Alternative 8b - Additional Road from Simiq Site to Kisimigiuktuk Site (Insulated Road Section)

Street	Road Segment Length (ft)	Road Segment Width (ft)	Side Slope (H:1)	Surfacing, E-1 Depth (in)	Surfacing, E-1 Width (ft)	Borrow-1, Type A Depth (in)	Borrow-1, Type A Width (ft)	Borrow-2, Type A Depth (in)	Borrow-2, Type A Width (ft)	Volumes E-1 (cy)	Volumes Type A (cy)	Weights E-1 (Ton)	Weights Type A (Ton)	Geotex. Area (sy)	Insul. Area (sf)	Bridge Width (ft)	Bridge Area (sf)	Sheet Pile Depth (ft)	Sheet Pile Area (sf)
Section 1 - Road (on tundra)	15,430	24	2.5	6	26.50	12	32	12	37	7,215	36,003	12,987	64,806	62,577	486,045	0	0	0	0
	15,430	**ft.**								**7,215**	**36,003**	**12,987**	**64,806**	**62,577**	**486,045**		**0**		**0**
	2.92	**mi.**																	

Appendix B

Kivalina Photos

Photo 1: Kivalina, Alaska.

Photo 2: Kivalina, looking northwest. Photo date unknown.

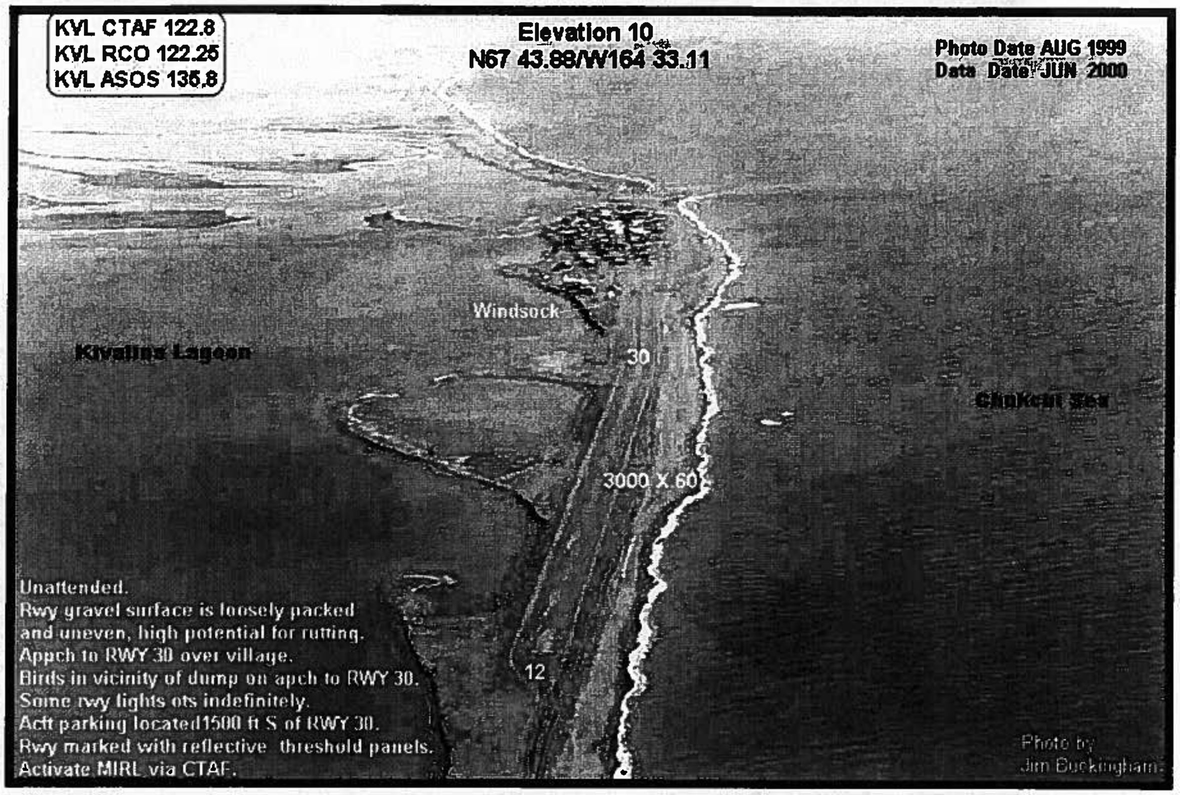

Photo 3: Kivalina, looking southeast. Photo date August 1999.

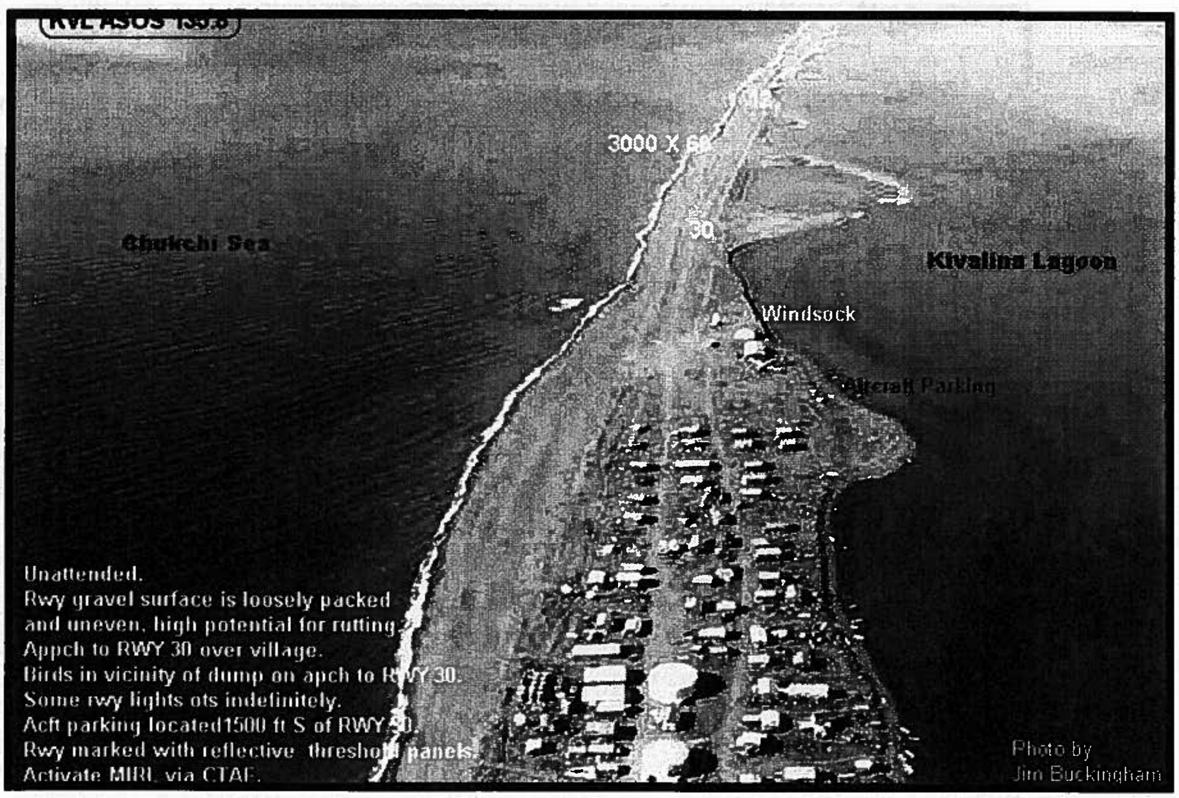

Photo 4: Kivalina, looking northwest. Photo date August 1999.

Photo 5: Kivalina. Photo date August 1998.

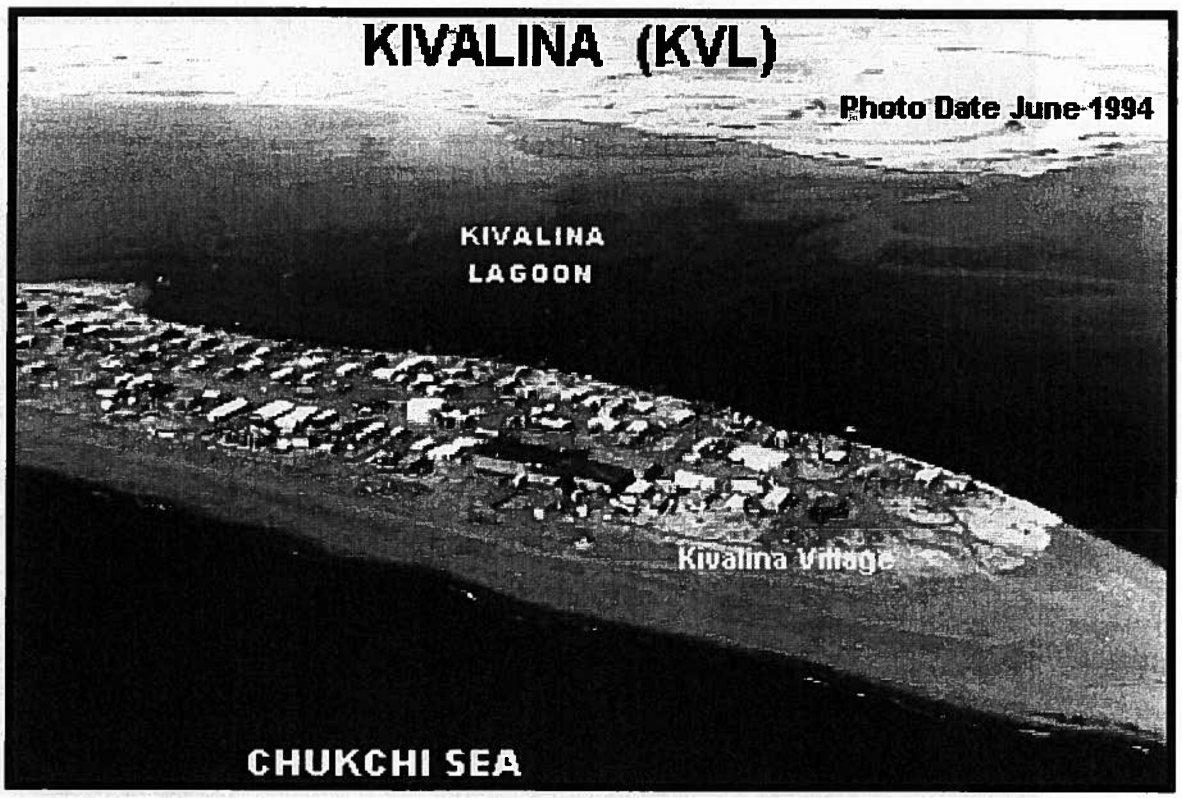

Photo 6: Kivalina, looking north-northeast. Photo date June 1994.

Photo 7: Kivalina. Northwest Arctic Borough School District (NABSD) principal's trailer during storm event. Photo date May ~~31~~, 2004.

Oct 19

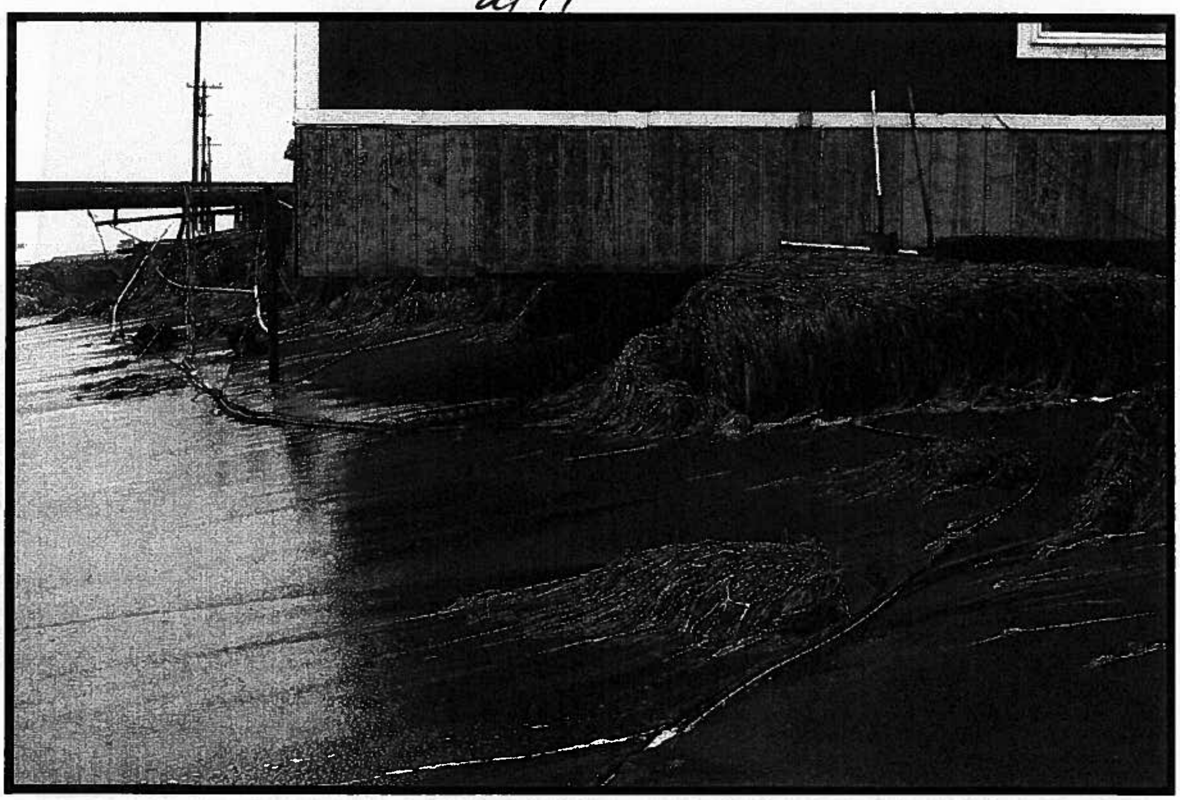

Photo 8: Kivalina. Northwest Arctic Borough School District (NABSD) principal's trailer during storm event. Photo date ~~May 31~~, 2004.

Oct 19

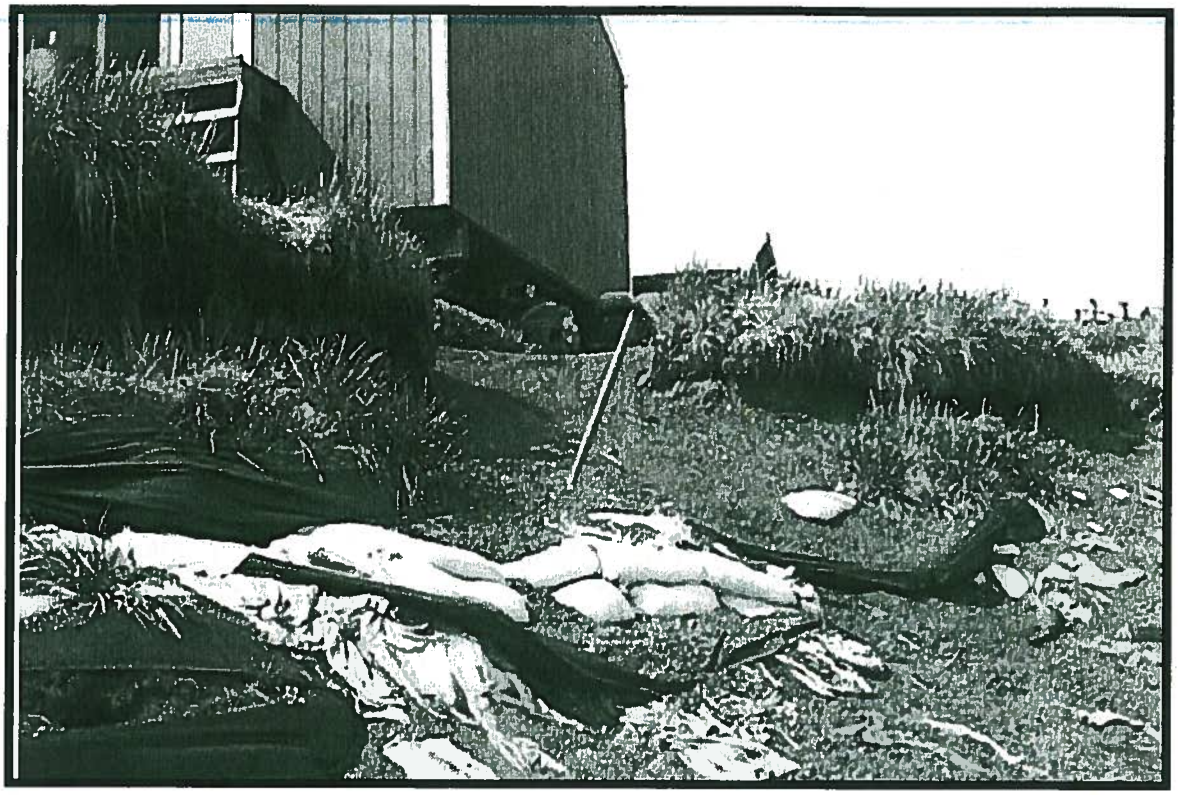

Photo 9: Kivalina. House on lagoon-side being undermined by erosion. Un~~known photo~~ date.
Oct 2004

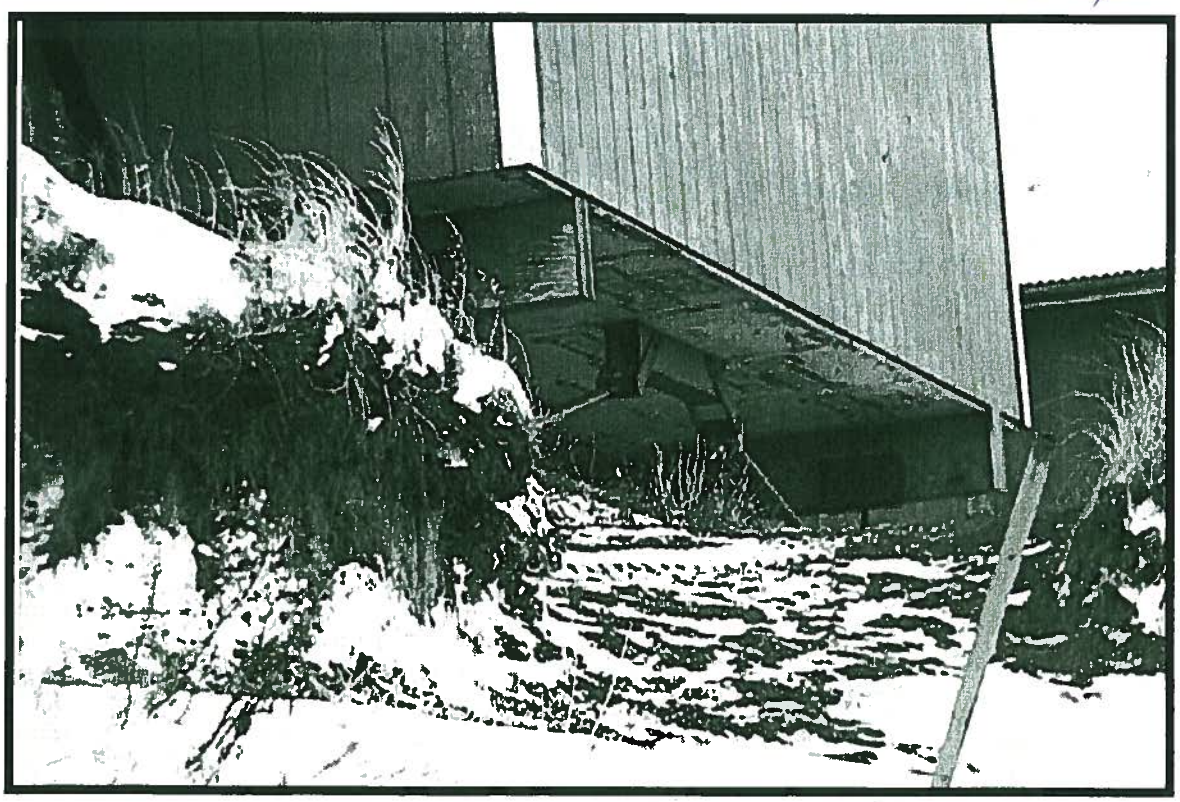

Photo 10: Kivalina. Same house as Photo 9, but after more erosion has occurred. Unknown photo date.
Oct - ~~Sept~~ 2004

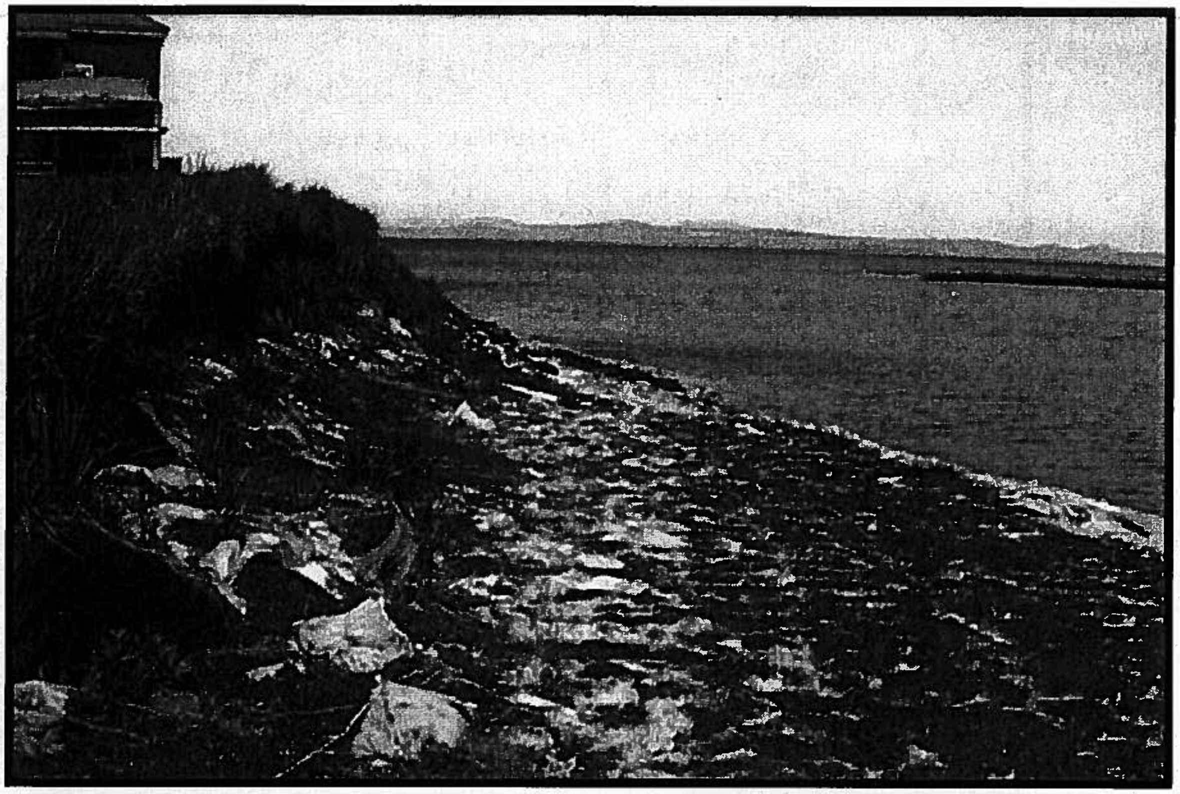

Photo 11: Kivalina. Beach erosion on lagoon side. Note sandbags used to slow erosion. Unknown photo date. 2003+

Photo 12: Kivalina. Beach erosion on lagoon side. Note sandbags used to slow erosion. Unknown photo date. 2003+

Photo 13: Kivalina. Beach erosion on lagoon side. Note sandbags used to slow erosion. Unknown photo date. ~~post 2002~~ 2003+

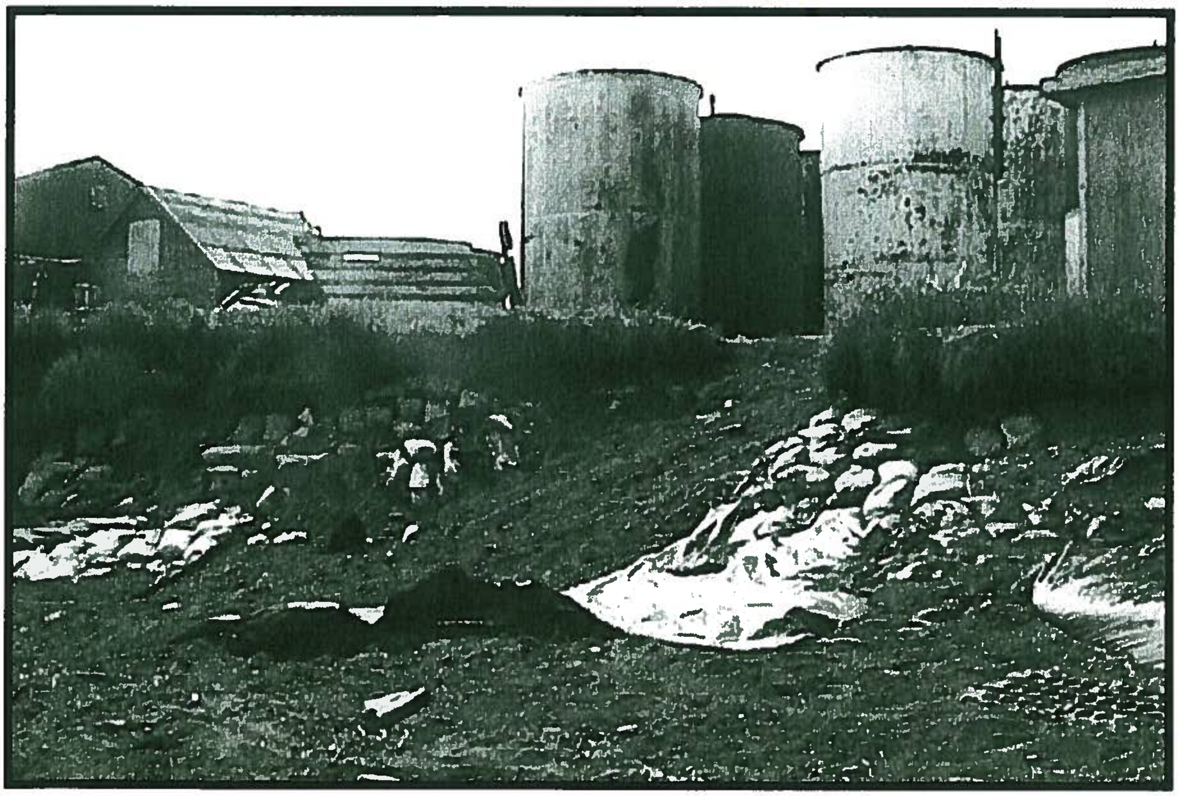

Photo 14: Kivalina. Beach erosion on lagoon side. Note sandbags used to slow erosion. Unknown photo date. 2003 +

Photo 15: Kivalina. Erosion occurring at runway. Photo date September 23, 2005.

Photo 16: Kivalina. Storm surge causing erosion. Note sewer outfall pipe exposed, sewage leach field has been destroyed. The power poles seen here have since been destroyed by storm surge erosion. Photo date ~~May 31, 2004.~~ Oct 19, 2004

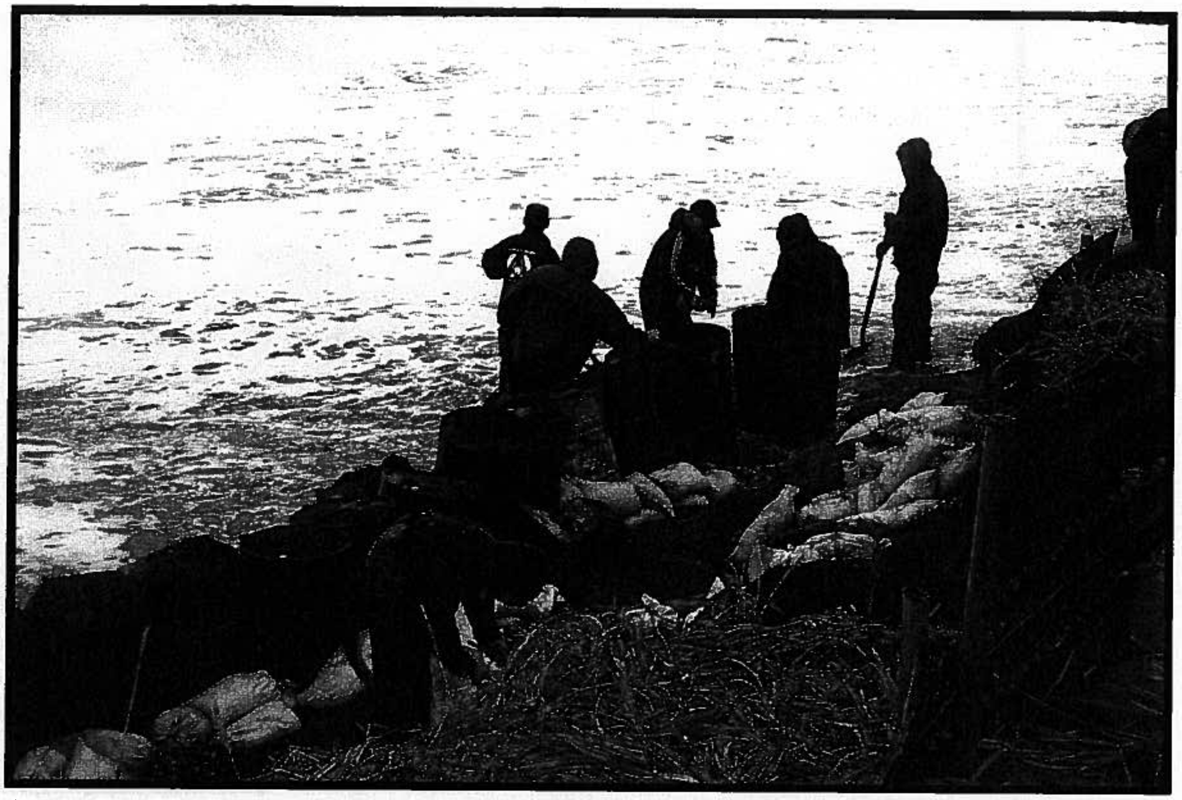

Photo 17: Kivalina. Residents building a revetment "wall" out of available material to try and stop storm surge erosion. Photo date September 21, 2005.

Photo 18: Kivalina. Finished revetment "wall." Photo date September 21, 2005.

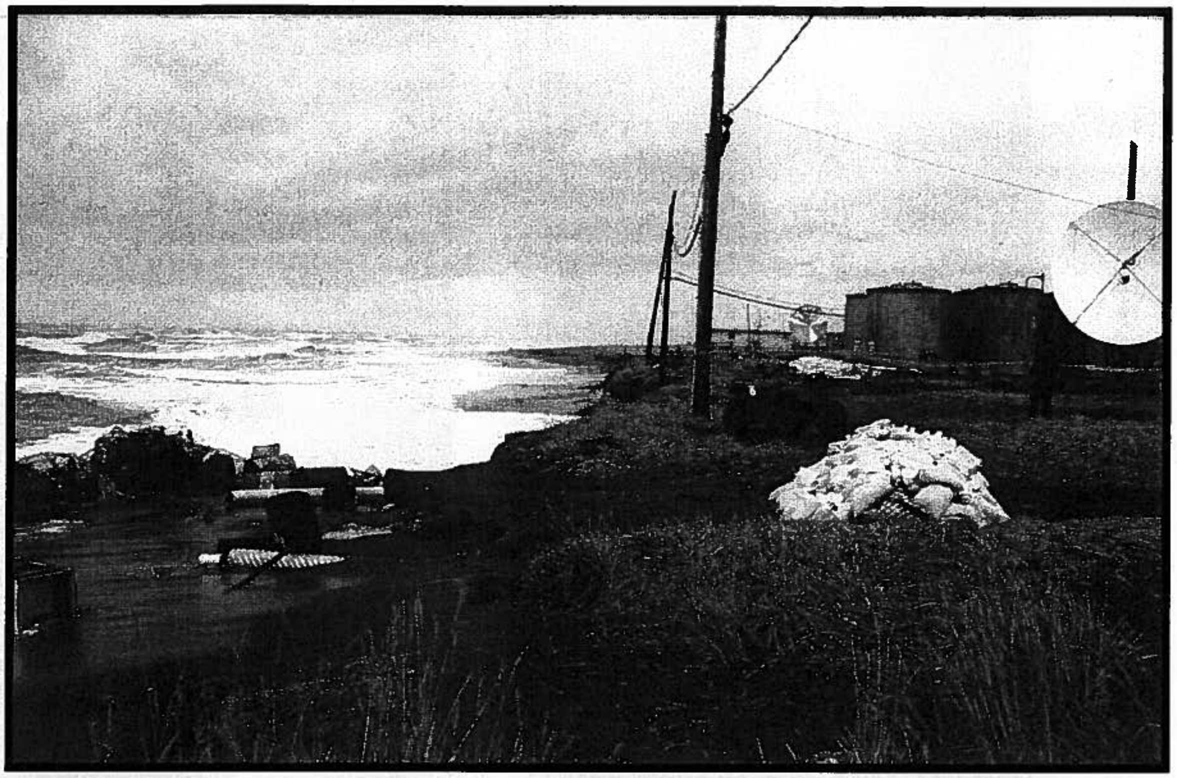

Photo 19: Kivalina. Note sewage drain pipes and leach field at left. Power poles seen here have since been destroyed by storms. Fuel tanks are now in danger of being undermined. Photo date September 23, 2005.

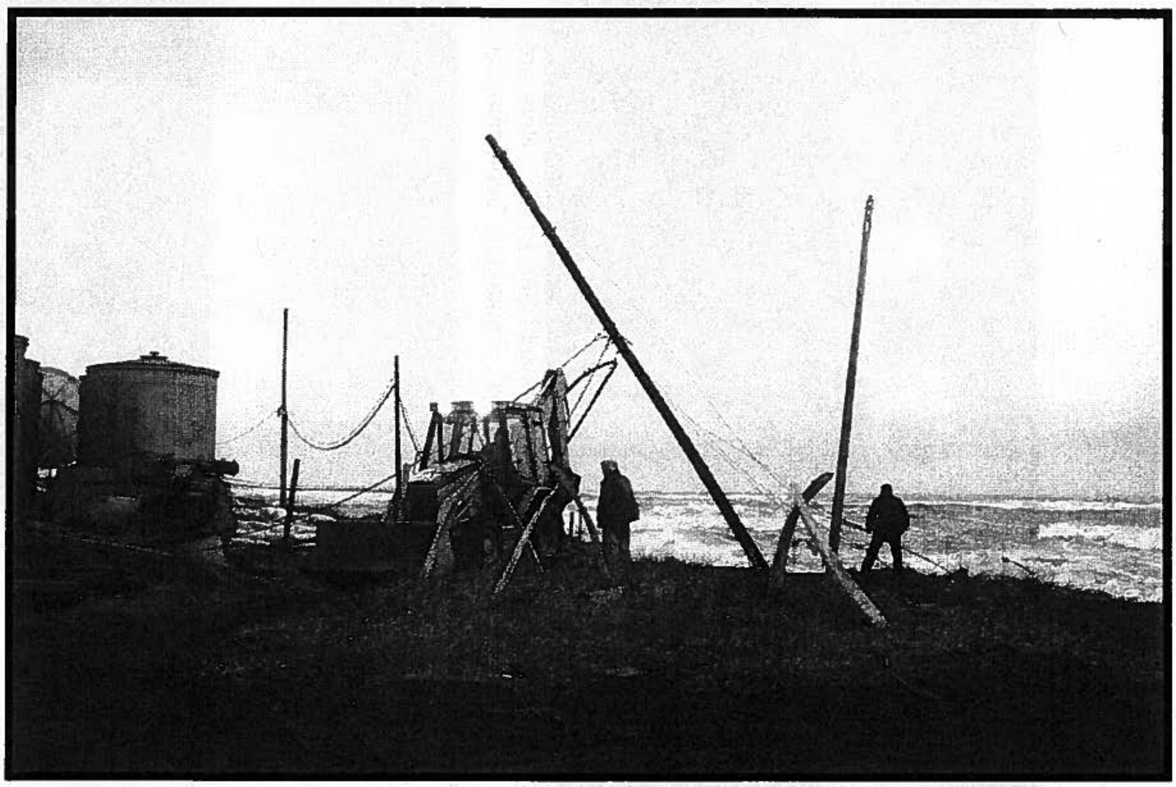

Photo 20: Kivalina. Residents trying to save power poles. These poles were destroyed. Photo date September 23, 2005.

Photo 21: Kivalina, looking east from Chukchi Sea beach. Note erosion near AVEC fuel tanks. Also, note sewage leach field in surf at right, which was once buried in "land". Photo date September 29, 2005.

Photo 22: Kivalina, looking northwest from Chukchi Sea beach.

Appendix C

References

The following information and reference material was used to prepare this Feasibility Study.

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