US Army Corps
of Engineers
Alaska District

RELOCATION PLANNING PROJECT MASTER PLAN

Kivalina, Alaska

JUNE 2006

Relocation Planning Project
Master Plan

Kivalina, Alaska

June 2006

Contract No./Order No.: DACW85-03-D-0006-0003
Delivery Order No. 0007

Submitted to:

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ADEC	Alaska Department of Environmental Conservation
ADOT&PF	Alaska Department of Transportation and Public Facilities
AE	Architect Engineer
AEA	Alaska Energy Authority
AIDEA	Alaska Industrial Development and Export Authority
ANA	Administration for Native Americans
ANCSA	Alaska Native Claims Settlement Act
ANTHC	Alaska Native Tribal Health Consortium
ARECA	Alaska's Electric Association
AS	Alaska Statutes
AVEC	Alaska Village Electric Cooperative, Inc.
BFRLF	Bulk Fuel Revolving Loan Fund
BIA	Bureau of Indian Affairs
Btu	British thermal unit
CBD	DCED Division of Community and Business Development
CCAP	Child Care Assistance Program
CES	Cooperative Extension Service
CDBG	Community Development Block Grant
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers, Alaska District
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
CRUM	Cold Regions Utilities Monograph
CWA	Clean Water Act
DCED	Alaska Department of Community and Economic Development
DEHE	Department of Environmental Health and Engineering
DHHS	U.S. Department of Health and Human Services
DNR	Alaska Department of Natural Resources
DOI	U.S. Department of Interior
DPOR	DNR Division of Parks and Outdoor Recreation
EDA	U.S. Department of Commerce, Economic Development Administration
EDD	Economic Development Districts
EPA	U.S. Environmental Protection Agency
FNDI	First Nations Development Institute
ft	feet
gpd	gallons per day
gpd/person	gallons per day per person
gph	gallons per hour
gpm	gallons per minute
gpy	gallons per year
hrs/day	hours per day
Hp	horsepower
HUD	U.S. Department of Housing and Urban Development
IDIQ	Indefinite Delivery Indefinite Quantity

IHS	Indian Health Services
ISA	Indian Set-Aside
KRPC	Kivalina Relocation Planning Committee
kW	kilowatts
kWH	kilowatt-hours
kWH/yr	kilowatt-hours per year
kWH/yr/person	kilowatts-hours per year per person
lbs	pounds
mbh	million Btu's per hour
n/a	not applicable
n.d.	no date listed
NPS	U.S. Department of Interior, National Park Service
NRC	NANA Regional Corporation
NRCS	USDA Natural Resources Conservation Service, formerly Soil Conservation Service
NWABSD	Northwest Arctic Borough School District
O&M	operation and maintenance
ONAP	Office of Native American Programs
PCE	Power Cost Equalization
PL	Public Law
RD	Rural Development
RHED	Rural Housing and Economic Development
RUBA	Rural Utility Business Advisor
RUS	Rural Utility Service (Old Rural Electrification Administration)
RWST	raw water storage tank
SBA	Small Business Administration
SBDC	Small Business Development Center
SDS	Sanitation Deficiency System
SOP	Regional Facility Program & Sustained Operations Program
sq. ft.	square feet
SuperNOFA	Super Notice of Funding Availability
SWDA	Safe Drinking Water Act
TNH	Tryck Nyman Hayes, Inc.
TWST	Treated Water Storage Tank
UAA	University of Alaska Anchorage
UA/CED	University of Alaska Center for Economic Development
UAF	University of Alaska Fairbanks
URS	URS Corporation
U.S.	United States
USC	United States Code
USDA	U.S. Department of Agriculture
VSW	ADEC Village Safe Water
WHIP	Wildlife Habitat Incentives Program
WST	water storage tank
WTP	water treatment plant
WTVP	water treatment vacuum plant

EXECUTIVE SUMMARY

The village of Kivalina, on a barrier island off the Chukchi Sea 80 miles north of the Arctic Circle, has been threatened by erosion caused by wave action and sea storms for several decades. It has long been apparent that the island would eventually succumb to natural forces, and that the village would have to be moved. To this end, village residents have pursued relocation for the last twenty years. Their efforts have been stymied by difficulties in choosing a new village site, funding the relocation effort, and social problems within the village stemming from overcrowding, poverty, and other difficult living conditions.

An increase in the frequency and intensity of sea storms, degradation and melting of permafrost, and accelerated erosion of the shoreline have recently forced the village into a state of emergency. Sea storms have eroded the shoreline out from underneath several structures and threatens the airstrip. Emergency erosion control measures are in place, but will only slow the sea's inevitable reclamation of the island. The relocation effort is now critical to the survival of the community.

The purpose of this report is to provide residents and stakeholders with the information necessary to make an informed decision regarding the best solution for the community of Kivalina. The current state of the community is discussed in detail in this report, as are each of the alternatives.

Kivalina is home to 402 residents, who live in very overcrowded conditions in just over 70 homes. The community is predominately Alaska Native, and residents depend on subsistence activities for a majority of their caloric intake. The community does not have a piped water or sewer system, except for running/piped water in its school and washeteria. Residents rely on self-haul water and on honey buckets for human waste.

The alternatives identified for this project are:

1. Do nothing,
2. Improve the current site, or
3. Move the village to a new site at:
    - Imnakuk Bluffs,
    - Simiq,
    - Tatchim Isua,
    - Kiniktuuraq,
    - Igrugaivik, or
    - Kuugruaq.

Kivalina residents have voted several times to choose a new village town site from the list of alternative sites. However, not only does a significant portion of the community disagree with the elected site, but the site chosen (Kiniktuuraq) has proven to be geotechnically inappropriate and strategically problematic with respect to the ongoing erosion of the northern Alaska coastline. Site selection and availability of funding are major obstacles to the progress of the project.

For the project to be successful in the long term, a site must be identified that is feasible in terms of:

- physical environment; including vulnerability to physical processes such as erosion, flooding, and weather;
- construction and utilities development, including cost of development and feasibility of cost efficient utilities;
- vulnerability to natural processes; and
- acceptable to community residents.

Relocation costs have been estimated for each relocation site. Costs include erosion protection at certain village sites. Section 5.3 includes a discussion of cost considerations. Costs for relocation, in 2006 dollars, not including engineering, permitting, and construction administration fees are shown below. Costs for the engineering are typically 8% of construction costs, with permitting and rural construction administration 5% and 6% respectively.

- Tatchim Isua - $154.9 million
- Improve Kivalina - $196.2 million
- Kuugruaq - $245.6 million
- Igrugaivik - $246.1 million
- Kiniktuuraq - $248.2 million
- Imnakuk Bluffs - $248.7 million
- Simiq - $251.5 million

The "do nothing" option will result in the current village site being overtopped with water during a storm or eroded away over time, and ultimately having to be abandoned. Improvements to the current site are limited due to location, vulnerability to storm surge flooding, overcrowding/lack of room to expand, and funding. Several sites identified as potential new village sites have significant problems relating to geophysical incompatibility with development, susceptibility to erosion or flooding, permitting, and social and cultural objections.

Although site selection has proved problematic, it is important that the project overcome this obstacle. The current community is reaching a critical state in terms of its continued survival in its current location.

The next steps in the relocation process involve three sets of activities.

1. Pursue Temporary Erosion Protection Measures. Temporary measures are needed to protect the school and fuel facilities from erosion. The community of Kivalina, working with the Northwest Arctic Borough, Alaska District Corps of Engineers, and other entities such as the Denali Commission should work cooperatively to obtain funding, design and construct suitable erosion protection structures.
2. Confirm Community Selection for Relocation Site. The community needs to carefully review this report and the advantages and disadvantages associated with each sites, including relative risk and likelihood of receiving addition funding.

The choice of a site for relocation should then be confirmed in a formal referendum.

3. Initiate Next Steps in Implementing Community Relocation. The Master Relocation Schedule in Appendix C lays out the estimated phases and specific steps to proceed from site confirmation to completion of relocation. The next steps in Phase Three, Planning, are as follows:

    - Obtain funding for selected site planning and design activities
    - Initiate comprehensive master planning for the selected site
    - Complete specific infrastructure and utility feasibility studies and initiate grant applications for design and construction
    - Identify agency to lead future funding, design and construction efforts associated with relocation
    - Acquire design and permitting phase funding

Completion of these steps will lead to initiation of project design phase (Phase 4).

1 INTRODUCTION

1.1 CORPS OF ENGINEERS STUDY AUTHORITY

The investigations documented in this report were conducted under the Tribal Partnership Program as defined in the Water Resources Development Act of 2000 (P.L. 106-541, Sec. 203) and the Planning Assistance to States (PAS) program, as authorized by Sec. 22 of the Water Resources Development Act of 1974 P.L. 93-251) as amended. The Water Resources Development Act authorizes the Assistant Secretary of the Army for Civil Works (Secretary), acting through the Chief of Engineers to cooperate with States to prepare plans for the development, utilization, and conservation of water; and related land resources of drainage basins located within the boundaries of the State. Section 319 of the Water Resources Development Act of 1990 (Public Law 101-460) directs the Secretary to collect 50% of the cost of PAS projects from non-federal entities. Funds and direction for Kivalina relocation planning were also provided in the Consolidated Appropriations Resolution, 2003 (P.L. 108-7, Division D, conference report H.R. 108-10, page 807 and Senate report S.R. 107-22, page 23), and further direction was provided in the Energy and Water Development Appropriations Act, 2004, P.L. 108-137, conference report H.R. 108-357, Sec. 112. Local signatories of the PAS agreement are the City of Kivalina, the Native Village of Kivalina, and the Northwest Arctic Borough. The Alaska Native Tribal Health Consortium also provided local funds for the sanitary facilities portion of this scope.

Previous studies relating to Kivalina relocation are referenced within this document when applicable. At times, information in this document may conflict with previous Corps studies when new information has become available. In such instances, the information in this document will be the most current and the most pertinent.

1.2 PURPOSE AND SCOPE

This master plan provides preliminary facility designs, costs, schedule, and a decision matrix for the community of Kivalina and its relocation stakeholders. This information is necessary to obtain funding for the village relocation and to begin designing the new town site. The master plan compiles information that allows a reasonable comparison between the eight (8) alternatives for relocation and develops a reasonable schedule of anticipated relocation activities.

This study includes six (6) new town sites, the "no action" option, and the option of making improvements at the existing site. Areas identified as possible locations for the new town site are:

- Simiq
- Imnakuk Bluffs
- Tatchim Isua
- Kiniktuuraq
- Igrugaivik
- Kuugruaq

In a community vote, Kivalina residents expressed a preference for Kiniktuuraq as the new town site. However, general comparisons of all alternative sites are included in this report.

Kiniktuuraq, Imnakuk Bluffs, Igrugaivik, and Kuugruaq were the subject of existing reports or supporting data, principally the 1994 Relocation Study, Kivalina Alaska by DOWL Engineers, and the 1998 Community Improvement Feasibility Report, Kivalina, Alaska by Alaska District Corps of Engineers. The scope of work for this report assumes that the existing information for these four sites is adequate. Simiq and Tatchim Isua were to be investigated and brought up to the same level as the above-mentioned four alternatives.

See Figure 1 for a visual layout of the Kivalina Relocation Alternatives.

1.3 PREVIOUS STUDIES AND/OR REPORTS

Reports and studies reviewed and referenced for this report include:

1.3.1 U.S. Army Corps of Engineers Studies

- Tryck Nyman Hayes and URS Corporation (TNH/URS). Relocation Planning Project – Village Requirements Report; Building and Facilities Inventory Map; List of Stakeholders; Resource Identification Report – Kivalina, Alaska for the U.S. Army Corps of Engineers, Alaska District. October 2003.
- R&M Consultants. Phase II Engineering Services Geotechnical Investigation – Kivalina Town site Relocation for the U.S. Army Corps of Engineers, Alaska District. August 2002.
- Tryck Nyman Hayes and URS Corporation (TNH/URS). Kivalina Relocation Community Layout Plan for the U.S. Army Corps of Engineers, Alaska District. December 2001.
- R&M Consultants. *Reconnaissance Geotechnical Investigation – Kivalina Relocation* for the U.S. Army Corps of Engineers, Alaska District. January 2000.
- U.S. Army Corps of Engineers. *Community Improvement Feasibility Report*. Alaska District, April 1998.
- DOWL/BBFM Joint Venture. *Geotechnical Investigation – Kivalina Borrow Material Exploration* for the U.S. Army Corps of Engineers, Alaska District. December 1998.

1.3.2 Studies By Others

- ASCG Incorporated. *Kivalina Sanitary Surve*y. May 2004.
- Golder Associates. *Geophysical Groundwater Source Investigation – Kivalina, Alaska.* October 1997.
- DOWL. *City of Kivalina Relocation Study*. December 14, 1994.
- CH2M Hill. Water & Wastewater Feasibility Study. January 1984.

1.4 PLANNING OBJECTIVES

The following planning goals and objectives have been established for the Master Planning Phase of the Kivalina Relocation Project:

GOAL: Assist the community of Kivalina in selecting the most feasible and appropriate alternative.

> **Objective:** Work with the community to identify site evaluation criteria that consider: safety, construction and operations costs, and social and cultural needs.

GOAL: Plan for efficient and orderly relocation of Kivalina.

> **Objective**: Identify specific phases of planning, design, permitting, construction, and moving associated with the relocation of Kivalina.
> **Objective**: Develop a preliminary schedule for the phases of relocation.
> **Objective:** Review phasing considerations and the preliminary schedule with potential local, state and federal partners and the community of Kivalina.

GOAL: Initiate conceptual engineering for utilities and other infrastructures for relocation sites under consideration.

> **Objective:** Develop engineering concepts that can be used for each of the sites under considerations for relocation.
> **Objective:** Evaluate each of the sites under consideration for relocation with regard to conceptual engineering.

1.5 PROBLEMS AND OPPORTUNITIES

Many of the problems that Kivalina faces are a result of erosion and flooding. The potential threats from erosion and flooding have inhibited investment in the community, whether it is improving water supply and distribution, sewage treatment, transportation systems, or providing adequate housing. The combination of erosion and flooding threats, combined with inability to invest in community improvements and lack of community expansion opportunities at the existing site results in the need for community relocation.

1.5.1 Erosion, Flooding, and Global Warming

For nearly two decades, local residents have been concerned with the threat that coastal erosion and storm surge poses to the community of Kivalina. Review of aerial photos since the 1980's indicate that there has been a loss of the width of beach from the mouth of the Wulik River north towards the airport, with a rapid increase in erosion into specific upland areas of the community over the last 5 years. The potential loss of the town site to the encroaching sea provides ample justification for its relocation. Moreover, there is no reason to believe that this trend will cease in light of the global forces that appear to be contributing to it. While causes of global warming are a matter for scientific debate, it is an indisputable fact

This 1983 photo of Kivalina shows the distance between the village school (the large brown building to the left of center) and the shoreline. The shoreline has now eroded so that the shoreline is a few feet from the school.

that climates are changing over most of the planet, and that some of these changes are most evident in the Arctic (e.g. Houghton 1997, Easterling et al. 2000).

Without addressing global scale effects on the Arctic climate, it is sufficient to note that some of the end effects have potentially dire consequences for Kivalina and other villages located on or near Arctic Ocean shorelines. First, the steady diminution of the Arctic Ocean ice pack (Linacre & Geerts 2004) enhances the potential for increased coastal erosion in at least two ways :

- Since the early 1980s the time between spring break-up of land fast sea ice and autumn freeze-up along Arctic shorelines has increased from barely three months to as much as five months. Longer periods of ice free water extend the "season" for coastal erosion.
- Larger expanses of ice-free water provide longer fetches over which winds can generate ocean waves that are higher, longer, and thus potentially more destructive to the shorelines where they ultimately dissipate their energy.

A short-term implication of these facts is that the present town site will require coastal erosion protection until relocation is completed. As already noted in Section 2.1.5, statistics indicate that the interval of occurrence for a 4-ft elevation storm surge, as occurred on 20 October 2004, is once a year. According to Wise et al. (1981), a 6-ft storm surge would have a recurrence interval of less than 5 years. The approximate island height of 10 feet would indicate that a 6 ft storm would result in 6 inches of water covering the community. Preliminary modeling by the Engineering Research Design Centre (ERDC) indicates that the 100-year storm surge event would have a water surface of 3.2 meters (10.5 feet) *with no ice cover***.** The status of ice cover during a storm surge event will play a major role in determining how much flooding could occur.

A 2003 working draft report prepared for the Alaska District Corps of Engineers (D. Mark 2003) that re-evaluated storm surge threat to the existing site of Kivalina states that "preferred site for community relocation is subject to storm surge from the Chukchi Sea." While it does not name Kiniktuuraq specifically, it likely refers to that site. The revised evaluation of storm surge indicates that existing 1970 storm of record resulted in a 13.57 foot surge that inundated portions of the existing site. Results of modeling calculated that the 50 year occurrence storm surge would reach and elevation of 13.5 feet and the 100 year occurrence storm surge would reach an elevation of 16.1 feet.

It is important to recognize that there is a 70% chance that an event with a 5 year recurrence interval will occur during the five-year period that will be required for relocation of Kivalina. There is better than a 50% chance of seeing a 6 foot storm surge before the relocation is completed; some provisions should be made to prepare for that occurrence.

Other consequences of global warming that are relevant to the selection of a new town site include sea level rise (EPA 2004) and permafrost degradation (Arctic Climate Project 2004). Implications of the former would include rejection of low-lying sites, even though they are considered to be a "safe" distance from the coast. While the amount of sea level rise that will be seen in Alaska is not yet determinable, it is projected to be as much as 1-2 feet over the next 100 years in more temperate locations. Permafrost degradation can result in lowering the elevation of the surface elevation and increasing the rates of erosion of ice rich soils along the coast. This in turn could increase the extent of storm surge inundation and site stability for construction of buildings and infrastructure.

Relocating the Kivalina town site to an inland area would alleviate concerns regarding potential island site flooding as well as providing relief from shoreline erosion. The new project site could be designed in such a way that impacts from future permafrost degradation are minimal.

1.5.2 Water Supply and Distribution

The present water supply and distribution system presents two major problems: storage tanks cannot be replenished for approximately three months out of the year while the Wulik River is frozen, and the majority of the community does not have a piped water supply. In addition, the water transmission lines are not heated, Water cannot be pumped when temperatures are below freezing. The total storage volume of approximately 1,200,000 gallons is minimal for current community needs as well as inadequate for fire fighting capabilities. The stored water occasionally runs low before the tanks can be replenished. During these times, public access to the watering point is halted and the treated water is reserved for the school. Mr. Enoch Adams Jr., Chair of the KRPC, indicated that since 1986 both community water tanks have run low five times, even with residents collecting water from other sources (TNH/URS, 2003).

Even though community water is usually available, the treated water has an unpleasant taste. Because some Kivalina residents do not like the taste of the treated water, they rely on several other sources including: 1) rainwater collection by roof catchments, 2) individual collection of water up the Kivalina River in the summer, and 3) blocks of river ice cut in the winter. Some residents employ a Brita filter in their homes to further treat the water and improve the taste. Residents also purchase distilled water at the store. Because of the lack of piped water, the upgrade of the current water supply system in Kivalina is a high health and safety priority of the community.

However, federal and state agencies will not support installation of a piped water system in Kivalina given the threat from flooding and erosion. The village cannot upgrade to a piped water supply system without moving to a new town site. Moving the town site to an area with an adequately sustainable, year-round water source that can provide for a piped water system would meet the community's sanitation needs.

1.5.3 Waste Disposal

1.5.3.1 Human Waste

The necessary distance from the community to the honey bucket bunker creates a potential hazard. The community must transport their honey buckets by four-wheeler trailers or snow machine sleds, which may result in spills that would be a threat to human health. Individual residences must manage their own septic waste, which is an unpleasant chore at best and a health hazard at worst.

The upgrade of the current sewer system in Kivalina is a top priority to the health and safety of the community. However, federal and state agencies will not support installation of a piped sewer system in Kivalina given the threat from flooding and erosion. When the village is relocated, a new piped sewage collection and disposal system could be installed. A piped system will greatly reduce hazardous spills and allow for a generally higher level of health and sanitation.

1.5.3.2 Solid Waste

Located near the honey bucket dump is a landfill-type garbage disposal facility. The landfill is located too close to the runway, in violation of the airstrip set back limits. This close proximity to the runway creates a hazard to aircraft when scavenging birds are attracted to the landfill. Bird strikes are extremely dangerous to aircraft and can quite easily cause an airplane to crash.

Both the current landfill and an older dumpsite (just north of the airstrip) have numerous hazards, including blowing trash, the potential for contamination of surface waters, and the creation of an attractant for nuisance wildlife in close proximity to the airport. Lack of cover material is also a problem. Kivalina has no centralized or coordinated collection or control system in place. No record of waste taken to the landfill has ever been kept, and it is not known whether hazardous waste is separated from municipal solid waste. The distance from the community and transport of garbage by four-wheel vehicle results in spilled garbage that can spread across the island and even into the Chukchi Sea and Kivalina Lagoon. Kivalina residents are not in compliance with ADEC regulations pertaining to the collection of solid wastes.

Relocating the town site will offer an opportunity to replace the current system. Replacing the current disposal facility would address ongoing critical safety and health issues, and provide an improvement to the collection process.

1.5.4 Transportation

Severe weather and increased storm surges affect transportation in Kivalina. Since there are no roads in and out of Kivalina, the community relies solely on supplies delivered by air and by barge.

Air service is available to the village throughout the year, however, inclement weather often prevents air travel during the winter. Airplanes bringing in supplies are often unable to land in severe weather. Recently, the airport has been threatened by erosion from storm damage. Air transportation is also very expensive, which for some residents means that air travel is cost prohibitive.

Crowley Marine Services makes two annual barge trips to Kivalina to deliver fuel and other supplies. Barges set sail to Kivalina from Kotzebue. Crowley attempts to run the trips back-to-back to take advantage of good weather, usually in July or August. Actual trip dates are weather dependent, as barge operators must take into account wind, swells, and general weather conditions. Erosion in the existing community is creating difficulties for barge landings.

Surface transportation difficulties have also emerged due to warming trends. Increasingly warmer temperatures have caused ice to retreat and have made it more difficult to travel across the ice in the winter. Hindrance in transportation highly affects subsistence activities, which are necessary for survival for the community.

While relocating the village to a new town site in the area will not solve the region's air transportation limitations, interruptions in transportation due to storm surges, swells, and erosion can be avoided at a different town site. A new town site on the mainland will also eliminate the necessity of traveling over the ice in the winter, greatly reducing the impact of retreating ice cover on surface transportation.

1.5.5 Housing

Problems associated with the housing at the existing community site include a limited number of houses, the poor condition of the existing housing, overcrowding, the lack of water and sewer connections, and potential flooding and erosion damage to existing housing. The potential threats to housing from flooding erosion and limited area for constructing new housing are major obstacles to improving the supply and quality of housing at the existing site.

Overcrowded housing lacking running water and sewer connections results in increased health risks. Funding for water and sewer to houses has been hindered due to erosion and relocation issues. The inability to expand has forced residents into overcrowded situations and hindered development.

Flooding and erosion have already forced the relocation of houses due to danger from storm surges. As the beach erodes, the amount of land decreases and residents are forced to move houses even closer together.

An opportunity exists to relocate Kivalina to a new site that would not be susceptible to flooding, erosion, or storm surge. A new town site would allow for additional homes to be built, relieving the overcrowding. Lastly, the construction of new homes would have stricter standards for energy efficiency than the existing homes. With heating costs a substantial portion of household budgets, new home construction could offer a financial savings to the occupants.

1.5.6 Social Conditions

Overcrowding, lack of infrastructure, loss of traditional cultural knowledge, and poor living conditions in general have created difficult social conditions. Residents indicate that people have moved out of the community due to the limited housing and lack of sewer and water. Kivalina residents have pursued the possibility of relocating the village for the last two decades. Residents have been tenacious and determined to see the project to fruition, however because the process has taken so long, residents have recently expressed concern over whether relocation will happen in the foreseeable future or at all. The difficult living conditions combined with feelings of hopelessness could greatly contribute to social problems in the village.

1.6 PLAN FORMULATION

The Water Resources Act of 1965 requires that the Corps of Engineers use planning principles in the formulation and evaluation of water and water-related land resources implementation studies associated with their Civil Works projects. The Corps planning model selects the best plan by identifying problems and opportunities, inventorying and forecasting alternatives, formulating alternative plans, evaluating plan effects, and comparing the effects of alternative plans.

Alternative plans must be formulated to address the problems identified by the planning objectives. Each alternative plan is evaluated according to four criteria: completeness, effectiveness, efficiency, and acceptability.

Figure 1 shows the possible relocation sites that were investigated for potential use as a new Kivalina town site over the last ten years. These sites were not fully evaluated due to a lack of adequate site geotechnical investigations. This deficiency was evidenced when geotechnical investigation revealed ice-rich soils in a seemingly favorable site, eliminating that site from future consideration. The community then chose Kiniktuuraq as the preferred site through a referendum during a recent municipal election. Since that selection, recent and severe fall storms confirmed that Kiniktuuraq is subject to coastal storm surge flooding and ice override. A 2004 site visit revealed that the site contains ice-rich soils, presenting significant site development constraints.

1.6.1 Formulation Approach and Methodology

The methodology for plan formulation involves identifying alternatives to a proposed action and developing each alternative to a comparable level. A “no action" alternative is included to access the consequences of taking no action and to allow for a complete comparison of alternatives. Eight alternatives, including the "no action," are presented in Section 3 of this report and are described in detail. Evaluation criteria are described in Section 1.6.2. A decision matrix (Appendix D) was designed to focus the site selection discussions into an easily comprehensible format including physical environment factors; construction and utilities requirements, social and access concerns and cost implications.

This plan re-evaluates the six previously identified town sites, the "no action" alternative, and the option of making improvements to the existing town site. Recent climate trends in northwest Alaska indicate an increase in the occurrence of severe storm flooding, accelerated erosion, and melting and subsidence of ice-rich soils. These trends indicate a need for adequate field studies and evaluation of long-term site stability. The potentially high cost of community relocation requires thorough evaluation of all alternatives.

1.6.2 Evaluation Criteria

The criteria for evaluating each site were developed to identify the risks and benefits associated with each alternative (see Appendix D).

Specific criteria were developed under four broad categories: physical environment factors; construction and utilities requirements; social characteristics and site access concerns; and cost implications:

- **Physical environment** factors refer to the sites' vulnerability to physical processes such as storm surges, riverine flooding, erosion, and high winds; other environmental factors such as site drainage, wetlands, ice-rich soils, and climate.
- **Construction and utilities criteria** assess factors associated with the feasibility of site construction including the development of cost efficient utility services. The primary construction factors include gravel requirements to develop the site and availability of gravel sources; ease of maintaining two sites during construction; potential for community expansion; and permitting obstacles. The primary utility factors include availability/suitability of community water source; sewage disposal; ease of water supply, storage, and distribution; availability/suitability of solid waste disposal; barge access and distance to the site; and site for an airport with proper wind configuration.
- **Social and access criteria** evaluate site characteristics that are important in terms of subsistence and other traditional activities. Factors identified include distance from the current village site; access to the ocean, Wulik River, Kivalina river, and Kivalina Lagoon (for travel and subsistence activities); access to subsistence camps and traditional use areas; location and size of boat and gear storage areas; potential for ice cellar construction; and general social acceptance of the site.
- **Cost implications criteria** assess relative construction and operational expenses associated with various sites. Factors include site preparation costs; road development costs; operation and maintenance costs; cost of living for housing and utilities; and cost of fuel for access to subsistence areas, the airport, and dock.

- Preliminary site evaluation criteria were presented to the community of Kivalina during the December 7, 2004 meeting, and initial feedback was received and incorporated into the criteria. On September 15, 2005, a meeting was held with the Kivalina Elders Council to ask more specific questions regarding each of the alternative relocation sites. The results of this meeting were incorporated into evaluation of sites and ranking criteria.

2 PLANNING AREA

2.1 PLANNING AREA PHYSICAL SETTING

2.1.1 Planning Area Location

The community of Kivalina is located 80 miles north of the Arctic Circle and 80 miles northwest of Kotzebue at 67° 44′ N latitude, 164° 33′ W longitude. The 700-foot wide, five-mile long barrier island on which the village sits borders the Chukchi Sea on the west and the Kivalina Lagoon on the east, encompassing approximately 1.9 square miles of land. The highest elevation point on the island is ten feet above sea level. The community itself is located at the southeast end of the island at the Singauk Entrance to Kivalina Lagoon, where the Wulik River flows into the Chukchi Sea. Northwest end of the island is bound by the Kivalik Inlet, which has been formed by the flow of the Kivalina River.

2.1.2 Planning Area Climate

Kivalina has long cold winters and relatively cool summers. Temperatures range from 58° F in the summer to -17° F in the winter. The Chukchi Sea is generally ice-free in the summer and open to boat traffic from mid-June to the first of November. Ice starts forming on the open ocean during the fall, and becomes shorefast as the temperature drops. Areas of open water may occur during the winter depending on changes in wind, currents, and temperature.

2.1.2.1 Wind – Planning Area

Prevailing winds at Kivalina are from the northeast, according to preliminary data collected by the Alaska Department of Transportation & Public Facilities (ADOT&PF) and the National Weather Service. However, the highest wind velocities are from the southeast, with the highest recorded wind speed of 54 mph. Strong northerly winds have also been recorded at Kivalina.

Whale bone near Kivalina airport (TNH/URS, 2001)

2.1.2.2 Storms

Kivalina is subject to storms at any time of year. During summer and fall months, sea storms bring high winds of 40 to 70 knots from the southwest. Winter storms usually bring winds from the northeast. Storm surges, ice override, and coastal flooding can occur in Kivalina due to storms. Drifting snow during winter storms is a common problem in the area as well (see also section 2.1.2.3). Additional information on the implications of storm characteristics on community location is presented in further detail under the sections addressing snowfall and oceanography.

2.1.2.3 Snowfall and Drifting

The mean annual snowfall for the Kivalina area is 50 inches (Environmental Atlas of Alaska). Snow is possible in Kivalina throughout the year, but is most common from October through April. During the winter months, blowing snow from the prevailing northeasterly winds creates large snowdrifts across the community, resulting in transportation and housing access problems. Because the airstrip is perpendicular to the prevailing winds, it is subject to heavy drifting during storms. A snowstorm in April of 2001 resulted in 20-ft snowdrifts throughout the community, trapping some residents in their homes until neighbors were able to rescue them. Drifting also creates hazards to the residents when snow accumulates near windows and doors that can provide emergency egress, and covers fuel tanks and other above ground facilities.

2.1.3 Geology

Kivalina is located in a coastal area of low topographic relief, consisting of gentle sloping, rubble-covered hills, separated by broad expanses of tundra. Test holes indicate that the soils appear to be gravel and sands at the beach, with ice-rich frozen silts farther inland. The areas around Kivalina have an elevation near sea level, while the hills located to the northeast rise to an elevation of a few hundred feet. Bedrock of limestone and dolomite is found in outcrops along river-cut bluffs of the Kivalina River. Marine deposits lie over bedrock near the mouth of the Kivalina River. Pleistocene glaciers originating in the mountains of the western Brooks Range covered the upper reaches of the Wulik and Kivalina Rivers, but did not advance into the lower elevations. Low-lying portions of land surrounding Kivalina are covered with unconsolidated quarternary deposits of unknown thickness, ranging in size from clay to gravel. The floodplains of both rivers are broad and braided. The region has continuous permafrost, which may be found within a few feet below the ground surface. Permafrost may be as thick as 600 feet, with the potential for thaw bulbs in the vicinity of the Wulik and Kivalina Rivers. (U.S. Army Corps of Engineers 1998 Community Improvement Feasibility Study).

Limited soils investigations were conducted as part of this study. The geology of Igrugaivik, Kiniktuuraq, Kuugruaq, Simiq, Imnakuk Bluff, and Tatchim Isua is described in the geotechnical report included in Appendix B.

2.1.4 Oceanography

Ocean waters adjacent to Kivalina are subject to the complex dynamics associated with Bering Strait flows between the Chukchi and Bering Seas. While the net oceanic flow along the Chukchi Sea's southeastern coast is generally northward, it is subject to short-term temporal fluctuations of both oceanographic and atmospheric origin, as well as localized spatial variations due to the presence of headlands, straits, and the influence of major rivers.

Of greater oceanographic relevance to the present Kivalina village site, however, is its exposure to wind-generated waves. Winds from the south to southwest generate waves that expend their full energy directly onto Kivalina's beaches, resulting in accelerated erosion and a redistribution of beach sediments approximately perpendicular to the coastline. While these storm waves can be destructive, the sediments that are moved offshore remain available to re-build the beach under the action of smaller waves that occur under lighter winds from the southwest.

Waves produced by south to southeasterly winds are not as high or long as those from

Kivalina community facing south (TNH/URS, 2001)

the southwest, because of the shorter fetch. However, these waves are more destructive to Kivalina beaches because they may ride atop a storm surge that can raise sea level by several feet along Kivalina’s barrier island Also, due to their oblique assault on the shoreline, these waves provide the energy for longshore currents that sweep the sediment away to the north. The effects of this combination of destructive forces is illustrated by the storm of 18-20 October 2004 which flooded the community in several locations, significantly eroded the shoreline, and damaged property at the school site. Forty-knot southeasterly winds (gusting to nearly 60 knots) produced a 4-ft storm surge, as measured at the Red Dog Mine dock a few miles to the southeast of Kivalina (National Ocean Survey 2004).

Although less common than waves from the southerly quadrant, waves from the northwest can potentially be higher, longer, and more destructive than waves from other directions. Patterns of sediment transport near Singauk Entrance provide evidence of the influence of these waves on local beach dynamics. Although sea level would be depressed slightly (i.e. “negative” storm surge) due to northwest winds along the southeast Chukchi Sea coastline, waves generated over the much longer fetch could be much more destructive than those that occur under the more frequent southerly winds.

2.1.5 Floods, Erosion and Seismic Activity

The statistics and analyses employed by Wise et al. (1981) utilized weather data from the previous several decades. Since then, there have been marked changes in weather patterns that appear to have caused such weather events described below to occur even more frequently, (Easterling et al. 1999).

2.1.5.1 Flooding

Flood hazards in Kivalina result almost exclusively from storm surges from south to southeasterly winds. Storm flooding has historically occurred in early fall, before the formation of shorefast or sea ice. Shorefast ice creates a barrier of grounded ice along the shore; waves break against the ice or are reduced in energy, rather than striking directly against the shore where erosion occurs. Local observations indicate that in recent years, shorefast ice has formed later in the year than usual, leaving the village without protection from fall sea storm flooding.

Kivalina beach erosion in 1983 facing south (left) and facing north (right) (Colonell, 1983)

Singauk Entrance (Colonell, 1983)

The extent of sea ice cover reduces the effective fetch by "dampening" the ocean surface and limiting the formation of wind generated waves. According to the storm surge climatology assessment produced by Wise et al. (1981), the 4-ft surge that occurred on 20 October 2004 and caused flooding in Kivalina has a statistical probability of occurrence, also called "recurrence interval," of about one year. That is, a storm surge of this magnitude should be expected to occur annually. However, prior to October 2004, there had been only two recorded storms to date that have overtopped portions of the island since the establishment of the current Kivalina town site in 1905.

It is possible that observed trends related to delays in formation of shorefast ice and sea ice are resulting in fall storms that 1) have more wave energy, and 2) cause damage later in the fall because the period of open water is greater. Recent beach erosion and sediment deposition patterns may also allow storm generated waves and surges to reach the community, resulting in a higher potential for flooding.

2.1.5.2 Erosion

Erosion near teacher housing (TNH/URS 2003)

Fall storms and storm surges can result in beach and shoreline erosion. Soils at the existing town site are permanently frozen except in the active layer and at the active beach zones, which allows beach erosion where tides and ocean waves can affect unfrozen ground. The erosion stability of the Kivalina spit relies on the integrity of the vegetative mat that keeps surface soil from washing away and insulates the underlying permafrost beneath the active layer. The absence of sea ice during recent fall storms has left the beaches vulnerable to erosion in the form of undercutting of the vegetative mat, which in turn creates a small bluff on the ocean side that exposes the vegetative mat to further undercutting and increasingly severe erosion. This process is further accelerated by destablization of the underlying permafrost due to climate change.

Significant beach erosion resulted from the October 18, 2004 storm, causing a loss of shoreline and damage to some structures along the beach. The teacher housing building had to be relocated due to storm surge erosion that turned the once slow-sloping beach into a drop-off. It is reasonable to deduce that beach erosion events, such as the one in October 2004, are occurring more frequently for reasons similar to those discussed under the flooding section. The marked reduction of beach width adjacent to Kivalina since the early 1980s attests to the greater frequency and severity of these erosion events. Storms in the fall of 2005 also resulted in severe erosion, undercutting a portion of the school and other structures.

2.1.5.3 Seismic

Earthquakes with the magnitude of 6.0 or greater have occurred four times in both the Chukchi Sea and Western Alaska. The largest earthquake on record for this region occurred in 1958, approximately 210 miles southeast of Kivalina near Huslia with the magnitude of 7.3, followed by two 6.0 aftershocks. During this earthquake, extensive failure in unconsolidated surface soils within an elongated northeast zone were observed. The Kaltag Fault System passes south of Huslia, but no significant seismic activity has been associated with this fault.

A magnitude 6.0 earthquake occurred on the Seward Peninsula in 1950; however, there is little information available about this earthquake. In 1928, a M6.9 earthquake and three M6.0 aftershocks occurred in the western Chukchi Sea approximately 155 miles west of Kivalina an earthquake. The Kobuk Fault, east-west trending fault that displaces Quaternary deposits, triggered a series of moderate M4.6 earthquakes approximately 225 miles west of Kotzebue.

A geologic map of the area prepared by the Geological Society of America, (Neotectonic Map of Alaska, Plafker, Gilpin, and Lahr 1993), does not show faults or linements with evidence of Holocene (0 to 11,000 years) or Quaternary (11,000 to 500,000 years) displacement within approximately 140 miles of the Kivalina site.

Cold winter storage, Kivalina, Alaska (TNH/URS, 2001)

Earthquake-induced geologic hazards that may affect the site include landslides, fault rupture, settlement, liquefaction, and associated effects (loss of shear strength, bearing capacity failures, loss of lateral support, ground oscillation, lateral spreading, etc.). Liquefaction occurs when excess pore pressures develop during untrained cyclic loading of uncohesive soils, causing a reduction in effective stress and strength. The presence of generally continuous permafrost precludes a liquefaction hazard at undeveloped sites, except within the thaw bulbs of rivers and lakes. Ground thawing induced by site development could result in a liquefaction hazard. The sites most prone to liquefaction upon thawing would be those in low-lying areas with a high water table.

Fault rupture on the seafloor can produce tsunamis, a hazard in coastal areas. There were no reported tsunamis associated with the 1928 submarine earthquakes in the Chukchi Sea. The closest recorded submarine earthquake that produced a tsunami occurred in 1991 in the Bearing Sea southwest of St. Matthew Island, (West Coast & Alaska Tsunami Warning databases). This M6.1 earthquake occurred near the edge of the continental shelf.

2.2 LIVING RESOURCES

2.2.1 Subsistence Resources

Subsistence contributes significantly to the culture and economy of Kivalina, and it is an important consideration in planning for the new town site. Subsistence resources harvested by Kivalina residents include fish, sea animals (including bowhead whale, beluga whale, and seal), waterfowl, and caribou. Resource sharing between households is common in Kivalina.

Specific subsistence activities vary with the seasons. In the spring, residents focus on hunting and trapping of species such as bowhead whales, seals, furbearing animals, and waterfowl. Residents fish through holes in the ice until spring breakup. Summer is usually dedicated to marine harvests of char, salmon, and other fish, as well as beluga whales. Summertime is also the season for berry harvests.

Caribou, waterfowl, and other game are harvested during their fall migrations. Residents also hunt other large game, such as bears and moose, during the fall. Winter is devoted to hunting seal along the coast, ice fishing on the Kivalina and Wulik Rivers and the lagoon, and small game hunting.

Data on subsistence harvest of fish and wildlife is available for six specific years (between 1964 and 1992) through the Alaska Department of Fish and Game. After initial declines in total harvest that may be attributable to the decline in use of dog teams, the total subsistence harvest poundage has stayed relatively stable, although the per capita consumption has dropped with the increase community population. Between years, harvest by species shows variation in the percentage of contribution to total harvest. Dolly varden, seal, caribou and have historically been among the top species harvested, although beluga whales have periodically made up a substantial portion of the subsistence harvest. Given this variability in harvest, different potential relocation sites will have advantages and disadvantages over the years. Coastal sites will be more advantageous for marine mammals, river sites (particularly the Wulik River) more advantageous for freshwater fish, and inland sites more advantageous for caribou.

Resource	Harvest Time	Peak Harvest Time	Harvest Area Relative to Portsite	Access Methods	Harvest Methods	Factors Affecting Harvest
Marine Mammals						
Ringed seal	November to early July	February to June	North and south of Portsite on shorefast ice or on drifting floes after breakup.	Access is by snowmachine over the ice during winter or by boat after breakup	Seals are shot with a rifle on the ice or in the water. If they are shot in the water, they retrieved with seal hooks and pulled into a boat or on the ice. They are butchered on the ice or back in the village.	Ice conditions (thickness, roughness), show depth, presence and size of leads and cracks, wind direction and speed, and abundance of animals.
Bearded seal	November to August	June	Same as above	Same as above	Same as above	Same as above
Beluga whale (spring)	Late April to June	Late May and early June	In leads up to 10 miles offshore, north and south of Portsite.	Same as above	Belugas are shot with rifles and recovered with seal hooks. They are pulled onto the ice or towed back the village and butchered.	Presence of and size of leads, wind direction and speed, abundance of animals.

Beluga Whale (summer)	June to August	July	In nearshore water north and south of Portsite.	Summer belugas are hunted from boats among drifting floes or in open water	Summer belugas are shot with rifles and recovered with seal hooks. Belugas are towed to the village or to shore and butchered.	Floating ice, wind, Portsite activity (possibly), abundance of animals.
Bowhead Whale	Late April to June	May	In leads up to 10 miles offshore north and south of Portsite.	Snowmachines are used to tow boats on sleds across the ice to open leads where bowheads migrate.	Bowheads are sot with harpoon bombs and speared with harpoons. They are pulled onto the ice with block and tackle, and butchered.	Presence of and size of leads, wind direction and speed, distance of migration route from shore.
Polar bear	December to May	March to May	On shorefast and pack ice north and south of Portsite	Snowmachines are used to follow tracks to the bear. Native hunters often shoot polar bears incidentally while hunting seals, walrus or whales.	Polar bears are shot with rifles and skinned on the ice or back in the village.	Ice conditions (thickness, roughness), snow depth, availability and size of leads and cracks, wind direction and speed, abundance of animals.
Walrus	June and July	June and July	Along the edge of pack ice up to 30 or more miles offshore.	Boats are used to hunt walrus hauled out along the edge of retreating pack ice.	Walrus are shot with rifles from boats. Because they are hunted far from the village, they are butchered on the ice where they are shot.	Distance offshore, wind, currents, weather, visibility (fog), and economics.
Birds						
Ducks	May to October	May to June	In and around lagoons along the beach, and around inland ponds.	Snowmachines, ATV'S, or boats are used to access the hunting area.	Ducks are shot with rifles and shotguns and brought back to the village or hunting camp.	Wind, visibility
Brant/geese	May to October	May and June	Same as above	Same as above	Same as above	Same as above
Ptarmigan	February to November	March and October	On the tundra north, south, and east of Portsite.	Snowmachines, ATV's, or boats are used to access the hunting area.	Same as above	Tundra conditions, weather, abundance of animals.
Fish						
Char	Year round	June, August, September	In Kivalina Lagoon, and the Kivalina, Noatak, Wulik, and other rivers of the region.	Snowmachines are used during winter and boats are sued during summer.	Char are caught in gill nets, in seines, and by hook and line. They are cached on site or brought back to the village.	Ice and water conditions, size of run, good fish-preserving weather, freeze-up timing,

						presence of grizzly bears and wolverines.
Grayling	Year round	June, August, September	Same as above, in lagoons, rivers of the region.	Same as above	Same as above	Ice and water conditions, size of run, good fish-preserving weather, freeze-up timing.
Salmon	June to August	July and August	Same as above	Same as above	Same as above	Water conditions, run size, preference for char.
Whitefish	June to September	August, September	Same as above	Same as above	Same as above	Ice and water conditions, size of run, good fish-preserving weather, freeze-up timing.
Cod	October to December, and July (rarely)	November, December	Kivalina Lagoon	Snowmachines during winter and boats during July.	Cod are mostly caught with hook and line through holes chopped in the ice.	Same as above

Given the emphasis on marine and river subsistence activities and fish, the community location and layout needs to consider areas for boat haulout and storage, drying racks for subsistence harvests and other resource processing needs, subsistence related activities (such as whaling festivals) and access to traditional subsistence areas.

The cost of access is also an important consideration in the location of a new community town site. Kivalina residents typically access hunting and fishing areas and traditional camps by boat during the open water season, and by snowmobile after snow and ice formation allow it. The current town site is strategically located to allow easy boat access to the Chukchi Sea and to the Kivalina and Wulik rivers. Some potential town sites on the northern end of the study area are either located adjacent to shallow areas of the lagoons or rivers, requiring an access road to deeper water, boats with shallower drafts, or a combination of the two. Such sites may result in more fuel usage or gear changes, resulting in higher costs associated with subsistence.

2.2.2 Wetlands and Other Waters of the United States

Kivalina's barrier island is narrow strip of upland and tidally influenced estuarine unconsolidated shore (USFWS, 1978). According to the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps, extensive salt marsh habitat is found along this narrow strip of land (USFWS, 1978). Salt marsh wetlands (estuarine emergent wetlands) are vegetated with grasses, sedges, and broad-leaved, salt-tolerant emergents, which are present for most of the growing season. Vegetation along the coastal lagoons tends to be abundant because of the high accumulation of nutrients in shallow waters (NPS, 1986). Estuarine emergent wetlands are valued for their excellent wildlife habitat functions and high ecological diversity (Adamus 1987).

Diverse wetland habitats surround the Kivalina Lagoon, including large salt marshes, palustrine scrub-shrub and emergent wetlands, and open water ponds. The southern wetlands adjacent to the lagoon are salt-water influenced with freshwater intrusions derived from the Kivalina and Wulik rivers flowing into the lagoon. This mixture of salt and freshwater influences provides for rich ecological diversity. Even upland areas may include areas that are classified as wetlands, requiring placement of fill and associated permits in order to develop a new town site.

The marine intertidal waters of the Chukchi Sea adjacent to Kivalina include unconsolidated shores composed of unknown substrates (USFWS 1978). Marine habitats are exposed to water and currents of the ocean where salinities exceed 30 percent, and support marine biota (Cowardin et al. 1979).

2.2.3 Wildlife and Wildlife Habitats

Kivalina's barrier island provides unique habitat for migratory birds, including white-fronted geese, cackling and lesser Canada geese, black Brant, mallards, and common and king eiders. The lagoon also provides important nesting, breeding and feeding habitat for large numbers of migratory birds (NPS, 2004). Approximately 21 species of terrestrial mammals, and 21 species of marine mammals are also found in this area (NPS, 1986). Terrestrial mammals in the region include: caribou, grizzly bear, musk ox, wolf, arctic fox, weasel, and wolverine. Marine mammals include spotted, ribbon, ringed, and bearded seals; Pacific walrus; and bowhead, gray, and beluga (belukha) whales. The Kivalina area is important caribou winter habitat and summer musk ox habitat, as well as arctic fox range (NPS, 1986).

2.2.4 Threatened and Endangered Species and Species of Concern

2.2.4.1 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale, a federally listed endangered species under the Endangered Species Act (ESA) of 1973, migrates to the southern Chukchi Sea during the summer months. Their population decline is largely attributed to historic commercial whaling, which has since been banned. Scientists estimate the current population to be between 1,000 and 2,000 animals (Faris, 2003).

2.2.4.2 Bowhead Whale (*Balaena mysticuetus*)

The bowhead whale is currently listed as "endangered" under the ESA and as "depleted" under the Marine Mammal Protection Act of 1972. The bowhead whale population was seriously depleted following heavy exploitation by the commercial whaling industry. The Bering Sea stock of bowhead whale migrate north and east following the leads in the sea ice in the eastern Chukchi Sea (Shelden and Rugh 1995). Kivalina subsistence hunters are given a strike quota of one bowhead whale per year by the International Whaling Commission and the Alaska Eskimo Whaling Commission (Burch 1985).

2.2.4.3 Arctic Peregrine Falcon (*Falco peregrinus tundrius*)

In 1982, the Arctic peregrine falcon was on the threatened and endangered species list. At that time, three peregrine falcon nests were located in the Wulik and Kivalina drainages; however, these falcon nests were not found during a 1983 study. The Arctic peregrine falcon has since been delisted from the threatened and endangered species list (50 FR 17, 1999) (NPS, 1986), but the Arctic peregrine falcon is still considered an

Alaska species of special concern (Swem, 2003).

2.2.5 Fish and Essential Fish Habitat

Both the Kivalina and Wulik rivers are listed as anadromous streams in the Alaska Department of Fish and Game (ADF&G) Fish Distribution Database. The Kivalina River supports pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), king (*O. tshawytscha*) and coho salmon (*O. kisutch*); and arctic char (Dolly Varden). The Wulik River and its tributaries support all five species of salmon; pink, chum, King, coho, and sockeye (*O. nerka)*; arctic char; and whitefish species (ADF&G 1998). Arctic char, or Kivalina char as it is called locally, is a mainstay of the Kivalina subsistence lifestyle (Burch, 1985).

Coastal and inland waters support four species of whitefish important to subsistence, including the humpback whitefish (*Coreganus pidschian*), least cisco (*C. sardinella*), Bering cisco (*C. laurettae*) and round whitefish (*C. cylindraceum*). Only the Bering and humpback whitefish are regularly harvested by Kivalina subsistence fishermen. Arctic cod (*Boreogadus saida*) and saffron cod (*Eleginus gracilis*) appear in the Kivalina Lagoon twice a year after freeze-up and in early July. They are harvested mainly in the fall. Other fish found in coastal waters that are occasionally harvested by Kivalina fishermen include grayling, sculpin, burbot, and smelt (Burch 1985).

2.3 COMMUNITY PROFILE

2.3.1 Culture and History

Kivalina is a traditional Inupiat Eskimo village located in the Northwest Arctic Borough of Alaska. Because residents depend on fish and wildlife for survival, their long-lived traditions are attributable to cultural connections with the ocean, rivers, and the land.

This coastal area of Alaska has been inhabited for thousands of years. It has long been a stopping-off place for seasonal travelers between Arctic coastal areas and Kotzebue Sound communities. In 1847 the village of Kivalina was reported as "Kivualinagmut" by Lt. Zagoskin of the Imperial Russian Navy. At that time, Kivalina was located at the north end of the Kivalina Lagoon. The community was founded at its present location when the Federal Government constructed a school on the island in 1905. A post office was set up in 1940 and an airstrip built in 1960. Kivalina was incorporated as a 2nd Class City of the Northwest Arctic Borough in 1969. New houses, a new school and electricity followed.

2.3.2 Demography

Demography addresses the existing and projected population characteristics of the community. The population projection forecast is an educated guess of future events that may have an affect on the community of Kivalina. Because conditions can change dramatically over a short period of time, the forecast should be reviewed and updated periodically.

2.3.2.1 Population Data

The population of Kivalina was first recorded in the 1920 census at 87 residents. Kivalina had a population of 377 in the year 2000, and the State of Alaska estimate for 2004 is 388. The population of Kivalina is predominantly Alaskan Native (96 percent), and relatively young with a median age of 20.8. The male and female composition is approximately 51 and 49 percent, respectively. Representatives of the City and IRA have indicated that families leave Kivalina due to a lack of housing, infrastructure, and potential for expansion.

It should be noted that the actual growth rate since the 2000 population census has been closer to 1 percent. A 3.5 percent growth rate would require a selection of a relocation site with room for community expansion.

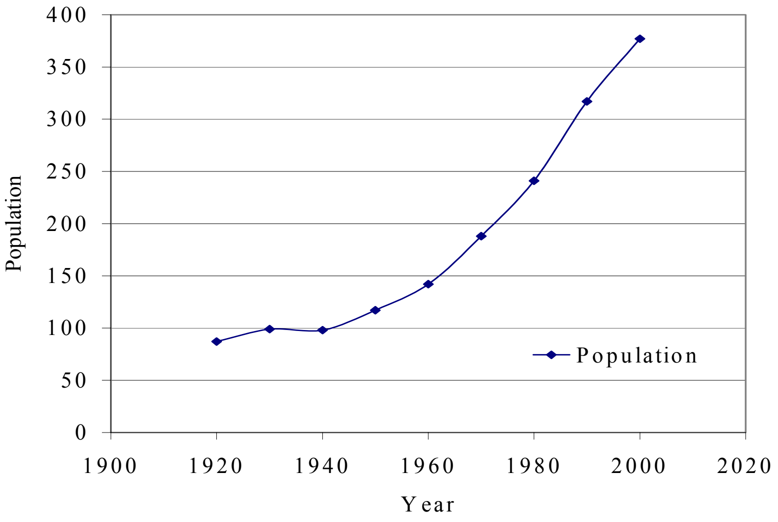
The table below shows the historic population for Kivalina. This report projects over a 30-year period through 2030. The best estimate projection was derived by projecting the data into the future at a growth rate of 3.5 percent. The forecast is based on the Northwest Arctic School District's recent projected expected growth for the area.

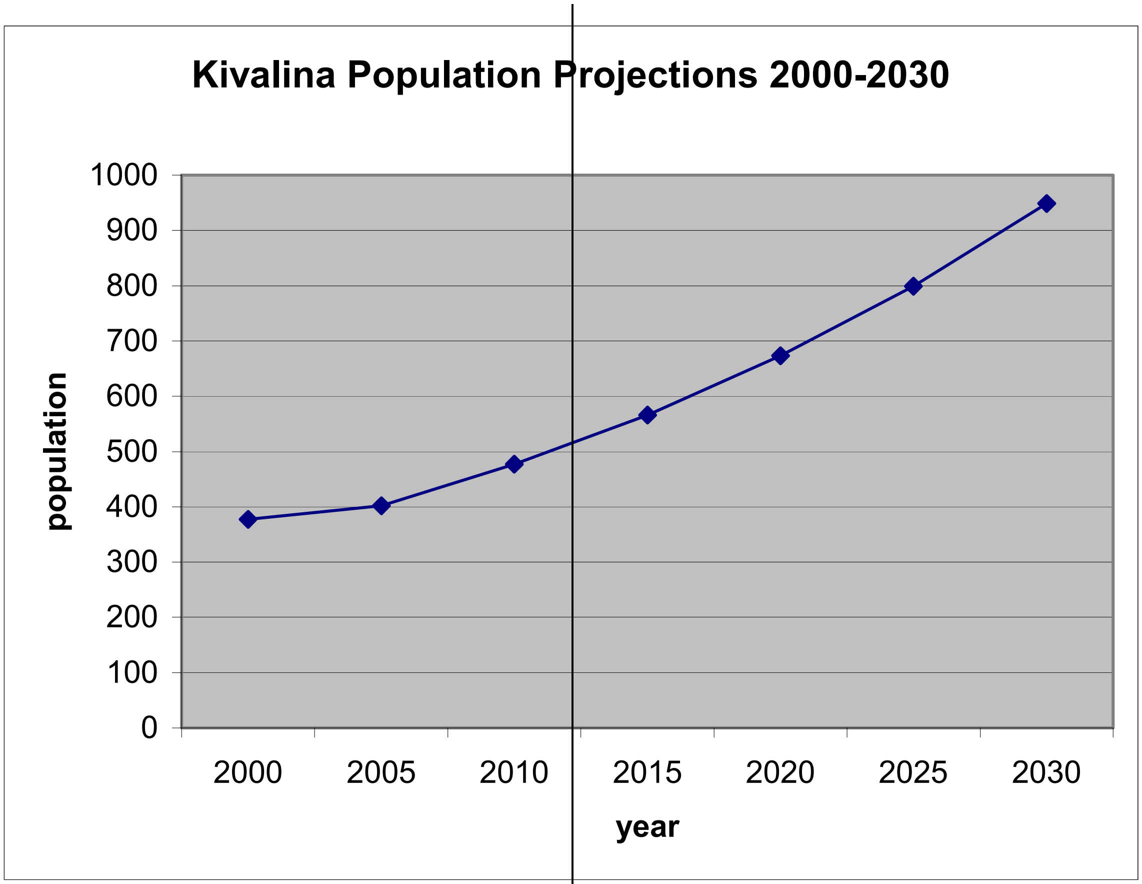
Year	Pop. With 3.5% Growth Rate
2000	377
2005	402
2010	477
2020	673
2030	949

When dealing with small population numbers, the addition or subtraction of a small number of people (for example one family) can radically affect the estimated growth rate. This is particularly true if the growth rate is already small. Consequently, significant changes to the growth rate can occur from year to year. After a new town site is constructed, families who have moved away from Kivalina may choose to return, which may dramatically increase the population growth rate.

The best estimate projection would require revenue and employment to continue to expand, but would not require major resource development. Under this scenario, the population of Kivalina would double in about twenty years. The population growth between 2020 and 2030 is more uncertain because of the changes that would have to occur in order to support that number of people. Factors ranging from infrastructure, housing, and local economic growth, to federal, state, and local revenue levels may most likely influence Kivalina's actual population growth.

Historic Population Data for Kivalina





2.3.3 Local Government

Kivalina is a 2nd class city organized under Alaska Statute 29, and maintains a 2% sales tax. A 2nd class city is incorporated under the rules and laws of Alaska and defined as having 400 or less permanent residents. Kivalina has two separate local governments: the Native Village of Kivalina (NVA), a federally recognized tribe; and the city of Kivalina, established under the state of Alaska. There is a seven-member city council, out of which a mayor and a city administrator are elected.

2.3.4 Regional Government

Kivalina is within the Northwest Arctic Borough, a home rule borough, formed in 1986. The Northwest Arctic Borough is 83% Alaska Native. The Borough provides programs and services to encourage development, coordination within and outside the region, and to improve employment and education. Kotzebue is the seat of the Borough government (NWAB, 2001). The Borough is also responsible for the Northwest Arctic School district, which provide education in Kivalina and other communities within the Borough.

2.3.5 Native Organizations

There are three Alaska Native organizations in Kivalina; the Native Village of Kivalina (NVA), the NANA Corporation, Inc.(NANA), and the Maniilaq Association. The Native Village of Kivalina is a federally recognized tribe, which has several active, federally funded programs.

Kivalina is located within the NANA Corporation Region. ThNANA Corporation, Inc. is a for-profit corporation established by the 1971 Alaska Native Claims Settlement Act (ANSCA) (ADCCED, 2004). NANA is a regional corporation acting on social and cultural needs of the Inupiat people of Northwest, Alaska (NANA, 2004). NANA businesses include management services, oil industry support, mining support and hospitality. There are approximately 10,000 shareholders and 3,085,532 acres of ANCSA land conveyed. Total revenues in 2000 were $176.2 million (DCED, 2004). NANA Corporation also merged with all of the ANCSA village corporations in the NANA region except Kotzebue. Therefore, NANA owns surface and subsurface lands in the Kivalina area, and is responsible for conveying ANCSA 14(c)3 lands to the city of Kivalina. NANA will be a major stakeholder in the potential sites for community relocation.

The third native organization, the Maniilaq Association, is a non-profit regional corporation representing twelve federally recognized tribes located in Northwest Alaska. The Maniilaq Association is a social, tribal and health service provider, servicing about 6,500 people and employing a 500 person workforce, and is the region's largest employer (Maniilaq, 2003). Maniilaq manages a hospital in Kotzebue as well as health clinics in all the villages.

2.3.6 Public Facilities

Figure 3 shows the key map of buildings in Kivalina. Structures in Kivalina fall under the following categories:

- Facilities, including the school, churches, store, community center, clinic, landfill, city office, airport, IRA office, barge landing, post office, fire hall, jail, National Guard Armory, and heavy equipment building;
- Utilities, including fuel tanks, washeteria, power plant, water tanks, septic fields, water treatment facilities, and telephone building, and
- Residential and General structures, including residential housing, teacher housing, drying racks, boat storage, cold storage, and other storage.

The school, school storage, store, and store storage area are on the south side of the island. The Army National Guard, clinic, city offices, two churches, community center, post office, jail and the fire hall are centrally located. Residential structures are generally scattered throughout the community. The airport and airstrip are on the north end of the island

The McQueen School is operated by the Northwest Arctic School District. Built in 1970, it has 117 students and, due to its age and condition, would be considered a candidate for replacement.

The community presently has a National Guard facility. The National Guard is a popular organization in many communities in rural Alaska. The residents would like to keep the presence of the Guard, and would like a facility at the new site.

The existing clinic is too small to adequately serve the community of Kivalina (Appendix A). It consists of a reception area, two examining rooms, a room that serves as an office, communications, and storage room, and a boiler room. The current design and layout of the clinic creates impediments for working physicians.

The city building houses the City Administration, the IRA Administration, and space for meetings.

The Kivalina public utilities and infrastructure, located towards the center portion of the island, consist of a water system and treatment plant, power generation, and bulk fuel utilities.

Currently, the community receives barged fuel oil deliveries once per year, usually in the fall. Delivery quantities are between

50,000-60,000 gallons. Fuel oil is stored in vertical cylindrical steel storage tanks of approximately 6,000 gallons each.

The power plant is operated by AVEC. It has four diesel fuel fired generators.

2.3.6.1 Water Supply

Kivalina's primary water source is a point approximately two miles upriver from the mouth of the Wulik River. The river is frozen for about 7 months. Freeze up generally occurs in October with break up coming in late May/June. Although the Wulik River is ice free in May/June, water is normally not pumped until July due to the high silt content of the river water after break up. Water is also pumped in October, prior to the freeze up of the Wulik River.

When the tide is low, 14,000 feet of 4-inch diameter fire hose is temporarily installed between the river and the raw water storage tank (RWST). A 15-20 horsepower (Hp) engine driven, palette mounted pump is transported to the collection point upriver by boat. The pump is capable of delivering approximately 85 gallons per minute (gpm) to the 692,000 gallon RWST, and runs 24 hours a day until the tank is filled, over approximately five to six days (TNH/URS, 2003).

Kivalina water storage tank (TNH/URS, 2003)

Treatment involves purifying the raw water through a small water treatment plant (WTP) located in the water treatment building attached to the north end of the washeteria. The WTP equipment is capable of treating 80 gpm. Treated water is pumped from the plant into a 500,000-gallon Treated Water Storage Tank (TWST). Treatment of the raw water involves the use of a 54" pressure sand filter and a *Giardia* barrier microfilter. When the 500,000-gallon storage tank is filled with treated water, the RWST is refilled and the pumping and transmission equipment is disassembled and stored.

Kivalina has no community piped water distribution system. The only buildings with piped water are the washeteria, school, and clinic. The public school complex is fully plumbed and has its own distribution system that serves the school building, shop, and teacher housing. A 1,965-gallon storage tank is used to buffer the school system from operational failure in the WTP. The storage tank, equipped with a level sensor, is filled automatically from the TWST as needed. The school system has a single canister filter, changed once a month, for additional treatment. Two 350-gallon pressure tanks maintain pressure for the cold water system and two 100-gallon pressure tanks operate the hot water system.

Sanitary facilities for the clinic are simple. The clinic contains two sinks, but no flush toilets. All wastewater effluent from the clinic to its lift station is graywater. Human waste is collected in honey buckets, as is typical in the village.

Residents obtain treated water from the watering point at the washeteria. They collect water in containers, such as 30-gallon garbage cans, and self-haul to their homes. Water is pumped into personal containers at a rate of $0.50 for 30 gallons through a paybox located on the east side of the washeteria. The individual collecting the water must keep a flow switch depressed until the 30 gallons has been pumped. Water is transported to homes by the individual using a small trailer towed by an all-terrain vehicle (ATV) or snow-machine. Information from the State of Alaska Department of Community and Economic Development (DCED) indicates only about one-third of residents have water tanks in their homes to provide running water for the kitchen. Many of the newest U.S. Department of Housing and Urban Development (HUD) homes have 30-gallon storage tanks and are fully plumbed, ready for connection to a piped water service. The storage tank is filled manually and feeds the plumbing by gravity.

Attempts to install a piped water distribution system are evident in Kivalina. An arctic pipe water system was installed in the village around 1978. Looped arctic pipes, remnants of this old distribution system, are still attached to some houses. This system was intended to be used as a summer distribution system for residences and not as a year-round piped system.

2.3.6.2 Waste Disposal

2.3.6.2.1 Wastewater

Kivalina washeteria watering point (TNH/URS, 2003)

The only facilities served by on-site wastewater disposal systems are the school buildings and washeteria/clinic. Residents dispose of non-septic wastewater and graywater by dumping it on the ground outside their houses. Kivalina residents currently rely on self-haul honey buckets for septic waste collection and a honey bucket bunker for disposal of most human waste. Honey buckets are 5-gallon buckets lined with plastic garbage bags. The bags are tied off and removed when full, and hauled to the honey bucket bunker. The honey bucket bunker is north of the airstrip, approximately a mile and a half from the community of Kivalina. The bunker is a 60’x 60’x 8’ galvanized H-pile and corrugated sheet steel containment basin with a capacity of approximately 215,000 gallons.

Kivalina honey bucket containment bunker at landfill (TNH/URS, 2003)

A potentially unsanitary condition arises in the village when the filled plastic garbage bags are not taken the full distance from the village to the landfill bunker. Bags deposited at the hatch of the already full wood bunkers in the village and along the way to the landfill bunker are potential sites of pathogen transfer to the community.

The washeteria and clinic each have a lift station that receives effluent by gravity, which pumps into a shared 4,000-gallon septic tank that has a pumped force main discharge going into a drainfield located on the western beach. The washeteria/clinic drainfield measured about 93 feet by 18 feet before it was destroyed by erosion during the October 2004 storm. The drainfield was not rebuilt after the storm because of feasibility issues. Due to the permanent loss of the drainfield, the washeteria is presently used as a graywater only facility, with no use of the toilets.

The McQueen School wastewater treatment system was installed in 1992. It consists of a gravity fed sump and duplex pump lift station, aeration tank, settling tank, chlorine contact tank, and a slow sand filter. Wastewater travels through an aeration chamber, clarifying tank, sand filters, and a chlorine contact chamber. A mound drainfield at the school is inoperable. Treated wastewater is discharged through an insulated 2” piped outfall onto the beach of the Chukchi Sea. The school wastewater treatment plant is, however, currently hydraulically and organically overloaded and does not meet discharge requirements.

A new septic tank for the school and a new wastewater treatment plant to serve the washeteria, clinic, and school is designed and funded by Village Safe Water (VSW) for construction; however construction has been delayed by VSW because the village does not meet certain grant conditions regarding essential capacity indicators under the Rural Utility Business Advisor (RUBA) program. Once the city meets the grant conditions, construction of the new wastewater treatment plant will be re-scheduled. The wastewater treatment plant project also includes separate funding designated for purchase and installation of equipment for a small scale community ATV honeybucket haul system at the existing town site.

The new wastewater treatment plant will use septic tanks for primary treatment, re-circulating aerobic fixed-film bioreactors for secondary treatment, ozone for final disinfection, and will discharge at the beach surface.

2.3.6.2.2 Solid Waste

Based on site photographs, Kivalina residents disposed of solid waste randomly at an old dump located in a two-acre area on the proposed Kiniktuuraq relocation site prior to 1996. Site photographs show minimal solid waste accumulation. The dumpsite appears to be abandoned, but was not covered due to lack of cover soil.

Built in 1996, the existing Kivalina landfill is located on a 3.4-acre parcel, 1.1 miles north of the village in Section 26, T.28 N., R.27W. This unpermitted Class III municipal solid waste landfill is a few hundred yards adjacent to the north end of the runway, and is bounded by water with the Chukchi Sea to the west and the lagoon to the east. The landfill was designed with a 20-year design life for a population of 373 people. Landfill capacity was calculated with assumptions that solid waste would be generated at a rate of 154 pounds per day, and that the waste would be compacted to a landfill density of 18-pounds/cubic foot. The landfill was to be operated as a trench and cover type facility according to a 1995 City of Kivalina Solid Waste Management Plan. Solid waste was to be processed by open burning, compaction by a bulldozer, and covered with soil.

Individual members of households haul waste to the landfill in small trailers (ANTHC March 2003). Residents deposit solid waste randomly on the ground surface, mainly toward the east side. Solid waste is uncontained and not segregated. The City of Kivalina maintained the landfill in the beginning of its operation. Cover soil was used until the initial stockpile was depleted. Unorganized burning around the landfill was noted during a July 2003 site visit (TNH/URS, 2003). Site containment berms and a fence were not noted at the landfill. Landfill and solid waste maintenance does not appear to occur. No cover soil was observed.

The size of the landfill was estimated to be

View of Kivalina solid waste facility and access trail (TNH/URS, 2003)

500 by 200 yards during a July 2003 site visit. The values are approximate because the waste was spread over a wide area and uncompacted. The depth of the debris was estimated to range from six inches to four feet. These dimensions average to approximately 75,000 cubic yards for uncompacted/unburned waste (TNH/URS, 2003).

Because total community refuse volume information is not available, Cold Regions Utilities Monograph (CRUM), 1996, was used to obtain the existing volume estimate using residential volume and population. For the average Kivalina residential refuse volume in cubic yards, a value of 0.018 cubic yards per day was used, which CRUM proposes for residential or municipal waste in northern communities. The existing uncompacted solid waste generated per year in Kivalina is therefore estimated at 2,786 cubic yards for a population of 383 people.

Kivalina is presently working on a grant to obtain a burn box (ANTHC 2004).

2.3.6.3 Fuel

Bulk fuel storage (BFS) tanks in Kivalina are owned and managed by McQueen School, the Kivalina Native Store, Alaska Village Electric Cooperative, Inc. (AVEC), the National Guard, and the Alaska Department of Transportation and Public Facilities (DOT&PF). The tanks consist of above ground steel tanks in a variety of sizes.

Kivalina washeteria/clinic drainfield before the October 2004 storm (TNH/URS, 2003)

BFS facilities are typically located near the owner's point of use. The school and Native Store tank farms are located at the south end of the spit, the AVEC tank is on the west side of the spit, and the additional tanks are distributed throughout the village. See Table A for tank volumes.

Kivalina currently has fuel delivered by Crowley Marine Services once a year. The existing storage volume is adequate to serve the unplumbed community of 383 people.

The Washeteria has two Burnham fuel oil fired boilers; each rated at a gross output of 404 thousand BTU's per hour with fuel consumption listed at 3.5 gallons per hour (gph). McQueen School uses approximately 33,000 gallons per year (gpy) and has a 1,467 gallon day tank (refilled twice weekly) to supply the school's boilers. The Native Store sells fuel oil for home heating; gasoline for ATV's, boats, and snowmobiles; and propane for home cooking needs.

2.3.6.4 Electricity

AVEC supplies all electric power to the village of Kivalina with diesel driven generators. The number and configuration of on-line generators at any given time is affected largely by season, time of day, storms, and Washeteria usage. Generally, winter electric generation requirements are higher than summer because school is in session. Conservative estimates indicate annual fuel usage of approximately 85,000 gallons.

Additional emergency electric generation for the Washeteria can be supplied by a local backup generator.

2.3.6.5 Housing

Housing in Kivalina is crowded and inadequate. According to the 1990 U.S. Census, Kivalina had 71 single-family residences. There is no multi-family housing in Kivalina. The residences have one to three bedrooms and house as many as five to 15 occupants. The 1990 average number of people per household in Kivalina is 4.70, which is nearly 50 percent higher than the United States average and about 40 percent higher than the state average. A state survey summarized several characteristics of homes in the Northwest Arctic Borough. The houses are among the smallest of all regions in the state, averaging just 731 square feet.

Housing conditions vary from older dwellings to new housing, with the newer homes being built by the Northwest Inupiat Housing Authority. The lack of utilities supplying water and sewer, the lack of flooding and erosion control, and the lack of available real estate for expansion have hindered development of new housing.

2.3.6.6 Public School

Kivalina houses the McQueen School, of the Northwest Arctic School District (NWABSD), which is operated by the Borough. As stated on the NWABSD web site, the NWABSD prides itself on "providing a well-rounded quality education that includes a working knowledge of traditional Inupiaq life skills including language, cultural customs and culturally practical skills."

The school has nine classrooms, a wood shop, darkroom, gymnasium, library, and modern computer and video equipment.

There are approximately 117 students attending grades K through 12 with approximately 9 certified staff. The school, as in most rural Alaska Native communities, acts as a focal point of activity for the community. It draws not only the students that attend the school, but hosts after-hours events associated with holidays and festivals as well. The school acts as the Chukchi Campus of the University of Alaska Fairbanks, and also provides recreational opportunities to the community, such as basketball and other sports.

2.3.6.7 Transportation

Transportation within Kivalina is primarily by foot, small boat, all terrain vehicle, and snow machine. There are no roads into or out of Kivalina. The major means of transportation into and out of the community are the state owned 3,000 ft by 60 ft gravel airstrip, and the Crowley Marine Services barge. Crowley makes two annual trips to Kivalina, usually taking place in July or August. Barges set sail to Kivalina from Kotzebue, and Crowley attempts to run the trips back-to-back to take advantage of good weather. The actual trip dates are weather dependent, due to wind, swells, and general weather conditions (ADCCED, 2004).

2.3.6.8 Economy and Employment

Kivalina has a mixed wage-subsistence economy. Wage income for the Kivalina residents is limited and includes year round and part-time employment through the McQueen School, City of Kivalina, Maniilaq Association, the Kivalina IRA Council, Alaska Village Electric Cooperative (AVEC), airlines, and local stores. The development of the Red Dog Mine, which is located 18 miles South of Kivalina at the headwaters of the Wulik River, has had a substantial economic impact on the NANA region through creation of employment and revenues to the NANA Corporation and Northwest Arctic Borough. Some Kivalina residents are employed at the mine.

There are several talented artists in Kivalina that produce traditional and contemporary carvings and jewelry from ivory, baleen, bone, and animal skins and furs. The native craft industry has recently expanded and the community is strongly committed to keeping arts and crafts as an important part of its culture and traditional heritage.

2.3.6.9 Land Ownership

A combination of several entities – the Northwest Inupiat Housing Authority, NANA Corporation, State of Alaska, and individuals in the form of native allotments – own the land in the vicinity of Kivalina. The State of Alaska owns a portion of land at the site of the airstrip that extends from the edge of the community. Because of its dedication to transportation needs, it is unavailable for community expansion. The NANA Corporation owns surface and subsurface land on the potential town sites. In addition, the state owns the land under the Kivalina lagoon, which is a potential source of gravel for the new town site pad. The City of Kivalina is entitled to select up to 1,280 acres of land for municipal purposes under Section 14 c (3) of ANCSA, although they have yet to make a selection. There are a number of Native allotments in the project area, including several in the vicinity of alternative relocation sites (Figure 2). The Bureau of Indian Affairs acts as trustee for Native Allotments and their approval is needed prior to lease or sale of allotments.

3 ALTERNATIVES

All of the alternatives for a new town site have the same site layout, gravel pad, and basic infrastructures, which include:

- barge and boat landing,
- water treatment and distribution system,
- sewage collection and treatment system,
- power generator system,
- airport,
- landfill,
- public buildings, and
- housing.

One possible community configuration is shown in Appendix G. This layout was developed in the "Kivalina Relocation Community Layout Plan", prepared by TNH in 2001. This layout was selected by the community as their preferred configuration. While one layout may be applicable to all sites, there will be differences, including:

- the location of the support facilities in relationship to the village gravel pad,
- the length of road to access the landing facilities,
- the thickness of the village gravel pad,
- requirements for erosion and flooding control,
- and the design issues posed.

There is not adequate data at this time to provide detailed locations of the support facilities for each site. Recommendations for the support facilities can be made on a generic level for those elements that are not site dependent. Once the site for each support facility has been selected, a detailed set of recommendations can be provided.

3.1 SUMMARY OF DESIGN CRITERIA

The following table summarizes the design criteria used throughout the Kivalina Relocation Master Plan. Design projections and assumptions were used for sizing facilities and cost estimating. Assumptions should be revaluated prior to the actual design of a new village site.

Design Criteria	Vacuum Piped System	Gravity Piped System
Planning Period	**30 years**	**30 years**
Current Population	**402**	**402**
Design Population (30-year)	**949**	**949**
Current School Population	**117**	**117**
Design School Population	**276**	**276**
Water (Entire Community)		
Average daily per capita usage (gpcd)		
2005 total average daily usage (gpcd)	47	60
2005 total maximum daily usage (gpd)	18,894	24,120
2030 design year maximum daily usage (gpd)	24,562	31,356
	44,603	56,940
Water (School)		
Average daily per capita usage (gpcd)		
2005 total average daily usage (gpd)	15	15
2005 total maximum daily usage (gpd)	1,755	1,755
2030 design year maximum daily usage (gpd)	1,755	1,755

	4,140	4,140
Wastewater (Entire Community)		
Average daily per capita flow (gpcd)		
2005 total average daily flow (gpd)	47	60
2005 total maximum daily flow (gpd)	18,894	24,120
2030 design year maximum daily usage (gpd)	24,562	31,356
	44,603	56,940
Wastewater (School)		
Average daily per capita flow (gpcd)		
2005 total average daily flow (gpd)	15	15
2005 total maximum daily flow (gpd)	1,755	1,755
2030 design year maximum daily usage (gpd)	1,755	1,755
	4,140	4,140
Solid Waste	Condition	Self Haul
Average per capita daily production (pcpd)		
	7.5	7.5
Village Site Design		
Size of Proposed Village	100 acres	
Assumed thickness of Village pad in those areas with thaw unstable permafrost	9 feet thick	
Assumed thickness road bed for transportation Roads from village to other infrastructure	5 feet thick	
Notes:		
gpcd = gallons per capita per day		
gpd = gallons per day		
pcpd = pounds per capita per day		

3.2 NON SITE SPECIFIC ALTERNATIVES

3.2.1 Site Preparation

Site preparation is primarily dependent upon the location and condition of the chosen site. Lower elevation sites that could be susceptible to storm driven floods require raising of the site with gravel or by building on pilings; while sites that have ice-rich, warm permafrost require constructing the site without risk of thawing the ground. For the purposes of the study, and due to constructability concerns, all sites include a gravel pad for placement of future buildings and installation of utilities.

Four of the sites, Igrugaivik, Kuugruaq, Kiniktuuraq, and Simiq, have very similar existing geotechnical conditions. They each share the same geotechnical characteristics over portions of their respective areas, with ice-rich soils, marshy wetlands, and susceptibility to erosion and/or storm surge. Imnakuk Bluff also has ice-rich permafrost, but is not susceptible to storm surge. Tatchim Isua test holes show soil characteristics that are more conducive as support material. The existing Kivalina town site does not share the geotechnical characteristics of any of the other sites.

For coastal sites (Kivalina, Kuugruaq, and Kiniktuuraq), elevations are approximately 10 feet. Those sites would have to be raised to an elevation of 16.5 feet (requiring 6.5 feet of fill) to be safe from 100 year storm surge. However, to avoid degradation of permafrost, Kuugruaq and Kiniktuuraq need to be raised a to an elevation of 19 feet, requiring 9 feet of fill.

Tatchim Isua has areas without ice-rich permafrost and is located above flood levels. For this site, a gravel pad depth of 3 feet is proposed to allow leveling and/or grading of the site.

Simiq and Imnakuk Bluff are at elevations above potential flooding. However, they have soils composed of ice-rich permafrost. These two sites also require a 9 foot pad to avoid degradation of permafrost.

Kivalina has land that needs to be raised above 100 year storm surge level, which would require 6.5 feet of fill.

Techniques to keep ice-rich permafrost frozen include: gravel pads, gravel pads with insulation, thermosyphen installation, and thermopile installation. Thermosyphen and thermopile designs are usually considered for buildings and/or tank farms. In order to have buried utilities on the sites, a gravel pad is recommended so that water, sewer, and other utilities can be located below grade. Thermopile or thermosyphens may still be used for individual buildings, however this will be decided during future design phases.

For relocation sites, there are two alternatives for site preparation. One alternative is to leave the existing vegetatative mat, and build boardwalk for roads and have pile foundations for buildings. The second alternative is to build up a site pad that can be used as the basis of construction.

3.2.1.1 Boardwalk and Pile Foundations:

Under this alternative, roadways within the community would be constructed of pile supported boardwalk. The boardwalk can be designed to hold 10,000 pound loads (two ATV's side by side, each hauling a trailer). Boardwalk would be supported by helical pile foundations. Similar boardwalk construction in Chefornak and Nightmute has been constructed over warm, ice-rich, permafrost. The cost for construction was up to $1 million per mile. Buildings and utilities would be required to be founded on pile foundations systems.

The community made a decision early in the relocation study process to only consider gravel roads. Boardwalks typically are not designed for vehicle traffic and are difficult and costly to maintain. In addition, if a village site pad is constructed, gravel roads will likely be considered as part of the construction infrastructure, eliminating the need for boardwalk systems. For the purposes of this study, boardwalk systems are not being considered.

3.2.1.2 Gravel Site Pad

Most sites, with the exceptions of the Kivalina "no action" option and Tatchim Isua, require an earthen pad to serve as the stable foundation for the construction of the new village infrastructure. The chosen site should be graded and laid out to minimize storm drainage manholes, piping, and to create the best surface drainage possible. Gravel applied to the Kivalina site is for raising the elevation of the site, and is not associated with maintaining soil thermal regime.

The chosen site may have a fill section constructed over the site to allow construction of buildings, utilities, and roads. Preliminary calculations show that a gravel pad must be 9 feet thick or greater at all sites except Kivalina and Tatchim Isua. The gravel should be placed over geotechnical fabric to separate the imported gravel from the existing grade.

Access roads that do not lie within the site pad could be built with five feet of gravel, but some settlement could be expected. The roads may have to be maintained by grading and occasional placement of fill. Placing a layer of high-density foam insulation over the geotechnical fabric before placing gravel can significantly reduce the thickness of the gravel pad. However, the use of insulation is not recommended due to potential risks of permafrost melting if the insulation is damaged or destroyed. If an entire townsite was underlain by insulation, there would be a significant risk of eventually disturbing the insulation or having fuel product come into contact with the insulation. Fuel can decompose or damage the insulation. Once the insulation is damaged, the permafrost can melt or settle.

Some research has been conducted into a potential borrow source for a village site pad. The material will have to be imported by barge, or a quarry site will have to be developed near the community. Potential local sources of gravel material include local deposits at Tatchim Isua and a site located approximately 7.5 miles north west of Kivalina (see below re: Kisimigiuktuk Hill). DOWL/BBFM (1998) states that granular borrow material has been identified along the beach areas and berms of the Wulik River and Kiniktuuraq. It is estimated that more than 200,000 cubic yards of material are available from the back side of the beach berm. However, beach deposits and river deposits do not have adequate volume to develop an entire village site pad. Local beach deposits could be used for small fill projects. NANA owns about 70 percent of this deposit. The remaining 30 percent of the deposit is owned by a private party and is part of a Native Allotment.

Kisimigiuktuk Hill is located approximately 7.5 miles north east of Kivalina. The hillside is over 1100 acres in size, and has a top elevation of 460 feet (USGS quad map elevation). The site has not been investigated by a geologist. The site was visited by the Northwest Arctic Borough (NWAB) in 2005. The borough confirmed that the site has exposed weathered bedrock and there are surface deposits of gravels along the north side. In addition, the NWAB has proposed that this site be used to mine gravel for an emergency access road. Similar hillside deposits were used by Red Dog Mine to construct the port access road. Local hillsides have adequate volume to support mining for roads or village pads. For cost estimating purposes, Kisimigiuktuk Hill was chosen as a potential gravel source.

The cost of gravel to create a new village site pad has been controversial since the Phase I Kivalina Village Relocation Project report was published in December 2001. That report estimates gravel costs for a 12 ft high pad to be approximately $85 million. Later reports by others estimated the gravel cost as closer to $200 million, and up to $400 million. As part of this study, the old gravel reports were analyzed.

After further analysis of existing reports, the updated estimated costs of importing gravel to a site is $70 per cubic yard. With most sites requiring a 100 acre pad, 9 feet deep, approximately 1.5 million cubic yards of material would be required at an in-place cost of $104 million. The feasibility of mining local material was discussed with a large earthwork contractor, who estimated that mobilization, hauling, and placing fill to a site 7 miles away could take 2 to 3 years to complete.

3.2.2 Construction Phasing

The phased construction of the infrastructure and relocation of the community should take place over approximately a 10-year period. The first facility to be constructed should be the gravel borrow site. After the borrow site is constructed, a pioneer road to the new runway location can be built. Optimally, this pioneer road should be routed adjacent to the new village site and provide construction access to both sites.

The barge landing should also be constructed early in the project to facilitate the landing of barges and offloading of equipment and materials. A boat landing should also be installed to support the construction camp and contractor staging area. The remainder of the boat launch pad can be installed during subsequent construction.

The contractor(s) selected for construction of the project infrastructure must build a support camp to provide facilities and housing for construction crews. The camp, used by all contractors, should be designed and constructed to be a stand-alone facility with its own water and sewage systems. The camp should be closed down and winterized in the fall and restarted each spring prior to the arrival of the construction crew.

The temporary construction camp should be established at the boat storage pad to provide facilities for the workers building the gravel access road and the new runway. The camp can be expanded to full capacity as the phases of the construction progress.

Both the runway construction and new village pad construction should take approximately 2 to 3 years each to construct, and can be undertaken concurrently, or the runway can be constructed on a separate schedule.

If the sewage lagoon is constructed prior to the placement of the village gravel pad, it should be available for safe and sanitary disposal of wastewater as soon as community infrastructure is in place. Once the village gravel pad has been completed, construction of the community infrastructure can begin. This work should be phased to accommodate the annual budgets of the various agencies having jurisdiction over the constructed elements.

The electrical plant should be constructed followed by the bulk fuel facility. This scheduling of facilities should provide electrical power for the construction process early in the project.

Construction following the power plant should begin with the water/wastewater treatment building and the infrastructure to transport raw water to the village and discharge wastewater to the lagoon. Water and sewer infrastructure can be installed concurrently with the construction of housing and public buildings in a phased program over the last 3 years of the build-out.

During construction of the village, two villages should be functioning simultaneously. It is unlikely that both sites will have operational schools or post offices. It is more likely that once the school at Kivalina is closed, equipment and teachers will operate out of a new school at the new town site. However, since homes are projected to be built over three seasons, not all people will be able to move at once to the new site. Transportation between the new and old sites must be available for schoolchildren and for moving freight and supplies. For the relocation sites located furthest away from Kivalina (Simiq, Tatchim Isua, and Imnakuk Bluff), a hovercraft system is recommended to move school kids and equipment between villages. The hover craft would travel across the tundra between village sites, possibly using the lagoon as a primary transportation corridor. For areas on bluffs, the hovercraft would have to stop short of the village and pick up people near the river.

At the conclusion of the construction process, the temporary construction camp should be removed from the boat launch ramp, and construction of the new facilities should be finalized.

3.2.3 Water

3.2.3.1 Water Supply

A continuous year-round source of fresh water is needed to support a piped distribution system for the community. Kivalina's current water system draws raw water from a surface water source, the Wulik River, and passes it through a small treatment plant. The local residents report that the water source does not flow year-round because the river freezes up in the winter. Although the river may freeze to the bottom, it may be possible to withdraw water year round from a shallow infiltration gallery in the river bed located upstream of the ocean saline water influence. This is further supported by a stream gauge information (USGS Station ID 15747000) located on the Wulik River, approximately 25 miles northeast of Kivalina. The station shows continuous year around flows in the Wulik River. Field investigations by Travis Peterson Group also witnessed year around base flow in the Wulik River (2005 investigations)

In order to use the Wulik River as a year round water source, the transmission line would have to be heated. The line should be continuously heated by using a circulating glycol loop in the arctic pipe. Glycol heating systems work by circulating temperature controlled heated glycol in a closed loop system that is located along side the water line. Long lines are very expensive to heat and to circulate. The village site should be in close proximity to the water source in order to avoid high heating and pumping costs.

Groundwater could supply a year-round water source if found in sufficient quantity and quality. Exploratory geophysics and drilling conducted in the site vicinity suggest that thaw bulbs along the Wulik or Kivalina Rivers may be the most likely source of groundwater in the area (Golder 1997; R&M 2002). Only one test well has been drilled to date, however, which yielded saline groundwater at a location approximately 1 mile inland from Kivalina Lagoon (R&M 2002). The source of the saline groundwater may be a subsurface intrusion effect, or surface infiltration during high tides and storm surges.

A literature review of local geology and hydrology, with respect to determining the most likely location depth and yield for a public surface, or groundwater water supply source for each of the seven potential relocations sites was conducted as part of a water investigation report (Appendix H). The recommendation of the report was to utilize surface water sources for all alternatives, for a number of reasons. In summary, the drilling of wells to establish a surface water source is not feasible for Kivalina, and is not likely to yield positive results based on an analysis of regional data. A proven subsurface water source has not yet been identified in the Kivalina area.

For all sites, a surface water source would be used. The surface water intake structure would either be a shallow infiltration gallery, or a direct intake from the river. Since freezing is a concern, an infiltration gallery is the recommended alternative for all water supply systems.

3.2.3.2 Water Storage

A community-wide piped distribution system requires community water storage for water treatment requirements. If surface water is used as a water source, the tank must be sized for disinfection contact time. The size of the tank is determined by comparing the requirements for disinfection contact time and the requirements for demands.

Storage helps alleviate water shortages and provides for better fire protection by supplying a large quantity of water quickly.

A bolted steel tank insulated and heated in the winter to protect the water from freezing is necessary. Such tanks are relatively simple to build and have superior factory paint systems than welded steel tanks. A circulating heat line should also be installed in the water storage tank to keep it from freezing.

The water tank should be sized for seven days' water demand, and with extra storage for firefighting needs. The average daily water demand for a fully piped community water system for a future population of 949 is estimated at 57,000 gallons per day. Fire flow is rated at 1000 gpm for a sixty-minute period, or 60,000 gallons of storage. At a rate of 1000 gallons per minute for fire flow, and adding seven days of average daily demand, approximately 460,000 gallons for storage would be needed for a fully piped system. A contact tank (CT) would be needed for disinfection purposes. A water storage tank can act as a contact tank. The tank should to be sized for the peak daily demand (twice the average daily demand) of 94,900 gpd. A 110,000-gallon tank is a sufficient size to satisfy CT requirements. Sizing was based on a baffle factor of 0.3, and an average demand of 66 gpm on peak days. A separate calculation was run based on a demand of 132 gallons per minute. A 110,000-gallon tank is adequate for both demand rates, however the larger tank discussed above is recommended to act as both fire flow storage and a contact tank.

3.2.3.3 Water Treatment

Water treatment alternatives are dependent on the quality of the source water. Since the water quality investigations are still pending, detailed analysis of water treatment alternatives cannot be conducted at this time. In addition to the quality of the water, the level of treatment is also determined both by State and Federal drinking water regulations.

All public water systems must comply with State of Alaska Drinking water regulations: 18.AAC.80. Kivalina should be classified as a Class A public water system, with either a surface water source or ground water source. Rivers, lakes, and streams are considered surface water, while water wells are typically considered ground water. Surface water is required to have filtration and disinfection of the water, while ground water may not require any treatment if the quality is suitable. For surface water, the goals set by the EPA are to achieve 99.9 percent removal and inactivation of Giardia cysts and 99.99 percent reduction in viruses, which are commonly found in surface water. EPA also requires maintaining a disinfectant residual in the water distribution system.

A short summary of regulations that apply to the design and operation of a public water system are included on the following page:

- Lead and Copper Rule
- Long Term 1 Enhanced Surface Water Treatment Rule
- Filter Backwash Recycling Rule
- Arsenic Rule
- Radionuclides Rule
- Interim Enhanced Surface Water Treatment Rule
- Stage 1 Disinfectants and Disinfection Byproducts Rule
- Consumer Confidence Report Rule

If a river is selected as a water source, the treatment equipment will likely consist of filtration, followed by disinfection of the water. The alternatives for treatments are a packaged rapid sand filter system, or a pressure sand filter system. During the winter months, heat would have to be added to the source water to keep the water from freezing and to enhance the performance coagulation and filtration of contaminants. Both alternatives would require storage to act as a chlorine contact tank. Preliminary sizing of the CT tank requires a 110,000 gallon tank based on the design population average and peak flows of 66 gpm and 132 gpm, respectively. Calculations are based on a pH of 6.8, a free chlorine residual of 0.2 mg/l, a treated water temperature of 3 deg Celsius, and a tank baffle factor of 0.3. Based on the results of a pilot water treatment study, a water treatment system can be designed.

The water treatment plant may be housed in a building shared by the sanitary sewer vacuum plant. Having one shared facility should save on heating, construction, and maintenance costs. The treatment system is likely to be a pressure sand filter system. The technology is well known and proven, has easy to find parts and materials, and is familiar to most operators in rural Alaska. The plant should be designed to remove all contaminants found in the raw water source to levels compliant with current ADEC regulations, and should be capable of treating a minimum of 50 GPM continuously. The treated water should be stored in an insulated 460,000 gallon steel storage tank located near the water treatment plant. The water tank will require an add-heat system to keep the tank from freezing in winter months.

For any source of water, the water may have to be filtered to remove: dissolved organic material, iron, manganese, and possibly other constituents. The water would likely have to be preheated to speed up the oxidation of metals in the water. Again, without detailed water quality results, the alternative for treatment cannot be selected.

For cost estimating purposes, the treatment system selected is multimedia sand filters, with injection of polymers to coagulate particles prior to the filters. This type of filtration is common for remote communities, as it allows for a small footprint within a building, and provides very efficient treatment of the water.

3.2.3.4 Water Distribution

When selecting a particular water system for a community, the type of water distribution chosen is a major factor. The type of water distribution utilized may affect other aspects of both the water and sewer systems.

The community has selected piped water and sewer systems. However, several options for water distribution are available for the village. Preliminary alternatives include self-haul, small-scale ATV haul, truck haul, and piped distribution.

3.2.3.4.1 Self Haul

A self-haul system, where village residents haul their own water from the watering points, is currently used in Kivalina. Capital cost for this option is zero, but it does not provide a high level of service. O&M costs are primarily related to the upkeep of the watering point and to water treatment, and are the lowest of the possible alternatives. However, because individuals must haul their own water, residents tend to get water less often, consequently leading to insufficient sanitation practices.

3.2.3.4.2 Small-Scale Community ATV Haul

This distribution system uses a four-wheeler or tracked vehicle and a small trailer to transport water from the water treatment plant to residences. These systems have been found to be best suited for communities with low water consumption and good roads. Rural Alaska communities typically don’t water lawns, wash cars, or have high water use devices such as washing machines and dishwashers. Water demands can be therefore be lower per capita than that of larger cities, making this distribution method appropriate.

Water usage usually increases with availability. Currently, Kivalina is on a self-haul system, which would be considered a low availability supply system. The small-scale community ATV haul would increase availability, but not to the extent of a piped system. The major components of this system are the fill station, delivery vehicle and trailer, and storage tanks at each home. Water is pumped from the watering point to fill the ATV tank, and a small electric pump is used to pump the water from the trailer to the storage tanks in the homes. An ATV haul system serving all residents of Kivalina would be classified as a Class A public water system by the Alaska Department of Environmental Conservation (ADEC).

This option requires very little technical oversight for maintenance and operation. If the haul vehicle breaks down, there are replacement vehicles in town that could be used in an emergency. Residents could return to hauling their own water again with very little loss of service if the community sees the system as undesirable. Capital and O&M costs can be lower than other, more complex distribution systems.

Disadvantages of a small-scale haul system are the relatively small size of the ATV hauling tank, which increases the number of trips and therefore decreases the level of service. ATV haul systems typically transport and serve water tanks holding between 100 and 300 gallons. Another possible disadvantage is that indoor tanks often require the operator to enter the home to deliver the water unless an outside fill point is installed.

Small scale haul systems are usually sized to allow 15 gallons per person per day. Studies show an increase in health standards if people use 15 or more gallons per day. However, since haul systems charge per haul, people typically ration water to save haul costs. Water rationing does not promote good sanitation practices.

3.2.3.4.3 Community Truck Haul System

This option is similar to the ATV haul, but on a larger scale, utilizing a truck rather than ATV. The major components of a truck haul system include a truck fill station, the delivery vehicle and tank, and a storage tank at each home. The delivery vehicle can be a conventional 1,200-gallon water truck or it can be a pickup truck with a water tank, typically 300-500 gallons, and delivery pump mounted in the bed. The tank would be filled from a central fill point, such as the washeteria. Water would be distributed to individual storage tanks on a scheduled basis or upon request by the consumer. A truck haul system serving all residents of Kivalina would be classified as a Class A public water system by ADEC.

Advantages to this system are that it has capability of delivering more water than a self-haul or ATV haul system, thus increasing the level of service to consumers and decreasing the number of trips to the watering point, which in turn reduces both labor and fuel costs. It can also provide a limited fire control capability. Haul systems require less technical expertise than the piped water distribution systems.

Disadvantages are that haul systems are labor intensive and require an operator to run the truck and maintain it. The roads and structure access must be maintained to ensure reliability of delivery. The trucks also require a larger heated facility for storage than ATVs, and are more maintenance intensive.

3.2.3.4.4 Piped Distribution

A piped distribution system provides the highest level of service for water users and was previously chosen by the community. The consumer has water on demand whenever it is needed, without the necessity of filling tanks or hauling water. It allows the treatment of all of the Community water to be monitored, to assure safety and quality control. This control decreases the likelihood of contamination.

Piped systems are capable of providing large quantities of water to residents. Pipes would circulate heated water from the water treatment plant to the homes and back. The major components of this system are indoor plumbing, service connections, piping, and the water treatment plant upgrades.

Insulating pipes in arctic conditions is typically done one of two ways: utilidor or arctic pipe. Utilidors are often more expensive to install and maintain and are commonly used in wetlands or when multiple pipes are located close together. For this reason, arctic pipe would be suggested for a Kivalina water distribution system.

The installation of arctic pipe has several alternatives. Routing can be varied to best fit the community. The most accepted and practiced method is to place the mains in the road right-of-ways. This method greatly reduces easement requirements and also places the pipe in easy to reach locations for maintenance access.

Another option, the extended main, is to install the mains as close as possible to the houses to be served to minimize the length of the service line. This is not as common as it once was due to easement requirements and ownership complications. It also increases the length of mainlines, and places the mains at risk in the event of structure fires.

Distribution systems to serve Kivalina can be constructed with above or below ground piping. Below ground piping is commonly installed when the soil consists of unfrozen ground or thaw stable permafrost. Advantages to below ground piping are that road and sidewalk crossings do not hinder traffic and the pipes do not segregate the village. Heat loss experienced with below ground piping is approximately one third that of above ground pipes in similar climates. Aesthetics and unobstructed vehicle movement are also much improved with below ground piping. Disadvantages are that the soil surrounding the pipes must be thaw stable or kept frozen. In arctic climates, this means the soil must be granular and free of excessive moisture. Also, if a leak were to occur in buried piping, locating and repairing the leak can be difficult and costly.

Above ground piping is common in locations with ice-rich, unstable soil. Advantages to above ground pipes are that they can be less expensive to install and maintain because no excavation is required. Leaks in above ground pipes are easier to detect, locate, and repair. Disadvantages are that above ground pipes tend to segregate a village, restricting or hindering access to certain locations. Above ground pipes are subject to physical damage because they are exposed, particularly when they are installed near roads.

Through a piped distribution system, water is supplied to each home with individual water service lines that utilize pitorifices to circulate the water. In order for the pitorifice to work properly the service line cannot be over 60 feet in length and the velocity in the main line must be at or above two feet per second (2 ft/sec). In the circulation system, there are two taps and two lines, an entry line and a return line. Services are connected to the main line through a brass plug valve called a corporation stop. The corporation stops are the pitorifice type. The inlet pitorifice is pointed into the flow and the outlet pitorifice is pointed away from the flow. The service line loops into and out of the house. Small circulation pumps can be installed in the home to circulate the water if the head loss is too great for pitorifices, but would require electricity to operate and need to be maintained. The service lines are usually installed with heat tape to provide thaw recovery should circulation stop and the lines freeze. The optional meter would be attached to a tee on the top of the loop.

One advantage of a piped distribution system is that it provides the highest level of service for water users. The consumer has water on demand whenever it is needed, without the necessity of filling tanks or hauling water. This system would also allow the treatment of all of the village water to be monitored, to assure safety and quality control. This control would decrease the likelihood of contamination as compared to a haul system. A disadvantage of piped systems is that this type of system often requires major modifications to existing water treatment plant equipment, or additional central facilities, to operate. These requirements make piped systems more complicated to operate than a haul system. The technical and financial requirements to operate and maintain a circulating water system are very high in relation to what the self-haul system in place now costs users.

3.2.4 Wastewater

3.2.4.1 Wastewater Collection

Alternatives considered for wastewater collection include ATV haul (with onsite holding tanks), truck haul (with onsite holding tanks), and piped collection systems. The health concerns that a collection system addresses are the lack of or minimal contact with the waste. A trained operator or employee of the village would have appropriate clothing (gloves, boots, mask, etc.) and would be the only individual(s) in contact with the waste, reducing the disease and illnesses associated with handling human waste. Small-Scale ATV Flush/Haul

ATV wastewater haul systems are similar to those used for ATV water haul. Advantages of the ATV system are that the equipment is less complex and easier to maintain, and access needs are less demanding than for a larger scale truck haul system. Also, waste would be contained and disposed of in controlled locations, increasing sanitation. The road system would not need large-scale improvements to ensure that the operator could reach the home, decreasing road improvement costs as well as road maintenance costs. Capital costs of necessary equipment are lower than for truck haul.

Disadvantages are that the tank cannot be as large as it is on a truck haul system, which increases the number of trips and amount of raw sewage handling, and decreases the level of service. ATV haul systems typically have in-home sewage storage and haul tanks between 120 and 300 gallons. Another disadvantage is that the homeowner must practice water rationing to limit the amount of hauls and keep the cost to the homeowner low. Water rationing does not promote good sanitation practices.

3.2.4.1.1 Truck Haul

A wastewater truck haul system is similar in many ways to one used for water haul. A truck- or trailer-mounted tank and pump are hauled to each residence and the wastewater holding tank is pumped out. The holding tank can be underground or inside the home. The tanks are fitted with quick disconnect cam lock fittings for easy cold weather hookup. The pumper then discharges the collected waste into a community septic tank or lagoon for treatment and disposal.

The O&M cost of this system is similar to the larger scale truck water haul, with fewer hauls per house per week. This means less cost to the homeowner (because the haul cost would likely be determined on a per trip basis) and less handling of the septic waste, which increases sanitation in the community. The waste would be stored and treated in controlled locations, increasing the sanitation benefit offered by the system. Truck haul systems are simple to operate and maintain, which is desirable in rural Alaska.

As with the other systems, disadvantages include the labor requirements to operate a haul system, a better maintained road system, and a larger maintenance building system than an ATV haul system, all of which increases capital and O&M costs.

3.2.4.1.2 On-site systems

Many of the potential town sites feature ice-rich soils. This permafrost is not suitable for onsite systems that depend on leaching for wastewater disposal, such as onsite septic tanks with leach fields. Depending on the soil temperature and type, and the amount of wastewater disposed, the frozen ground may eventually cause the liquids to freeze or the liquid may thaw the soil and create settlement problems.

3.2.4.1.3 Piped Collection

For this report, the village selected piped collection systems as the preferred alternative to be considered for all relocation sites. Many of the same parameters that were listed for piped water distribution also apply to piped sewage collection. This type of collection provides the highest level of service and the highest sanitation levels of all of the options. Several different options exist for piped sewer collection. Gravity, pressure, or vacuum sewer systems are all constructible in Kivalina depending upon the site chosen.

Gravity sewer collection systems are commonly installed in communities where suitable topographic relief is present. Wastewater flows by gravity from the house, downhill through a pipe, into the main collection lines and to a treatment/disposal location. With aboveground piping, the sewer pipes can be placed on piles to assist drainage; and for belowground pipes, this can be accomplished by installing the pipe at varying grades. Where sufficient slope cannot be reached to drain the wastewater to the desired location, lift stations are often installed. Lift stations pump the wastewater either to the treatment area or to a high point where gravity flow can resume. Lift stations require electricity to pump, as well as maintenance to ensure the pumps are clean and operating properly. The advantages of gravity sewers are that both capital and O&M costs are typically lower than those associated with other types of collection systems. The main disadvantage is that gravity sewer systems are completely grade-dependent and may only work in areas where it is topographically feasible.

Two options exist for pressure sewer systems. The first consists of the waste draining by gravity from the homes to a central sump (similar to a lift station) where it is pumped to the treatment location. The second option requires pumping the sewage from the home directly into the pressure sewer. This can be accomplished with the installation of either a grinder pump or a septic tank effluent pump (STEP) system. The grinder pump reduces the solids in the waste and produces a slurry, which is injected into the pressure main. The STEP system uses a tank to settle out the solids, and the remaining effluent is then pumped into the system. It is necessary to periodically pump the solids out of the septic tank to allow proper detention time for the effluent. Pressure systems are often used to pump effluent long distances where there are no service lines and not enough grade to flow by gravity, such as out to lagoons located away from the village. An advantage of pressure sewer systems is that because they are under pressure, achieving a downward slope is not necessary. Long distances can be covered without the need for deep excavations to maintain grade. This also makes construction easier because a specific grade does not need to be maintained during installation. The disadvantages are that pumps require electricity to operate, which increases operating costs, and pumps also require maintenance to perform properly, which requires time and labor. Pressure mains also require active heating and cannot be installed inside the same utilidor as a water main.

Another option that would be possible to construct in the village would be a vacuum system. Vacuum systems utilize vacuum valves, vacuum pumps, and atmospheric pressure to transport sewage from the homes to a central vacuum station. From there, the wastewater is pumped to a treatment and disposal facility. The advantages of a vacuum system are that it is less grade-dependent than a gravity system, and can transport wastewater uphill. If a leak occurs, it will not cause a spill, but rather cause the system to lose vacuum, which would alert operators of a problem. Leaks can be pinpointed more readily than other systems because of the many valves in the network. Vacuum mains can be located inside a single utilidor with adjacent circulating water mains that can provide heat without need for a separate glycol heat loop. A disadvantage of the vacuum system is that there are a large number of valves and moving parts involved, which increase the O&M cost and complexity. Homeowners must exercise care in using the system to prevent shutdowns and loss of service. A vacuum system in the village is possible to install, although the O&M costs are high and there are many technical requirements for maintaining the system. Vacuum mains should not be buried due to grade sensitivity.

3.2.4.2 Wastewater Treatment and Disposal

For a piped sewage collection system, there are three main types of treatment technologies that are typically used for small Alaskan villages: Septic tank /drainfields, package sewage treatment systems, and sewage lagoon systems. The design and construction of treatment and disposal facilities has to comply with Federal and State regulations. In summary, the regulatory authority set forth in 18 AAC 72 (Wastewater Disposal), the Alaska Department of Environmental Conservation (ADEC), regulates the design, review, and permitting requirements of the system. Specifically, the design and application submittals will conform to the requirements included in 18 AAC 72.010 and 18 AAC 72.205. A permit to operate the treatment system is also anticipated as described in 18 AAC 72.910.

For sites where soils conditions have sand, gravel, or a combination of sands/silts and gravel, a septic tank/drainfield system could be considered. However, based on preliminary geotechnical information, most of the village sites appear to have permafrost and saturated/silty soils that are not suitable for a septic tank/drainfield system. Without detailed geotechnical information, a septic/drainfield system cannot be further considered for this study.

Wastewater disposal alternatives are based on the type of wastewater treatment that is selected. Disposal is generally limited to discharge to water body, discharge to land, or discharge to subsurface. Surface discharge can outfall from a septic tank, package plant or sewage lagoon. The treated effluent flows into a pipe or surface containment swale to be dispersed over the surface of the ground or to a water course.

This method of effluent disposal needs to be contained by a fenced area to prevent accidental human contact. The site selection process for surface discharge requires the route and dispersal area to be a distance from the village, and the flow to be away from the village.

Marine outfall entails a pipe routed from land into the ocean to a depth allowed by regulations, and determined from tide and current studies. The discharge works by means of the pressure head between the treatment unit discharge point and the outfall discharge below the ocean surface. Marine outfalls are susceptible to wave/ice action and erosion, and can cause controversy regarding pollution of the marine environment.

3.2.4.2.1 Lagoons

Sewage lagoon systems are a common, low cost alternative used throughout Alaskan villages. Sewage lagoons naturally treat sewage without requiring pumps, equipment, power, heat, and testing/monitoring, For Kivalina, the most feasible low-cost method of wastewater treatment and disposal is a lagoon system. Sizing of the system is based both on biological treatment requirements and hydraulic requirements. EPA recommends the organic loading rate be limited to 20 lb/ac/day (22.4 kg/ha/day) Biological Oxygen Demand (BOD) to avoid over loading and anaerobic conditions and odors. During the cold winter months, natural biologically treatment is not effective, so lagoons are also sized to hold wastewater throughout the months when the lagoon is frozen. Lagoons are typically sized to hold sewage for a nine-month duration.

The main advantage of lagoons is that they are inexpensive to maintain once constructed. Based on a design population of 949 people, a single cell lagoon would have to be 8 acres in size with a 6 ft depth. Alternatively, a smaller footprint could be used if a 3-cell lagoon facility composed of a primary settlement cell (1 acre), a treatment cell (2 acres), and a polishing cell (2 acres). The polishing cell discharges treated sewage directly into a wetland or the ground. This size lagoon will meet the state standard for discharging to wetlands or a water body. The discharge is done either in the fall after the lagoon has experienced facultative action, or in the spring during break-up when little aquatic life is in the river system. The lagoon should be bermed and have a dimension ratio of approximately 2:1 in the flow direction. The lagoon and discharge swale should be fenced to prevent access by unauthorized personnel and ensure that flooding does not inundate the site..

Based on the 3-cell lagoon treatment recommendations listed above, the disposal of treated wastewater will either be to the surface or to a wetland.

3.2.4.2.2 Wastewater Treatment Package Plants

Package sewage treatment systems are also used for wastewater treatment in some Alaskan communities. In the regions surrounding Kivalina, package treatment systems are located in Emmonak, Chevak, and are used in the North Slope Borough villages. These systems are self-contained units that treat sewage prior to discharging to land application or to sewage lagoons. To prevent freezing, the treatment plants must be located in heated buildings. Sewage treatment plants require certified operators and ongoing wastewater quality testing/reporting. The ongoing operation and maintenance costs for a package treatment are much higher than sewage lagoon systems. Because of the high costs of operation and maintenance; requirements for highly trained and certified operators; and requirements for a warm building to house the treatment plant, this alternative has not been considered.

3.2.5 Solid Waste

3.2.5.1 Solid Waste Collection

The 1995 City of Kivalina Solid Waste Management Plan proposed the implementation of a Solid Waste Ordinance to adequately address ADEC solid waste requirements. The Solid Waste Ordinance states:

> The City of Kivalina will administer solid waste management in the city according to the Solid Waste Management Plan. A utility manager will be directly responsible for the oversight and control of this operation.
> Everyone within the city will be required to participate in managing his/her household's solid waste.
> Individual yards will be kept free of unsightly waste. Littering is prohibited.
> Waste will be kept in proper containers.
> The ordinance will regulate the disposal method, illegal dumping, and dictate fines for indiscriminate dumping.
> The council will declare an annual village cleanup day, sometime after break-up. As an incentive, a prize for the most bags of trash will be offered to encourage resident involvement.

The current resident solid waste management and collection system is ineffective. The above Solid Waste Ordinance has not yet been implemented. Without enforcement of the Ordinance, residents do not properly dispose of solid waste. The current self-haul system does not meet 18 AAC 60 requirements and quality of life needs for the village. Implementation of the proposed Solid Waste Ordinance detailed in the 1995 City of Kivalina Solid Waste Management Plan would provide a starting point to begin development of an effective solid waste management and haul system. Other options for waste collection should be further evaluated during design of the new landfill.

3.2.5.2 Solid Waste Disposal

The new landfill should be sited and designed in accordance with 18 AAC 60 regulations as an unlined Class III municipal solid waste landfill. Although this landfill may not be designed specifically as a permafrost landfill, an aboveground design with insulating cover and side berms is recommended to minimize disturbance of underlying permafrost. Siting and constructing a new landfill requires:

- conducting an adequate soils investigation,
- locating the landfill in a stable, well-drained area and out of a flood plain,
- maintaining a minimum separation distance from groundwater and surface water according to ADEC standards,
- maintaining a minimum distance from the airport, and
- ensuring an accessible location of the landfill to Kivalina residents by road and to a docking area if hazardous materials are shipped out.

Hazardous material containment (such as storage and disposal of batteries, used oil, and other household hazardous waste), septic sludge, and recycling programs as well as the location of a sludge disposal pit must be considered during the design process. If stored properly, hazardous materials can be barged out of the village once a year to a safe disposal site.

A large burn box may help reduce the volume of burnable products in the landfill. Burn boxes have been successfully installed in several communities in recent years and have proved very effective at reducing the volume of trash that must otherwise be buried in a landfill. The State of Alaska allows and encourages burn boxes in rural communities, provided that the burn box acts only as designed for primary burning and not as an incinerator. State regulations must be met if an incinerator is installed. Material for daily or weekly covering of refuse should be stockpiled close to or inside the landfill. This material should be accounted for during design of cells, as well as the cost to have it stockpiled. Having cover material is essential to keeping debris from blowing out of the confined landfill and re-entering the community. It also prevents scavenging birds and animals from feeding on the waste.

Preliminary volume estimates have been calculated. Using 7.5 pounds per person per day, the uncompacted solid waste generated per year for a population of 949 is estimated at 10,391 cubic yards. To estimate the minimum uncompacted landfill volume capacity for twenty years, CRUM, 1996 was used. The average community growth rate was assumed to be 3.5% per year (TNH/URS, 2001). Assuming an initial population of 402 (current population) and a twenty five-year design life, the minimum landfill volume was estimated to be 259,788 cubic yards (October 2003 report). The given volume is an uncompacted volume. This volume may be reduced through compaction and burning to one-third to one-quarter of the uncompacted volume (CRUM 1996). Industrial and bulky waste would need to be estimated separately and added.

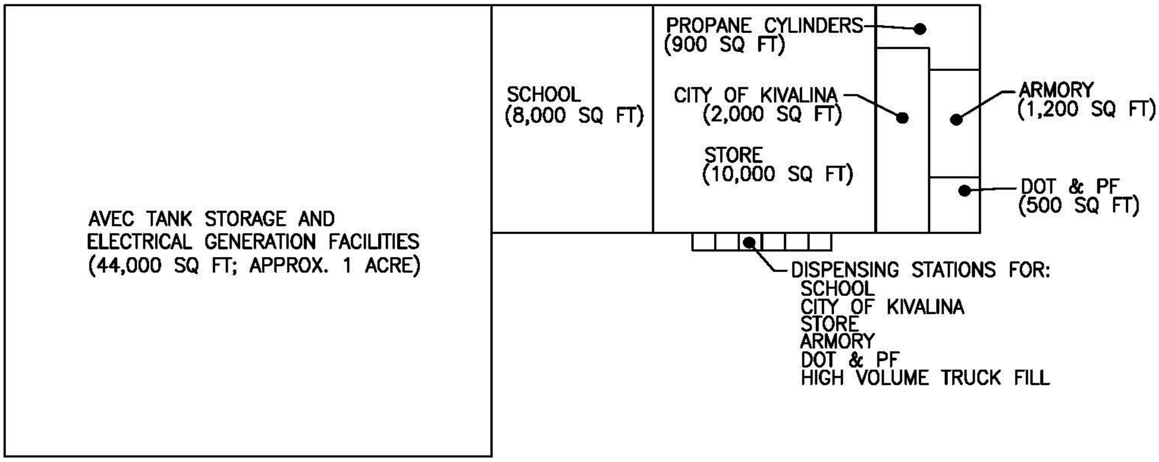
Calculation show the landfill will likely encompass 20 acres if no compaction or burning is performed. The landfill should be fenced to prevent the spread of blowing trash. In addition, the landfill should be sited a reasonable distance from the new village, above the flood plain, and out of any drainage paths. To minimize the number of roads required, it is recommended that the landfill be located along the access road from the village to the airstrip. The required separation distance between a landfill and an airstrip serviced by piston-type aircraft is 5,000 feet; however turbojet aircraft are used throughout the region and will likely access the Kivalina town site in the future; therefore a new landfill should meet the 10,000 foot separation distance required between a landfill and an airstrip serviced by turbojet aircraft.

3.2.6 Fuel

3.2.6.1 Fuel Supply

Separate marine headers should be provided at the barge docking point for the offloading of #1 fuel oil and gasoline for tank storage in the Bulk Fuel Storage (BFS) facility. Camlocks caps should be provided for barge marine header connections. Lockable block valves, check valves, and basket strainers with bolted covers and threaded bottom connections should be installed at the headers. A covered containment drip pan should be installed to contain minor spills and leaks.

Separate aboveground fill pipelines can be used to transport #1 fuel oil and gasoline from the marine header site to the BFS facility. Pipeline size and routing is site dependent; for pipelines longer than 2 miles, an additional booster pump station may be required to ensure adequate flow rates. Where the pipelines cross roadways, they should be installed underground with coated pipe and anodes for protection against corrosion. The fill pipelines should be connected to the tank headers for each type of fuel for filling of the individual bulk storage tanks. Trained personnel should protect against overfilling of the bulk storage tanks during filling operations by watching a tank’s clock faced level gauge and by listening for an air operated whistle vent that alerts at 85% full. In addition to the gauge and whistle alarm, the tanks



Estimated Bulk Fuel Storage (BFS) Facility Area Allocations

should be individually equipped with automatic mechanical overfill valves.

3.2.6.2 Fuel Storage

The single, consolidated BFS facility should consist of multiple single-walled steel separate 27,000-gallon storage tanks for #1 fuel oil and gasoline. The BFS facility should be partitioned into individually secured areas to accommodate individual owners/users of the facility.

All bulk and dispensing tanks should be located within bermed and lined containment areas. The size of the contained area and the height of the berm should be designed to accommodate a spill equal to the largest tank, plus seasonal rainwater accumulation, plus 12 inches of depth. In addition, large bermed areas should be sectioned into smaller areas by fluid tight barriers in order to minimize spill area sizes.

Individual 100 lb propane tanks should be stored within a separate unbermed area adjacent to the fuel oil and gasoline BFS site.

The entire storage facility should be fenced with lockable gates and lighted for security purposes. Fences and lockable gates should also limit access to individual owner's areas within the BFS facility. Valves outside secured areas should be lockable.

Preliminary Bulk Fuel Storage (BFS) Facility Summary

Owner	Fuel Type	Projected Fuel Use (Gal) (1)	New Storage Req'd (Gal) (2)	New Fuel Tank Config (3)	New Tank Capacity (Gal)	Intermediate Tank Size (Gal)	Transfer Tank at BFS (Gal)
School	Fuel Oil	74,000	118,400	5 – 27,000	135,000	4000 (6)	5,000
City of Kivalina	Fuel Oil	8,000	8,000	1 – 10,000	10,000	4000 (6)	(8)
	Gasoline			1 – 5,000	5000 (1b)		(8)
Store	Gasoline	57,000	60,000	2 – 27,000		1,000 (7)	10,000
				1 – 10,000	64,000		
	Fuel Oil	98,000	104,400	4 – 27,000	108,000		10,000
	Propane	11,800 (4)	11,800 (4)		11,800 (4)		
AVEC	Fuel Oil	145,000	200,000	8 – 27,000			
				1 – 10,000	216,000	N/A	N/A
Armory	Fuel Oil	10,020 (5)	10,020 (5)	1 – 10,000	10,000		
	Gasoline			1 – 5,000	5,000		
DOT & PF	Fuel Oil	3000 (5)	3000 (5)	1 – 3,000	3000		

1. Tryck Nyman Hayes, Inc. bases fuel use projections upon modified numbers for a Kivalina population of 500 with plumbing as stated in the Oct 2003 'Relocation Planning Project' report for Kivalina, Alaska. The numbers were modified as follows:
   a. School: The assumption of 1.13 gallons of heating fuel oil per sq. ft. per year was increased by 30% for the school building to account for increased ventilation rates required by today's building codes. The teacher's quarter's fuel allotments were not increased.
   b. City of Kivalina: Listed in the October 2003 'Relocation Planning Project' report for Kivalina, Alaska by Tryck Nyman Hayes, Inc. as the "Washeteria," it is assumed the City of Kivalina will have either a community center or city office center as well as a washeteria. Therefore, gasoline storage and dispensing capability was added for City vehicles.
2. The October 2003 'Relocation Planning Project' report for Kivalina, Alaska by Tryck Nyman Hayes's ratio of 'existing fuel oil used to existing fuel oil storage' was used to calculate the New Storage Required value.
3. Fuel tank configurations shown optimize the commonly used 27,000-gallon single wall storage tank.
4. Stored in individual 100 lb cylinders.
5. Based upon the existing capacity from the October 2003 'Relocation Planning Project' report for Kivalina, Alaska by Tryck Nyman Hayes, Inc.
6. Connected to and filled from the Bulk Fuel Storage facility via pipeline.
7. Filled manually via vehicle transport of fuel.
8. Combination 5,000-gallon fuel oil and 5,000-gallon gasoline (1 tank).
9. No transfer tank required; storage tank connected directly to dispensing station.

3.2.6.3 Fuel Distribution

All tanks of a common fuel type should be connected through isolation valves to the fuel fill and issue system header and pipelines.

Individually owned and operated duel fuel dispensing stations should be located near the BFS facility for local dispensing of either #1 fuel oil or gasoline. The dispensing stations should be equipped with arctic hose and dispenser nozzles with automatic shut off. Flow should be between 6 and 12 gallons per minute. These metering dispensers may be similar to those found at most gasoline stations on the highway system. Each individual dispensing station should be separately fenced, gated, locked for security, and covered with a roof for protection from the weather.

In the event that a fuel truck delivery system is provided for the village, a high volume pump or metering station should be provided for filling the delivery truck. All dispensed fuel should be pumped from transfer tanks associated with a particular Owner and dispensing station. The transfer tanks should be filled from the Owner's large storage tanks. In the case of Owners with storage tanks of 10,000 gallon capacity or smaller, a separate transfer tank may not be required.

A spill response building containing spill containment devices and cleanup kits can be stored near the BFS facility.

Individual self-priming fuel transfer pumps and distribution pipelines should be provided for the distribution of #1 fuel oil to the school and the City of Kivalina's intermediate storage tanks. The transfer pumps can be sized to transfer fuel at a rate of approximately 60 GPM. These pumps can be protected from running dry by a differential pressure switch and time delay relay control circuit. To control spillage, the pumps can be automatically controlled to run for 10 minutes (approximately 600 gallons) at which time a manual reset will be required for them to run for another 10 minute period. These 10-minute periods should continue until the desired quantity of fuel is transferred.

Individual double-wall intermediate building storage tanks may be provided for larger buildings or groups of buildings such as the school, washeteria, community center and/or City of Kivalina office building(s). Small buildings and private residences may have small individual storage tanks which may be filled manually via private vehicle transportation of fuel from a dispensing station located at the BFS facility.

The intermediate building storage tanks should be provided with three levels of overfill protection:

- Personnel will continuously monitor the level in the tank during filling operations. The tank will be provided with a level gauge, a whistle vent and an amber panel light to indicate when the tank is nearly full.
- Secondary overfill protection is provided via a float activated overfill protection valve with level switch and alarm that will stop the flow of fuel when the tank reaches a predetermined level above full (high alarm).
- A mechanical, float actuated fill shut-off valve provides the third level of overfill protection (high-high level protection).

Bulk fuel storage and distribution requirements for local emergency power generation equipment is not addressed at this time.

3.2.7 Heating

3.2.7.1 Public Facilities

Larger buildings and public facilities may be heated with a hydronic heating system utilizing #1 fuel oil-fired water boilers. Individual buildings should have an exterior double walled intermediate building storage tank and a small double wall interior day tank (approximately 50 to 100 gallons), where a small quantity of fuel is stored for a short period of time before being fed to the boiler. The small interior day tank should be equipped with a level sensor and should automatically transfer fuel from the exterior storage tank as required to keep itself full. Level sensors will detect an abnormally high level of fuel in the day tank and disable the transfer pump to avoid overfilling. The day tanks should also be equipped with overflow piping which directs fuel back to the exterior storage tank. A sensor in the secondary tank can detect primary tank rupture or leakage.

3.2.7.2 Private Residences

Private residences are heated with either a hydronic system utilizing #1 fuel oil fired water boilers or an oil fired hot air furnace system. Individual residences should be provided with small exterior storage tanks that are filled manually by hauling fuel from the BFS facility's dispensing station.

3.2.7.3 Heat Recovery System

Heat from the stationary engine-generator plant can be made available for use in public building hydronic and/or domestic water heating systems, or for use as added heat for freeze protection in the village's potable water distribution system. A heat recovery system could also be used to keep firefighting equipment in service throughout the winter months when tanks are subject to freezing.

In a heat recovery system, rejected heat is recovered from the generator's engine water jackets and/or from an economizer heat exchanger on the engine's exhaust manifold or pipe. This heat is then distributed via a heat exchanger and distribution system to wherever it can be used. Automatic temperature controls on both ends of the system determine when heat can be safely recovered and when it is available for use.

While there is an economic benefit to the recovery of heat, there are costs associated with the installation and maintenance of such a system. Seasonally, more heat becomes available during winter periods when demand for heat goes up. However, the inherently more complex nature of the temperature controls associated with a heat recovery system can render the system ineffective or useless if not maintained properly. An economic cost analysis is required to determine if a heat recovery system is feasible, and the commitment and ability of the system's maintenance personnel must be evaluated.

The heat recovery module should be located near the AVEC facility and within 1,000 feet of the customer connections to reduce heat transfer losses. A metered electrical service to the heat recovery module should be provided via a 240/120-volt single-phase 100 Amp service. The service should include a meter base and exterior disconnect and should be installed per AVEC service standard 93-23. Additionally, one metered 480-volt three-phase service for the electric boiler and one 480-volt three-phase feeder for the AVEC node pump and its controls should be provided. Connection to the services and feeder should be from an AVEC generator/control module and should be coordinated with AVEC.

A main heat recovery control panel provides control for building lighting, receptacles and the AVEC node heat recovery pump. The panel monitors system temperatures and drives the main circulation pump at variable speed proportionally to the electric boiler power. Secondary customer pumps are metered separately and driven via a winter/summer control scheme. Control panels will give visual status indication of pump operation; main pump speed and variable frequency drive fault status. Refer further to the mechanical section of this document for additional information regarding the heat recovery system and heat recovery feasibility.

Energy (BTU) meters are to be installed in the heat recovery module as well as the school. BTU meter data, boiler control data and the heat recovery module's electrical metering data should be used to accurately quantify the energy being consumed, recovered and transferred to customer site(s).

3.2.8 Electricity

3.2.8.1 Generation

Electrical generation facilities should be sized for a modest growth rate of the community, but should not be sized to immediately fill electrical demands for the 25 year growth projection of 949 people. Electrical generation facilities can be expanded as the community grows. For the new community, the facility should be sized for 500 persons living in new housing with plumbing. It is estimated that the electrical need will be 1.9 million kilowatt hours (M kWH) per year. This estimate includes the power usage for private buildings, community buildings, commercial buildings, school buildings, churches, the consolidated Bulk Fuel Storage (BFS) facility and the Alaska Village Electrical Cooperative (AVEC) station power, and allows for additional appliance usage and lighting required for the new village.

AVEC is the electrical supplier for the community and it is anticipated that it will also supply the community with electricity at the new site. A new power generation facility should include fully automatic control panels, individual cooling systems, support enclosures for hot and cold storage, lube oil storage, and living quarters. The facility should be of modular construction elevated on piles above grade in a configuration to reduce snowdrift problems.

An integral part of the AVEC generation facility should be the consolidated BFS facility. The BFS should be located adjacent to the AVEC power generation facility. A preliminary BFS facility layout can be found in the mechanical portion of this document. As discussed in that section, the BFS should feature separate containment areas for AVEC, City of Kivalina, the Northwest Arctic Borough School District (NABSD), the Kivalina store, the National Guard Amory and the ADOT&PF entities. Separate electrical distribution, lighting and fuel dispensers should be included for the separate BFS areas. Operations building(s) may also be provided near the fuel dispensers for conducting day-to-day fueling operations. Further discussion of the electrical systems in the BFS is included under the distribution section.

3.2.8.2 Wind Generation

AVEC has had some success using wind generation to supplement fossil fuel power generation. The potential difficulty of transporting fuel to some of the potential relocation sites makes wind generation an attractive and possibly essential option. It is not known which site location will be most suitable to make wind generation feasible, however the better sites are likely to be Tatchim Isua, Imnakuk Bluff or Kiniktuuraq. The installation of three or four wind generation turbines should be considered. Though most turbines may be connected directly to the power grid, AVEC has employed a means of utilizing turbine power off of the main power grid by connection to an electric boiler. Connection of the turbines to an electric boiler with integration to a heat recovery system allows usage of the off-peak surplus turbine power.

An electric boiler could be provided to produce hot water from the surplus wind generated electrical power. A control panel for the boiler should also be provided. The boiler control panel will allow accurate control of the electric boilers heat output. The boiler control panel can be monitored remotely to obtain energy consumption data.

3.2.8.3 Electrical Distribution

Primary electrical distribution should typically be overhead power lines, but underground lines may be used depending upon certain applications to the site selection. Those sites where substantial well-drained fill is required are best suited for underground utilities. Those sites with in-situ soils and potential permafrost problems are best suited for overhead utilities. Pad–mounted or pole-mounted transformers will convert 3-phase primary voltage to secondary 3-phase and single-phase low voltage (208/120 volts 3-phase or 240/120 volts single phase) for building electrical services. All services will meet AVEC service standards. The service sizes for typical private homes should be 100 or 200 Amp, 240/120 volts single phase and 200 Amp or greater 208/120 volts 3-phase for community buildings, commercial buildings, school buildings and churches. All electrical services should be metered, with demand type metering employed for commercial and larger community buildings.

Pole-mounted light fixtures should be provided for street lighting. High pressure sodium (HPS) fixtures with cutoff optics at 100 or 250-watt sizes will likely be used as these are usually readily should be metered for billing to the appropriate entity.

Electrical service to the BFS site should be provided to the site from the AVEC operations building. A transformer can serve multiple separate 240/120-volt single-phase 100 Amp services. The services include a meter base and exterior disconnect, and should be installed per AVEC service standard 93-23. Electrical power to all devices in the BFS site should be provided by load centers via fuel control panels. Devices in the BFS bulk fuel area include lighting, pumps and controls. A fuel control panel for each entity should be provided. Fuel control panels and load centers will likely be installed inside of an operations building near the fuel dispensers. Branch circuits should be provided for building lighting receptacles and fuel control panels, devices and ventilation. Rough service fluorescent light fixtures with cold weather ballasts should provide for interior lighting.

3.2.8.4 Communications

Because of limitations in delivery methods, primary communications services will be delivered to Kivalina via satellite, as is the case in most isolated Alaska communities. Communications should be distributed in the new village via copper cabling, fiber optic, and cable television.

The copper communications cabling system should be routed from the Kotzebue Telephone Cooperative (OTZ) and ALASCOM to all locations in the community. A minimum total of 2500 pair copper is required for serving the community.

A single mode optical fiber communications cabling system should also be installed. Fiber should be routed from the OTZ and ALASCOM to schools, commercial buildings, and larger community buildings in the community. The higher performance and speed of a fiber connection to these buildings is especially critical for applications such as distance learning programming. A minimum total of 200-strand single mode fiber is required for serving the community.

A cable television distribution system should be provided. Coaxial cabling with necessary distribution components should be routed from the OTZ and ALASCOM to all locations in the community. Optical fiber cabling may also be used instead of, or in additional to, coaxial cabling for transmission of video signals.

As with the electrical distribution, communications distribution can be either overhead or underground (direct bury), depending upon the site selection.

3.2.9 Access

For each alternative, access to the sites must be provided for barge landing and boat landing facilities, which can be connected to the community via a road. The airport, landfill, and other boat access points to the lagoon and rivers can also be on the road system. Without additional geotechnical information, it was assumed that the soil conditions around all sites are similar and the general structural cross section will remain relatively the same, though the length of the road may vary.

With the exception of the existing site of Kivalina, each site should have a gravel staging pad at the lagoon to serve as a haul-out and dry storage area for boats. Ideally, the boat staging area should be on the route from the barge landing to the village.

3.2.9.1 Subsistence Access

As discussed in Section 2.2.1, subsistence activities contribute significantly to the culture and economy of Kivalina. Maintaining traditional access to subsistence areas must be considered in the selection and layout of a new village site. Access to subsistence areas is gained by boats, four-wheeler, snow machine, and on foot.

Water access is critical for the new village. The community is a coastal culture depending on close proximity to the ocean for a large part of their subsistence needs. Water access from the lagoon should allow egress to the rivers to the east and ocean to the west. All sites will need an access route from the village proper to the lagoon for boat moorage and subsequent use of the marine and riverine subsistence environments.

The villagers will require access to the Chukchi Sea, the lagoon, and nearby rivers. The existing village site provides excellent access to the lagoon from the east side of the village, which in turn provides access to the Kivalina and Wulik river channels as well as to the Chukchi Sea. The rivers provide access to inland subsistence areas.

The particular configuration of accesses shall depend on the location of the new village. Individual problems associated with topography, distance and ground type will affect what design criteria and methodologies are employed. Continued access to river entrances from the lagoon should be considered when selecting a new village site. A road from the new village site to the lagoon may be necessary for continued access needs. However, if a road is not developed, the new site could provide continued access to subsistence areas via river access to the lagoon.

3.2.9.2 Bulk Goods and Fuel Access

The community has three main methods of obtaining bulk goods, fuel, and supplies: barge access to the ocean, barge access to the lagoon, and by air. There are two barge deliveries to Kivalina every year, both in the summer.

A barge landing is very simple, consisting only of two concrete deadmen large enough to securely hold the moored barge. To maximize efficient loading and unloading of the barge, a land route into the village to distribute goods must be constructed and maintained, as well as a staging area. The staging area should be at the immediate site of the barge landing to allow temporary storage of loaded and unloaded goods. This should allow the barge to maintain a short turn-around time, and the community to ferry goods into the village at their own pace.

The estimated area for the staging area is one acre. This should allow goods stacked on the barge to be placed on the ground for easy loading and transport to the community.

While landing on the ocean beaches can be acceptable for barge traffic, at times heavy seas make loading and unloading a beached barge very difficult. If an ocean barge landing is selected as a best option, then a breakwater should be constructed to provide protected moorage to ensure the barge's ability to land at the site.

3.2.9.3 Air Transportation

The existing airstrip provides almost daily aircraft access to the village by small planes and some larger propeller-driven, cargo aircraft. All of the village's mail is brought by air. Since barge trips are infrequent, most cargo, such as groceries and personal goods, is brought to the village via air.

Siting of the new airport must take into consideration soil conditions and required depth of gravel, distance from the new village, distance from the landfill, wind conditions, and flight path safety.

Air transportation for the new village, including access to emergency air evacuation, should be through the existing airstrip until a new airport is located, designed and constructed. The master relocation schedule includes construction of the airport prior to the construction of any structures. The new airstrip should be in operation as people move into the village.

The new airstrip should be located within a convenient distance to be driven by four-wheeler/snowmobile during the winter. An airstrip that is located further from a village could result in increased travel and costs associated with getting passengers and freight to and from the airport. In addition, the long distance raises concerns regarding emergent evacuation and access during bad weather. The runway length of 4,000 lf for each site has been taken from the 1998 USACE report. This length should allow a C-130 Hercules aircraft at 130,000 lbs. to take off and land.

The locations of airstrip runways for this report have been obtained from existing literature as much as possible. For several sites, the location of a runway proposed in previous reports can serve more than one of the sites. Access road lengths and routes have been adjusted from the sites to accommodate a single runway location.

3.2.9.4 Road and Streets within the Community

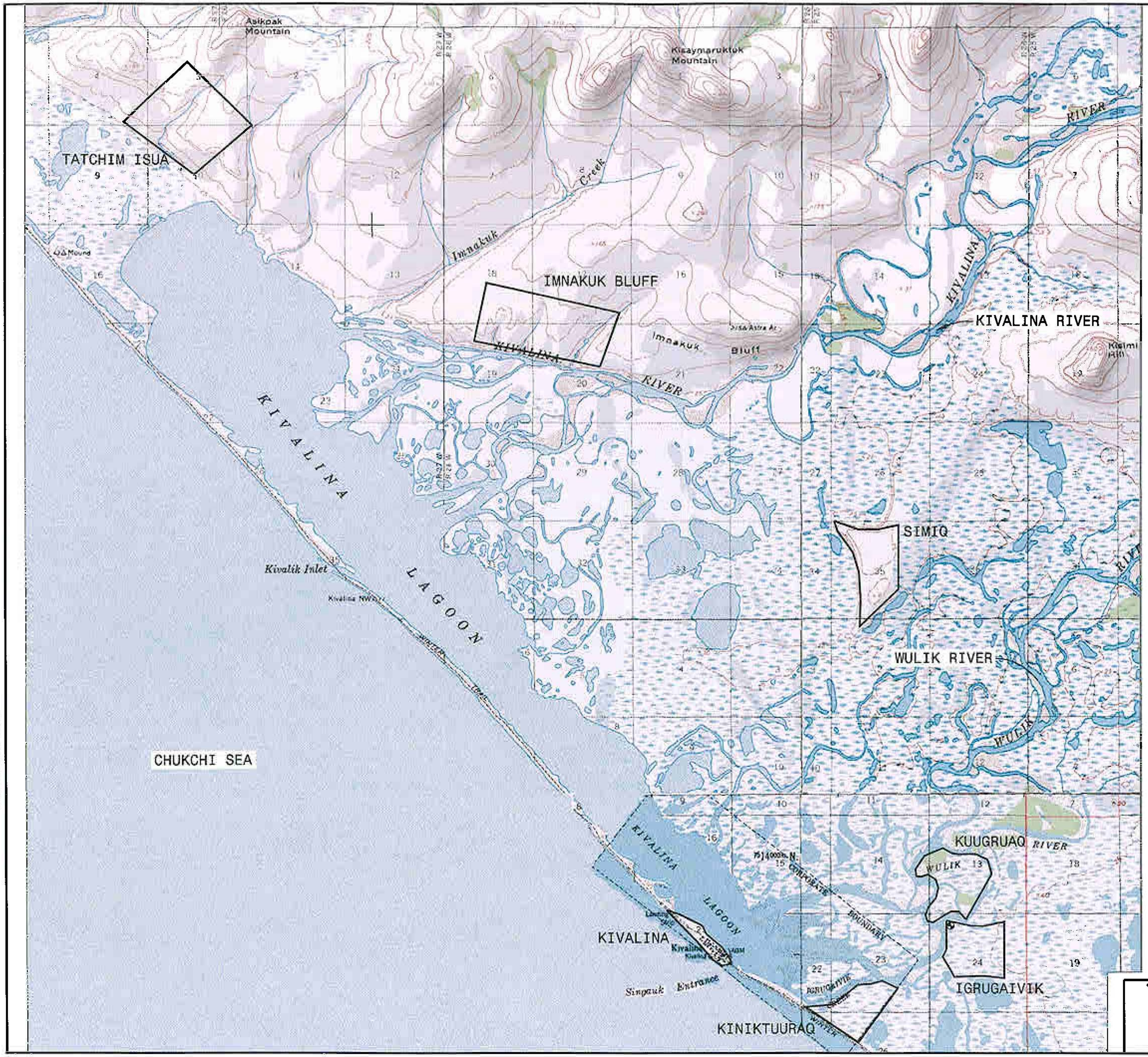
The relocated village layout selected during the Phase I study features a grid type road system (Appendix G). Oriented properly, this type of system is easy to navigate, maintain and provides protection from snow drifting. Since road funding could be obtained through BIA, road design and construction should follow BIA standards of a 20-foot wide road. Other road standards should apply; however, the typical road section is likely to consist of two 8 ft wide lanes flanked by 2 ft shoulders. The road depth will be the thickness of the gravel pad or 5 feet thick, whichever is greater, and side slopes should have a grade of 2:1. This should allow four-wheelers to pass each other side-by-side and share the road with pick-up trucks. The relatively small size of the road should help keep costs down.

All roads associated with the new community, both inside and around the village, should be gravel. No paved roads are planned at this time. Design of the roads should be based on geotechnical recommendations, but a minimum structural roadbed depth of 5 ft is anticipated with the top 6 inches being a crushed surface course to facilitate ease of maintenance.

The actual design of the roadway structural gravel section will depend on the site selected. For sites where the subgrade is composed of silts and clays, a geotextile separation fabric can be used to provide separation and added support to the road prism. The roads should be crowned at 2-3% to drain to each shoulder. Run-off should be carried in roadside ditches to low points where HDPE culverts should be installed to transport the water to main drainage channels, and then off the site.

One problem noted in the existing village that will need to be addressed in the design and maintenance of the roads for the new community is the displacement of gravel caused by high-speed 4-wheeler traffic. A method of controlling four-wheeler speed in the village will need to be developed to ensure the required maintenance to keep the new roads/streets in good shape.

The community has requested fire hydrants to facilitate fire fighting. The hydrants can be located in the street rights of way, and should have a ‘clear zone’ staked around them to preclude placement of private structures that can endanger access during a fire.



LEGEND

RELOCATION SITE

TNH

SCALE: 1 INCH = 1 MILE

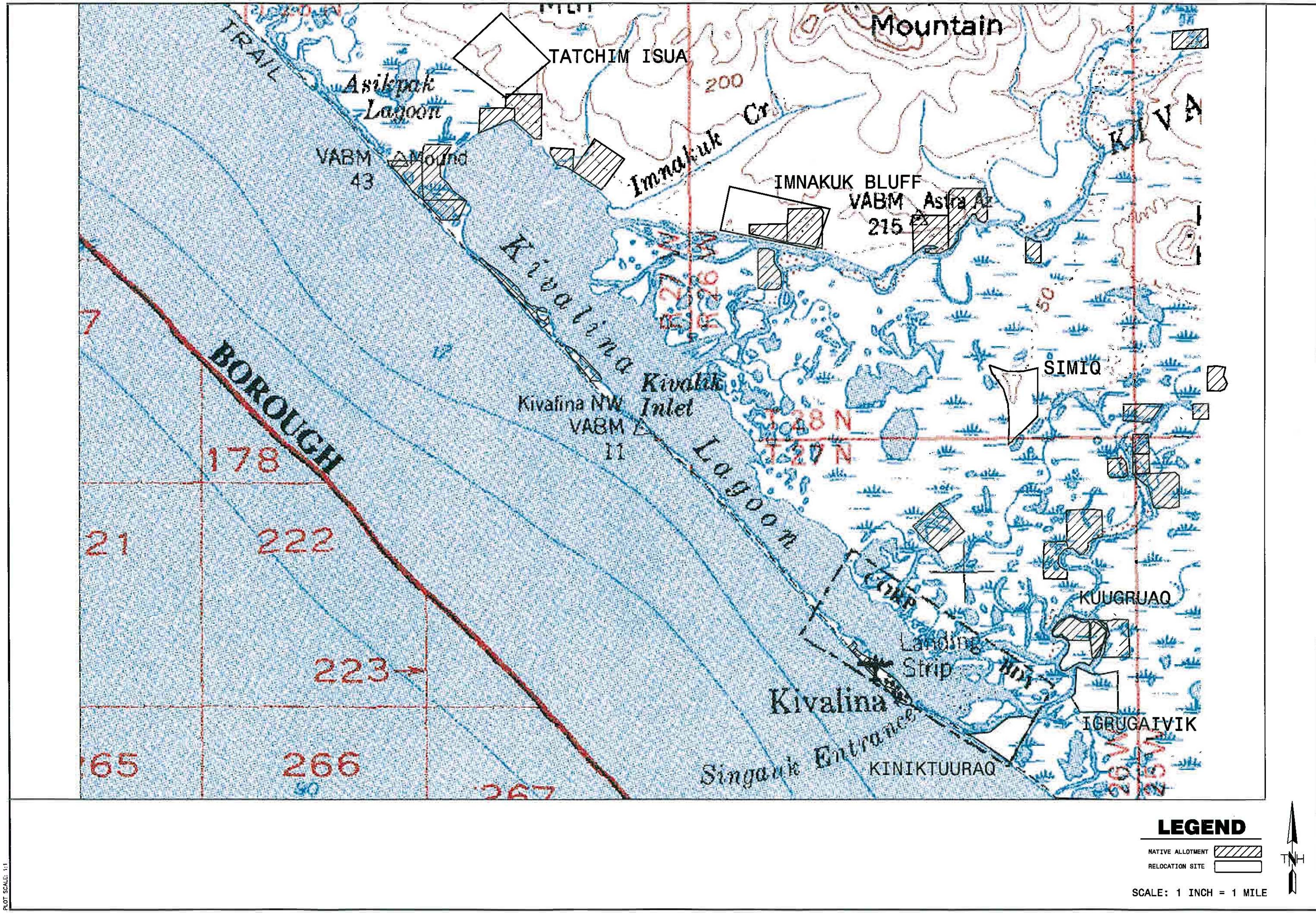
TNH
ENGINEERING/SURVEYING
& LANDSCAPE ARCHITECTURE
Tryck Nyman Hayes, Inc.
911 W. 8TH AVENUE, SUITE 300
ANCHORAGE, AK 99501-3407
TEL: (907) 279-0543 · FAX: (907) 276-7679

FIGURE 1
KIVALINA RELOCATION SITE MAP

SHEET
1 OF 1

FILE NO.
03003.007

DRAWING NAME: 99122V100.DWG
PROJECT No. & LCTN: M:\99XX
LAYER MGR: .LAY
M:\
M:\
M:\



PLOT SCALE: 1:1

KIVALINA VILLAGE
RELOCATION PROJECT

FIGURE 2 RELOCATION MAP

ALL TOPO MAPS ALASKA, IGAGE, 2000
KIVALINA, ALASKA

SHEET 1 OF 1

FILE NAME
KIVALINA_ALLOTMENTS.DWG

ENGINEERING/SURVEYING
& LANDSCAPE ARCHITECTURE
Tryck Nyman Hayes, Inc.

FIELD BOOKS	DESIGNED OFC
DESIGN	DRAWN OFC
STAKING	CHECKED MEW
AS-BUILT	DATE 10/10/05
SCALE	GRID
HOR. AS SHOWN VER.	JOB NO. 03003.007

REV.	DATE	BY	REVISION

GRAPHIC SCALE

8400 0 4200 8400 16800

(IN FEET)
SCALE: 1" = 8400'

▨ NATIVE ALLOMENT

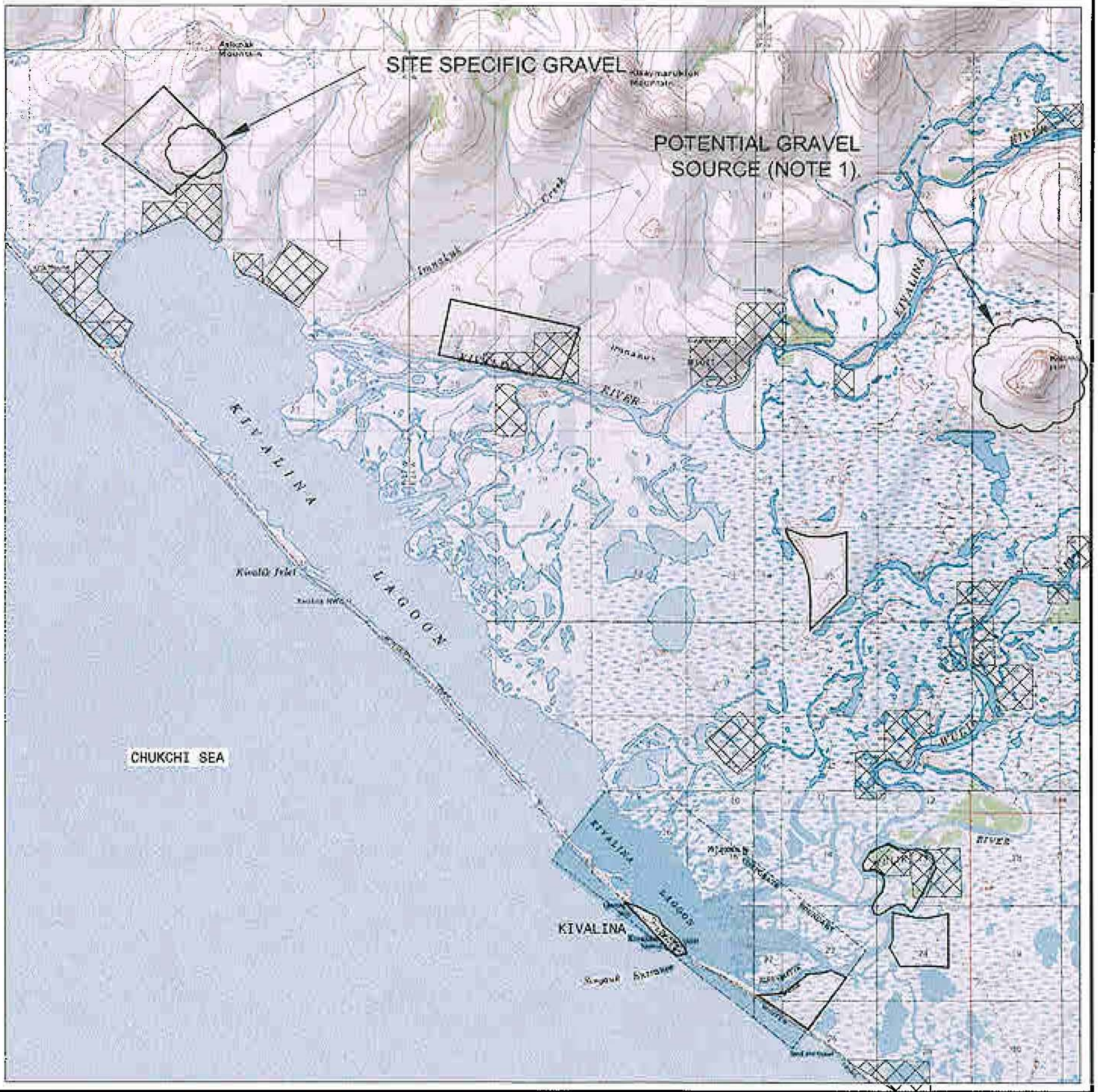
○ POTENTIAL GRAVEL SOURCE

☐ VILLAGE SITES

TNH

NOTES:

1. POTENTIAL GRAVEL FOR ALL SITES EXCEPT TATCHIM ISUA.
2. IT IS ASSUMED THAT LOCAL GRAVEL CAN BE MINED FOR TATCHIM ISUA SITE.
3. VARIOUS LOCATIONS EXIST FOR SMALL QUANTITIES OF GRAVEL TO BE MINED FROM THE WULIK AND KIVALINA RIVERS.



XREF's/IMAGES USED FOR THIS DWG:

PLOTTED: 06/16/06
TIME: 4:32 pm

LAYER MGR: *.lay
CTB FILE: *.ctb

DRAWING NAME:
village site infrastructure maps.dwg

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FIGURE 3

POTENTIAL GRAVEL SOURCE

LOCATIONS TO EXPLORE FOR GRAVEL

DESIGN BY: MEW	DATE: 6/16/06
DRAWN BY: DH	PROJECT No: 03003.007
SCALE: 1" = 8400'	REV. -
CAD DWG FILE: M:\03003.007Kivalina\WRP\Mapping\DrainageBasin	
FIELD BOOK: -	SHEET 1 OF 1
GRID: -	

LEGEND

001 - NOAA WEATHER STATION
002 - AIRPORT WARMUP SHACK
003 - ADOT GARAGE
004 - ADOT STORAGE/SHOP
005 - ABANDONED HOUSE
006 - LOWELL SAGE SR.
007 - ANDREW KOENIG
008 - ANITA HAWLEY
009 - BRENDA NORTON
010 - GARY SWAN
011 - AUSTIN SWAN SR.
012 - MYRA HENRY
013 - STAN HAWLEY
014 - ROY ADAMS SR.
015 - MIDAS KOENIG SR.
016 - EPISCOPAL MISSIONARY HOUSE
017 - BERTHA ADAMS
018 - LARRY ADAMS
019 - LOWELL SAGE JR.
020 - JAMES HAWLEY JR.
021 - FRIENDS CHURCH HOUSE
022 - WILLIE HAWLEY
023 - DOLLY HAWLEY
024 - MARILYN BOOTH
025 - ABNER HAWLEY
026 - ABANDONED/STORAGE
027 - SARAH HAWLEY
028 - SARAH HAWLEY
029 - ROCKY HAWLEY
030 - ROSSWELL STALKER
031 - DENNIS SWAN
032 - ALBERT KOENIG SR.
033 - ORAL HAWLEY
034 - LOUISE L. HAWLEY
035 - LOUISE L. HAWLEY
036 - BERT ADAMS
037 - WILLARD ADAMS SR.
038 - LUKE KOONOOK JR.
039 - JOY KOENIG
040 - JOY KOENIG
041 - STORAGE BUILDING
042 - WILLARD ADAMS SR.
043 - THEODORE BOOTH JR.
044 - RUTH ADAMS
045 - CITY STORAGE BUILDING
046 - CITY CONNEX
047 - CITY RESIDENCE
048 - CITY/IRA OFFICE
049 - BRUCE WESLEY JR.
050 - CHESTER BUNDE
051 - LOUIS WESLEY SR.
052 - POST OFFICE
053 - VICTOR ADAMS JR.
054 - STORAGE
055 - VICTOR ADAMS JR.
056 - ENOCH NORTON
057 - ANNA PEARL KNOX
058 - ENOCH ADAMS SR.
059 - ENOCH ADAMS JR.
060 - JANET MITCHELL
061 - JOE SWAN JR.
062 - FRANCIS SWAN
063 - FRANKLIN KNOX
064 - JOE SWAN SR.
065 - STORAGE
066 - EPISCOPAL CHURCH
067 - STORAGE
068 - JANET MITCHELL
069 - MAY ADAMS
070 - DELLA BOOTH
071 - AVEC FUEL FARM
072 - AVEC POWER PLANT
073 - AVEC STORAGE
074 - BOYS & GIRLS CLUB
075 - OLD COMMUNITY BUILDING
076 - NEW STORAGE TANK
077 - NATIONAL GUARD ARMORY
078 - AVEC POWER PLANT
079 - OLD CLINIC/CITY
080 - NEW CLINIC
081 - ALICE B. SWAN
082 - DOUGLAS SWAN
083 - OTZ TELEPHONE COOP.
084 - ORAN KNOX SR.
085 - JERRY NORTON
086 - CITY RENTAL RESIDENTAL
087 - WINONA CARTER
088 - SMALL WATER STORAGE TANK
089 - DOLLY FOSTER
090 - RUSSELL ADAMS SR.
091 - WATER PLANT STORAGE
092 - ALLEN KNOX
093 - OIL STORAGE TANK
094 - OLD FRIENDS CHURCH
095 - RUSSELL ADAMS SR.
096 - RUSSELL ADAMS JR.
097 - MARIAM NORTON
098 - RAY AND WINONA HAWLEY
099 - MARIAM NORTON
100 - RAYMOND HAWLEY
101 - RAYMOND HAWLEY
102 - WATER PLANT STORAGE
103 - CHERYL SAGE
104 - STORAGE
105 - STORAGE
106 - LOWELL SAGE JR.
107 - MCQUEEN SCHOOL
108 - CHERYL SAGE
109 - FRIENDS PASTOR CABIN
110 - SAMMY BARR
111 - CALEB WESLEY
112 - STORAGE
113 - RAYMOND HAWLEY
114 - TEACHER HOUSING
115 - CLARENCE KENNEDY
116 - CHARLES ADAMS
117 - MIDA SWAN
118 - RICHARD SAGE
119 - SCHOOL STORAGE
120 - SCHOOL SHOP
121 - NATIVE STORE CONNEX
122 - NATIVE STORE STORAGE
123 - NATIVE STORE STORAGE
124 - OLD STORE TANK FARM
125 - TEACHER HOUSING
126 - TEACHER HOUSING
127 - TEACHER HOUSING
128 - KIVALINA NATIVE STORE
129 - OLD STORE TANK FARM
130 - SCHOOL STORAGE
131 - TEACHER HOUSING
132 - TEACHER HOUSING
133 - OSCAR SWAN
134 - OSCAR SWAN
135 - TEACHER HOUSING
136 - OSCAR SWAN
137 - SCHOOL STORAGE
138 - SCHOOL FUEL TANK FARM
139 - TOMMY ADAMS SR.
140 - VILLAGE STORE FUEL DISPENSER
141 - KIVALINA NATIVE STORE TANK FARM
142 - ANDREW BALDWIN SR.
143 - SCHOOL RELOCATABLE
144 - WASHETERIA
145 - SCHOOL DRAINFIELD
146 - CLINIC/WASHETERIA DRAINFIELD
147 - EROSION PROTECTION
148 - OTZ TELEPHONE EQUIPMENT
149 - TEACHER HOUSING
150 - RAW WATER INTAKE
151 - NEW FRIENDS CHURCH

PROPERTY

PUBLIC/COMMUNITY 🟩
INDUSTRIAL 🟦
COMMERCIAL 🟥
RESIDENTIAL 🟨

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)
SCALE: 1" = 100'

PLOT SCALE: 1:1

THE SCHOOL DRAINFIELD, CLINIC DRAINFIELD, SCHOOL RELOCATABLE AND FRANKLIN KNOX BUILDING ARE SHOWN IN APPROXIMATE LOCATION FROM DATA COLLECTED DURING JULY 23-25, 2003 SITE VISIT BY TNH. THE LOCATION OF THE HUD HOUSES WAS PROVIDED BY U.S. ARMY CORPS OF ENGINEERS. HUD HOUSE SIZE WAS MEASURED IN THE FIELD BY TNH ON 7/25/03. MAP LAST UPDATED ON 9/13/04 TO INCLUDE SITE VISIT DURING AUGUST 23-28, 2004 BY TNH.

KIVALINA VILLAGE
RELOCATION PROJECT

FIGURE 4
KIVALINA AERIAL MAP

AERIAL PHOTO TAKEN AUG. 25, 2000
KIVALINA, ALASKA

SHEET 1 OF 1
FILE NAME KIVALINA AERIAL.DWG

TRYCK NYMAN HAYES, INC.
ENGINEERS/PLANNERS/SURVEYORS & LANDSCAPE ARCHITECTS

FIELD BOOKS
DESIGN
STAKING
AS-BUILT
SCALE HOR. VER. AS SHOWN
DESIGNED OFC
DRAWN OFC
CHECKED MEW
DATE 10/10/05
GRID
JOB NO. 03003.007

REV. DATE BY REVISION

3.3 EXISTING SITE – KIVALINA “DO NOTHING”

Evaluation of the existing village site has two alternatives: 1) the ‘Do Nothing’ Option, where the existing conditions are allowed to remain without alteration, and 2) a site modification program, whereby the site is raised to elevate it above the level of the storm surge, the seaward side of the spit is armored against storm wave erosion, and the lagoon side of the spit is armored against further erosion on that side.

The “Do Nothing” alternative will leave the village in the same condition it is currently in. The shoreline will continue to erode, shrinking the village until residents are forced to move or be displaced by the ocean. Residents will almost certainly be forced to abandon the village as the ocean reclaims the barrier island.

The “Do Nothing” option would leave the existing water and wastewater utilities unchanged. The ability of the residents to maintain sanitary and healthy conditions is restricted by a limited supply of water that must be individually hauled to each home. Only the school and clinic have running water and sewer systems. Furthermore, government funding agencies will not fund sanitation projects in quite justified fear that the investment will be destroyed by the village’s exposure to storms, erosion, and flooding.

Clearly the “Do Nothing” option is not a viable alternative for the people of Kivalina. The imminent threat of erosion and flooding, the village’s overcrowding and lack of room to expand, and the health dangers associated with the existing water and sewer systems eliminate the possibility of leaving the village in its current state. Rebuilding the existing site presents problems with funding and infrastructure development and protection. The village of Kivalina should be relocated to a new site for the health and well-being of its population.

3.4 EXISTING SITE – KIVALINA IMPROVEMENTS

3.4.1 Location and Site Description – Kivalina Improvements

See Section 2 for a description of the village location.

3.4.2 Site Development – Kivalina Improvements

Alternatives to make the Kivalina site habitable involve a program of engineered improvements to raise the elevation of the village above the storm surge, install erosion protection and armoring along the seaside of the village, and construct needed grading, sanitation, and building improvements. It should be noted that the existing Kivalina townsite has little potential for community expansion in response to community growth, compared to any of the other sites. Developable land is restricted on three sides by water, and by the airport on the north side of the townsite. There is insufficient land to meet community growth needs at this site.

The high point of the village is at a 10 ft. elevation. To be above the projected storm surge, the village would have to be raised to elevation 16.5 feet. In rough numbers, and assuming that no improvements will be made to elevate the runway, the amount of gravel needed to raise the entire village 6.5 feet would involve an area 1,800 ft long by 600 ft. wide. This includes the area from the runway to the north to Singauk Entrance, as well as filling part of the lagoon. The outside of the spit for the entire perimeter of the village would be armored for about 4,285 lf and would require over 31,000 yards of rock. Twenty-four new homes can then be added.

With the village site raised above the storm surge and the edges armored against wave erosion, a buried utility system could be installed in the village to carry water to every building and convey sewage away to a treatment plant. Utility piping buried below the storm surge elevation would be anchored to prevent floating and constructed of a watertight material to ensure no infiltration occurs.

Placing gravel over an already developed site requires the work to be done in phases. Completing the work in a single construction season requires coordination of gravel delivery and offloading, placement and relocation of buildings. Gravel would be barged to the site, offloaded, and placed concurrently. Gravel deliveries would be spaced out to allow time for the buildings to be moved onto the newly raised gravel section.

Optimally, each building would only be moved once. Raising the village could potentially be done by placing gravel and armor rock from the north to the south in sections. As each section of gravel is installed, the nearby houses can then be moved onto the gravel pad, leaving an area with no structures for installation of the next section of gravel. At the same time, armor rock could be placed along the water edges. This "leapfrog" method of raising the finished grade elevation and moving the buildings would continue to the south end of the site.

However, some buildings in the village are not structurally sound enough to be moved and would need to be replaced. Other structures, such as the water tanks, store, school, and power plant either provide essential services or are too large to move easily. These buildings must be moved or elevated by more complicated means.

The economic implications of moving the existing water tanks must be analyzed. It may be more economically feasible to install a temporary water storage system, dismantle the existing tanks, raise the site, and erect new tanks that would be larger, better insulated and more well-protected.

The same is true for the school. The existing structure was constructed in the mid '70's, and is due for replacement. A local site raising could be performed after the existing school is torn down. The raising and armoring of the existing site should take place over the period of a single summer, so the existing school may not need to remain in service during construction. Since a new school would take more than a single year to construct, a replacement, such as modular units, would have to be installed while the new school is under construction.

It may be possible to raise the existing school and install a new foundation as described above. This would allow the existing school to remain in service while a new school is being constructed. Because of the tight space on the spit, any new school would have to be built on an area raised to the finished grade elevation of the village and extended to the west to add additional buildable land. This process would involve removing the existing teacher housing and replacing it with new, consolidated housing.

The modular units could then be moved and used for other purposes in the village, whether it is housing or public/community buildings.

Immediately after the gravel is placed and the buildings moved onto the new gravel pad, excavation for water and sewer lines in the new pad could begin. A system of water and sewer mains and services could be installed and remain unused until a water treatment system and sewer treatment system could be constructed and connected, probably in the year following the gravel/armor rock placement.

The process of raising the existing village site may require an enormous amount of cooperation, coordination, and funding to ensure a continually efficient construction process.

3.4.3 Infrastructure Development – Kivalina Improvements

3.4.3.1 Water – Kivalina Improvements

A piped water system has been selected for any new town site, including improvements to Kivalina. Based on developing a system in Kivalina, continued use of the Wulik River is proposed as the water source. An infiltration gallery located approximately 2 miles east of Kivalina could be developed to ensure year round water. For a piped distribution system, a year around water source, with storage, treatment plant, and distribution mains are proposed per Section 3.1, Non Site Specific Alternatives. Water mains within the village site could be buried below ground, while water transmission mains from the water source would have to be constructed above ground away from any ice-rich permafrost. Circulation and the addition of heat is required to keep the water lines from freezing.

3.4.3.2 Wastewater – Kivalina Improvements

Improvements to the current site's sanitation facilities are limited by funding restrictions; the U.S. Environmental Protection Agency (EPA) and VSW will not fund any sanitation facilities that cannot be relocated to the new town site. Because piped utilities are being planned for the new town site, a flush and haul system would not be relocated; therefore the EPA and VSW have cancelled existing funds planned for upgrading the existing sewage lagoon to prepare for the installation of a flush and haul system at the existing town site.

Limited space on the island makes it difficult to place a lagoon system. In addition, flooding from storms would affect a lagoon system. Due to space constraints at the village site, this report recommends pretreatment using a package treatment plant, followed by discharged to a buried drain field. An alternative to a drain field is discharging directly to the Chukchi Sea. Sludge could be discharged to a sludge disposal pit located at the landfill. Refer to Section 3.1, Non Site Specific Alternatives for more detailed discussion of each component of the system. Discharging to a buried drain field has been a problem in the past.

The soils consist of sandy soil or beach sand typical of barrier islands in the region. Golder (1997) found the top of the permafrost approximately 12 ft below the surface. A well drilling log (1976) indicates permafrost between 18 and 58 ft. Due to the high permeability of the soil, depth of permafrost, and the failure of currently installed systems serving Kivalina, a subsurface disposal field should not be considered.

USACE (1998) discusses sizing and location of the disposal field. From EPA recommended application rate, the disposal field would be 20,000 sq. ft, or approximately one-half acre. The proposed location of the disposal field would be in the northern half of the proposed new landfill.

3.4.3.3 Solid Waste – Kivalina Improvements

Kivalina's current Class III municipal solid waste landfill does not comply with ADEC or FAA regulations. Specifically, the landfill is located approximately 1,984 feet to the north end of the Kivalina Airport runway. 18 AAC 60.305 requires a minimum 5,000 feet set back limit separating the airport runway end from a municipal solid waste landfill. This close proximity to the runway creates a hazard to aircraft when scavenging birds are attracted to the landfill. Bird strikes are extremely dangerous to aircraft and can quite easily cause an airplane to crash.

Limited space and continued erosion at the existing site makes it impossible to meet the minimum 5,000 feet set back requirement.

3.4.3.4 Fuel – Kivalina Improvements

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6: Fuel applies to all potential sites equally.

3.4.3.5 Heating – Kivalina Improvements

The information in 3.2.7: Heating applies equally to all sites.

3.4.3.6 Electricity – Kivalina Improvements

3.4.3.6.1 Generation

Electricity for the community is supplied by AVEC. Electric usage (2002 statistics) for the existing community was 1.17 M kWH with peak load of 263 kW and an average load of 134 kW at any given hour. The usage numbers are based upon a community of 383 persons without plumbing. The usage numbers include the power for private buildings, community buildings, commercial buildings, school buildings, churches, the community clinic, the National Guard Amory, the community Washeteria and the AVEC station power.

Presently, AVEC serves the community with three generators: 229 kW, 203 kW, and 271 kW. The Washeteria also has its own 12 kW backup generator. A fourth 337 kW generator is currently not being used for power generation and is in need of replacement. Of the three other generators on line, the 229 kW is the newest and was installed in 1996. The 229 kW generator has clocked about 33,000 hours; typical retirement time for generator drivers has been 100,000 hours at best. Extrapolating actual usage hours from the typical retirement time, there are about eight years of life remaining on the newest of the AVEC generators.

3.4.3.6.2 Distribution

Overhead primary distribution is used throughout the community. Pole-mounted transformers convert 3-phase primary voltage to secondary 3-phase and single phase low voltage (208/120 volts 3-phase or 240/120 volts single phase) for building electrical services. All electrical services are metered, with demand type metering used for commercial and larger community buildings.

3.4.4 Access – Kivalina Improvements

The only access to the village is by boat, air, and snow machine (during the winter). There are no roads to the village. Regularly scheduled air transportation service is provided by several small air carriers local to the region.

Access by boat is from the Chukchi Sea. There are no dock facilities at the existing village site. All boats either anchor in the lagoon or the Chukchi sea, or tie up to shoreside deadmen.

3.4.4.1 Access for Subsistence Activities – Kivalina Improvements

The community has immediate access to the sea and all points inside the lagoon by boat. Singauk Inlet at the South end of the village spit affords a passage between the lagoon and the sea. Generally rougher waves on the sea side of the village make tying up in the lagoon the safer choice.

The lagoon is the main access to the Kivalina river to the north of the village and the Wulik River immediately south of the site. The lagoon itself is approximately 14 miles long and an average of 1 mile wide. Since the lagoon fronts the entire length of the existing village, direct access is available to all members of the community.

3.4.4.2 Goods & Supplies – Kivalina Improvements

All goods and supplies, including bulk fuel, are brought into the village by barge or aircraft. During the summer months when the sea is ice free, shallow draft barges can access the lagoon through Singauk Inlet and offload cargo in the relatively protected saltwater inlet. Vessels with too deep a draft to enter the inlet can tie up on the shore near the village. The seaside mooring is exposed to the wind, waves and storms off the Chukchi Sea, so delivery that must be made to this side is weather dependent. All cargo off loaded can be taken directly into the village, which fronts the barge mooring area.

Barge service for goods and bulk fuel is delivered once a year during the summer.

Small packages and mail are brought in daily by air. The airstrip also serves as a means of emergency evacuation in case of illness or injury. During periods of fuel shortages, fuel has been flown into the community.

3.4.4.3 Air Transportation – Kivalina Improvements

The village has a 3,300 ft long gravel runway, maintained by the ADOT&PF, at the immediate north end of the village. The runway's location is convenient, but it restricts expansion of the village. Currently, the runway is in violation of FAA regulations as it abuts the existing solid waste dumpsite to the north without the required 5,000 feet distance between the two facilities. There is no immediate solution to this problem.

3.4.4.4 Roads & Streets within Community – Kivalina Improvements

The road layout within the community is essentially an 'oval,' with two roads running parallel to each other at the third points of the width of the village. These roads are joined at the south end by a curved gravel trail that has become banked as years of four-wheeler traffic has pushed the loose sands and gravels to the outside of the turn. The rest of the roads have no distinct layout and were formed as residents simply took the shortest path to their destination.

3.4.4.5 Roads Outside the Community – Kivalina Improvements

There are no roads outside the community. There is a trail that is an extension of the North end of the gravel runway that provides access to the solid waste dump site. Beyond that there are primitive four-wheeler trails that allow access to the north end of the lagoon and points beyond.

3.4.5 Native Allotments

There are no Native allotments in the vicinity of the existing townsite (see Figure 2). Expansion of the existing Kivalina townsite is not constrained by Native Allotments.

3.4.6 Site Costs – Kivalina Improvements

A construction cost estimate to redevelop the existing site has been prepared. Design and construction administration are not included in the costs. The estimate includes adding fill to the entire village site, adding erosion projection, creating new fill sections for immediate growth, and adding infrastructure similar to the proposed relocation sites. The cost estimate to rebuild Kivalina within the existing site is **$196.2 million.** Detailed costs are included in Appendix A. A summary is included below:

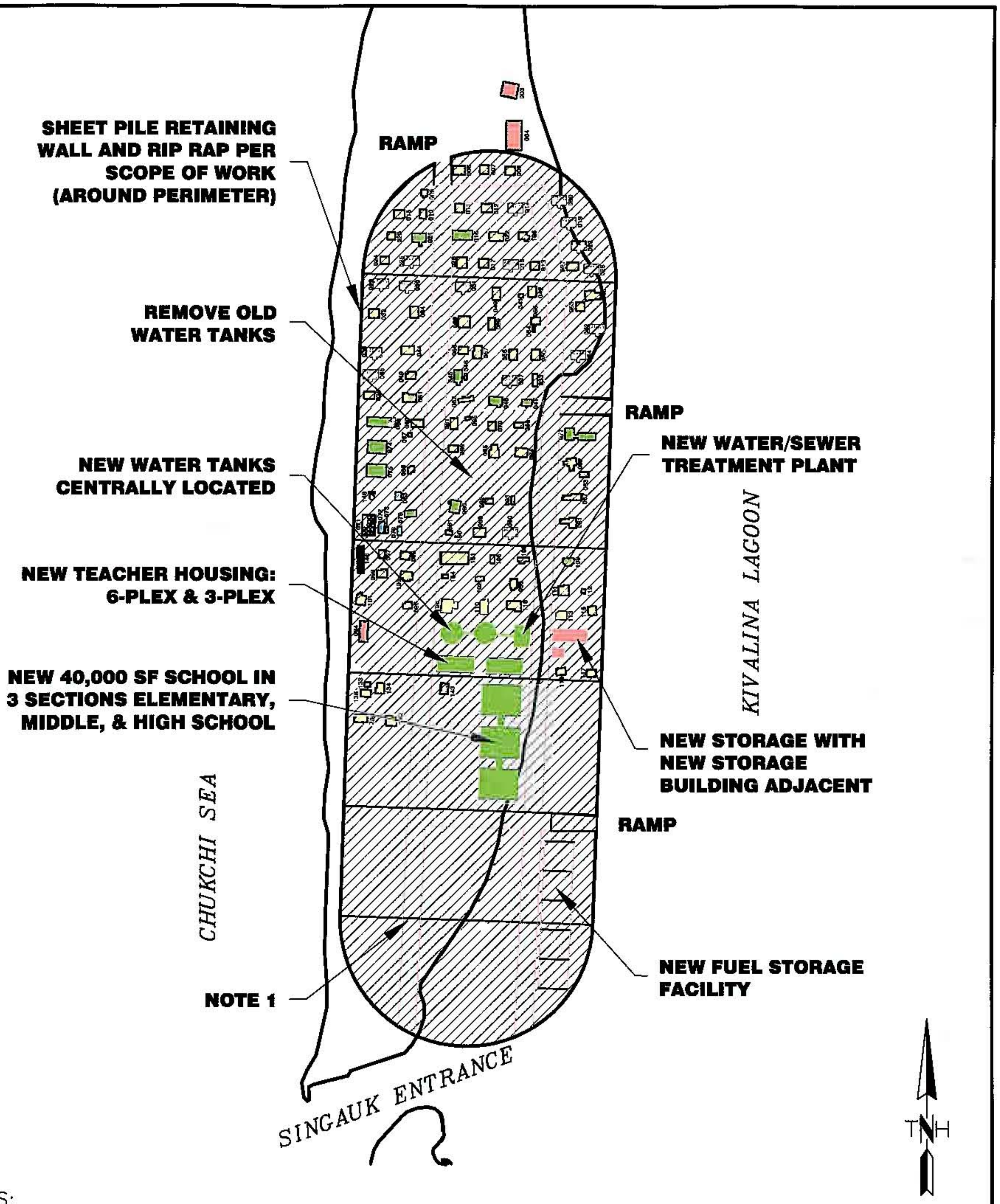
Site work and Airport Construction	$109,600,000
Erosion Protection	$7,151,550
Construction Camp	$902,670
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$19,473,814
Transportation System	N/A
Total Cost	**$196,200,000**

XREF's/IMAGES USED FOR THIS DWG:

PLOTTED: 06/19/06 TIME: 5:05 pm

LAYER MGR: *.lay CTB FILE: *.ctb

DRAWING NAME: KIVALINA Improvements.dwg



NOTES:
1. PHASED CONSTRUCTION TO ALLOW BUILDINGS TO BE MOVED TO NEW FILL SECTIONS.

GRAPHIC SCALE

250 0 175 250 500

(IN FEET)
SCALE: 1" = 500'

ENGINEERING/SURVEYING & LANDSCAPE ARCHITECTURE
TRYCK NYMAN HAYES, INC.
911 W. 8TH AVENUE, SUITE 300
ANCHORAGE, AK 99501-3497
TEL: (907)279-0543 • FAX: (907)276-7679

Figure 5

KIVALINA IMPROVEMENTS

DESIGN BY: MEW	DATE: 6/16/06
DRAWN BY: RH	PROJECT No: 03003.007
SCALE: 1" = 500'	REV. –
CAD DWG FILE:	
FIELD BOOK: –	SHEET 1 OF 1
GRID: –	

Simiq, Photo 1

View NE from E edge of Simiq site

Simiq, Photo 2

Looking E from Simiq landing site

Simiq, Photo 3

View of pond SE of landing site at Simiq

Simiq, Photo 4

View of Kivalina from Simiq site

Simiq, Photo 5

Wet drainage swale on E side of Simiq site

Simiq, Photo 6

Aerial view of Simiq site

KIVALINA VILLAGE
RELOCATION PROJECT

FIGURE 6 SIMIQ

PHOTOS BY TRYCK NYMAN HAYES, INC., AUGUST 24, 2004
KIVALINA, ALASKA

SHEET 1 OF 1

FILE NAME KIVALINA_SIMIQ.DWG

ENGINEERING/SURVEYING & LANDSCAPE ARCHITECTURE
Tryck Nyman Hayes, Inc.

FIELD BOOKS		DESIGNED	OFC
DESIGN		DRAWN	OFC
STAKING		CHECKED	MEW
AS-BUILT		DATE	10/10/05
SCALE		GRID	
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VER.			

REV.	DATE	BY	REVISION

PLOT SCALE: 1:1

3.5 SIMIQ

3.5.1 Location and Site Description – Simiq

The Simiq site is located approximately 4 miles north-northeast of the existing village and 2.5 miles north-northeast of the west side of the lagoon, over muskeg terrain. The maximum extents of the elevated portions of the site are ½ mile wide in the east-west direction and between ¾ and 1 mile long in the north-south direction. The site is raised above the tundra pond terrain to the west by about 20 ft. Its highest elevation is in the approximate center of the site about 200 yards from the west shoulder. The site grade tapers off in all directions from this area at slopes of less than 5%. To the west and southwest, the gradual slope extends for several hundred yards.

The north and west sides of the site terminate into bluffs that drop off a maximum of 30 ft and 20 ft, respectively. The west face of the site tapers from the middle to each end, blending into the tundra pond/muskeg very gradually. The north face of the site is shorter than the west face, with a slope that drops off to the muskeg below at approximately 45 degrees.

Reference the geotechnical portions of this report for the composition and temperatures of the site soils.

The site is covered in low tundra growth characterized by sedges, scrub alder, and Arctic Willow. Berries, such as crowberries, blueberries and cranberries, along with tundra flowers and arctic cotton grass can also be found in the tundra. There are no trees on the site, and the scrub willows and alders are located only on the north and west faces.

The site is wet between the tundra grass tussocks and has small tundra ponds at the edges. Walking is difficult. Preliminary investigations show frozen ground at a depth of 3 inches with ice from 1.5 feet to at least 25 feet in depth. The active layer of the site is composed of saturated plastic silts with no sand or gravel.

Drainage of the site is facilitated by little infiltration into the saturated subsoils and micro-channel flow around tussocks to major drainage swales on the west and north sides of the site. These existing channels are shallow and do not extend into the site more than 50 feet from the swale..

The location of the Simiq site, inland from the lagoon, places it far enough away from the Chukchi Sea so that watching for whales from the site will not be possible, in spite of being higher than the surrounding terrain.

3.5.2 Site Development – Simiq

Reference the geotechnical report regarding the depth of gravel recommended to maintain the thermal regime of the site after development. The depth of fill applied to the site is determined by maintenance of the existing frozen thermal regime. Appendix G shows a conceptual layout of infrastructure.

The fill depth should be a minimum of 9 ft, and deeper in those areas called for by grading. Reference Section 3 for a discussion of gravel depth determination criteria.

Grading should maximize the utilization of swales and roadside ditching as much as possible. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

General site grades should be kept to the minimum 2% on undeveloped (soil) surfaces as much as possible, and less than the minimum slopes that promote scour and erosion for the soils used. Pipe grades should be the minimum 1%. Storm drainage outfalls should be rock-lined to prevent erosion .

3.5.2.1 Construction Considerations – Simiq

Initial geotechnical investigations of Simiq assume that the site is underlain by highly thaw-unstable permafrost. Ongoing follow-up geotechnical investigations may change the assessment.

Based on thaw unstable conditions, construction considerations for the site should consider the presence of thaw-unstable, ice-rich fine-grained materials. Significant settlement should be expected if thawing occurs.

For a site with these conditions, R&M (2000 & 2002) and Shannon and Wilson (2004) suggest the use of pile foundations or a granular fill pad with a post-on-pad foundation to protect from settlement due to thawing of ice-rich soil. Post-on-pad foundations are for areas with little or no massive ice, and require periodic leveling. Another option would be insulated and/or refrigerated shallow foundations; however this method is generally not used for ice-rich conditions and maintenance cost could be very high.

Embankments for roads and runways will also need to be protected from settlement due to permafrost degradation. An estimated embankment thickness of 9 feet should reduce the depth of thaw penetration into the ice-rich soil to nearly zero. Rigid board insulation or allowing for some settlement can reduce embankment thickness. The settlement would occur mostly within the first few years of service. Culverts beneath the embankments are expected to settle due to permafrost degradation, and may need to be re-leveled periodically during the first few years of service. Insulation beneath the culverts may reduce the magnitude of settlement.

Direct bury of settlement-sensitive gravity, pressure, or vacuum sewer systems might be risky due to the settlement potential. Unless the thermal impacts to the permafrost can be minimized by the design, utilities might have to be located above ground.

3.5.3 □ Infrastructure Development – Simiq

3.5.3.1 Water – Simiq

The closest feasible surface water source to Simiq would be either the Kivalina or Wulik Rivers. TNH visited two ponds adjacent to the west and northeast of the site (in August 2004). The ponds are approximately 11 and 3 acres in size, respectively. Neither appeared to be capable of use as a year-round water supply. Ponds along the southeast side of the Simiq site were not visited, however, they are similar in size to the west and northeast ponds. Ponds in the area typically freeze to the bottom in winter (DOWL 1994).

Simiq is centrally located between the two rivers. Piping distances of 1-1/2 to 2 miles would be required to access either of these sources.

If a surface water source from one of the rivers were used for Simiq, a collection, treatment, and distribution arrangement similar to the existing Kivalina site would be required. Water would be withdrawn through a hose and pipe transmission line placed in the river and pumped to a raw water storage tank (RWST). If the rivers could be tapped with an infiltration gallery year round, the transmission line would have to be heated with a glycol loop to avoid freezing.

Due to the potential for massive ice wedges and unstable thaw conditions, an underground distribution system is likely not feasible at the Simiq site (S&W 2004). If an aboveground distribution system were used, continuous grade adjustments would be needed.

3.5.3.2 Wastewater – Simiq

Simiq has a slope of less than 5%, and appears to have ice-rich permafrost. The gentle slope of the terrain would allow for a gravity collection system for wastewater disposal. The ice-rich permafrost soils would limit the design to an aboveground arctic pipe system. A pump station located at the base of the slope could collect all the wastewater if needed. A naturally-occurring tundra pond could be used for wastewater disposal.

3.5.3.3 Solid Waste – Simiq

The potential village site is a high point in a swampy area. The land surrounding the site is lower by as much as 50 feet. Based on an August 2004 site visit, there is no location readily suitable for a solid waste site within 2 miles of the potential village site at Simiq. To reach potential solid waste sites to the northeast or east of the site, additional roads of one or more miles would have to be constructed. No nearby gravel source is present, and the very poor soils in the Simiq area would require import of gravel to build roads.

All the land around the site is low enough to be affected by floodwaters of the 100 and 500-year floods. Any solid waste dump located northeast or east of the Simiq site would need to be constructed so that the possibility of flooding is eliminated.

3.5.3.4 Fuel – Simiq

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies to all potential sites equally.

3.5.3.5 Heating – Simiq

The information in 3.2.7 Heating applies equally to all sites.

3.5.3.6 Electricity – Simiq

The information in 3.2.8 Electricity applies equally to all sites.

3.5.4 Access – Simiq

Road access to the Simiq site from the lagoon may entail construction of a road approximately 3.5 miles long over muskeg type soils from the west side of the lagoon. This road would allow access from the village to boats moored in the lagoon, and from a barge landing on the lagoon to the village.

There is no regular trail access to the Simiq site. Community members questioned about access indicated that a trip from the lagoon to the site takes about a day via four-wheeler due to the poor conditions of the terrain.

Road prism size for an access road from the lagoon to the site would be approximately 5 ft tall at the shoulders with 2:1 side slopes and have a volume of 6.7 cubic yards of material per lineal foot of road length. In addition, a staging pad having an area of approximately one acre may be required at the barge-mooring site. With a gravel depth of 5 ft, this would require an additional 8,800 cubic yards of gravel over geotextile fabric. Regrading of the roads may be required since some thawing of permafrost is anticipated with embankment depths of less than 9 feet.

3.5.4.1 Access for Subsistence Activities – Simiq

The Simiq site has no direct access to the Chukchi Sea. All sea access should be by road to the lagoon and then by boat across the lagoon, out the Singauk Inlet to reach the sea. All equipment needed for marine subsistence activities, all game obtained, and equipment to be stored may need to be hauled across the village access road to the lagoon. The 3.5-mile road distance could make hauling larger items, such as boat engines and small boats needing repair, difficult with the existing vehicles available in the village.

The location of the site, inland from the lagoon, places it far enough away from the Chukchi Sea so that watching for whales from the site will not be possible, in spite of the elevation being above the surrounding terrain.

The nearest point on a river to the site is a northerly loop of the Wulik River approximately 1.2 miles south of the southern edge of the site. No direct access to any river is planned. Access to all rivers is to be gained from the lagoon.

Beach access may be difficult from the Simiq site. To access beaches north or south of Singauk Inlet, a resident may have to traverse the lagoon access road and take a small boat across the lagoon.

Winter travel by snowmobile should be much easier; as the community members can drive anywhere the ice is thick enough to support the vehicle.

3.5.4.2 Goods & Supplies – Simiq

The main source of goods and supplies for the new village should be by barge. A new barge landing and access road will need to be designed and constructed on the beach on the west side of the lagoon, approximately two miles northwest of the current town site. An access road crossing the lagoon would require culverts placed within the lagoon. Supplies would then need to be transported approximately four miles overland from the barge landing site to the new village site.

Goods and supplies can also be transported to the village via the airstrip, the location of which is discussed in the following section.

3.5.4.3 Air Transportation – Simiq

For the purposes of this study, we have selected a possible airstrip location approximately 5,000 feet southeast of the village. This site would require a road of approximately 6,500 feet, along which the Additional information will be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. For the purposes of this study, we have selected a location approximately 1 mile east of the site on a low ridge. A new airport should be constructed prior to occupancy of the new village site. Refer to Section 3.1 for general recommendations.

3.5.4.4 Roads and Streets within Community – Simiq

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

The thermal regime described in the geotechnical report for the Simiq site may require a gravel pad a minimum of 9 feet thick.

3.5.4.5 Roads Outside the Community – Simiq

The location of the Simiq site and the soil conditions of the surrounding terrain make road construction difficult and expensive. The very poor soils in the area of the Simiq site preclude any specific development of roads outside the village except to access the airstrip and solid waste site. It is anticipated that there should be as few roads as possible outside the village to access the new airstrip, the solid waste facility, and the lagoon boat moorage area. To reduce the amount of road development necessary, two or more of these facilities should be located along the same road.

We have routed two roads connecting the village site to the barge landing and the runway. The barge access road should be 3.5 miles long and extend to the west from the site. The runway access road should be 1 mile long and extend to the east from the site.

3.5.5 Native Allotments

There are no Native allotments in the vicinity of the Simiq townsite (see Figure 5). However, there are two Native allotments along the Wulik River near a potential airport site. Siting of an airport at this site should be able to avoid the Native allotments.

3.5.6 Relocation Costs – Simiq

Design and construction administration are not included in the following construction cost estimate for relocation to Simiq. The cost estimate to build a new village site at Simiq is **$251.5 million**. Detailed costs are included in Appendix A. A summary is included below:

Site work and Airport Construction	$167,400,000
Erosion Protection	$231,000
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$21,119,261
Transportation System	$3,056,000
Total Cost	**$251,500,000**

3.5.7 Recommended Plan for Simiq

The Simiq site is located the greatest distance from the Chukchi Sea and the lagoon. This means the Simiq access road will be one of the longest out of the six mainland sites, along with that of the Kuugruaq site. The access road should be around 3.5 miles long over the lagoon and over muskeg that does not provide adequate support for the gravel road prism. Geotextile fabric should be placed in order to support the gravel road base. Even with this addition, the stability of the road may not be good.

The barge landing and should be established on the east side of the Singauk Entrance at the head of the new village access road. Accessing the village road through the existing Singauk Entrance may require the construction of a directional dike to channel the flow of the Wulik River to prevent it from depositing silt in the entrance and requiring intermittent maintenance dredging.

The area to be investigated for the runway to serve the Simiq site is located approximately 1 mile east of the town site along the lower slopes of Klaimigiuktuk Mountain. It is anticipated that this area should provide better subgrade on which to base the 150 ft X 4,000 ft runway. Locating the runway here should provide a better base, but necessitate an additional mile of access road.

Raw water for the Simiq site will most likely come from the Kivalina River approximately 2 miles to the northwest of the new village site. A surface water intake and gravel sump may need to be developed in the river at a depth that will provide year round water and avoid freeze-up during the winter.

Our recommendation for the siting of the landfill for Simiq is close to the village on the west side of the site. This side of the town site is lower than the site itself. A location close to the village should ensure that solid waste makes it to the landfill, and this area should provide some protection from the winds. By placing the landfill on the west side of the town site, access to haul recyclable materials, batteries, and hazmat to the barge landing for shipping out of the area should be easier. In addition, this location will place the village between the landfill and the runway, and ensure a minimum of 10,000 ft between the landfill and runway.

Siting the sewage lagoon to the northwest of the village site should provide excellent separation between the wastewater treatment unit and raw water intake site. Discharge of the treated effluent into the surrounding muskeg should increase treatment in a 'bioswale' type environment.

XREF's/IMAGES USED FOR THIS DWG:

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TIME: 4:15 pm

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CTB FILE: *.ctb

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village site infrastructure maps.dwg

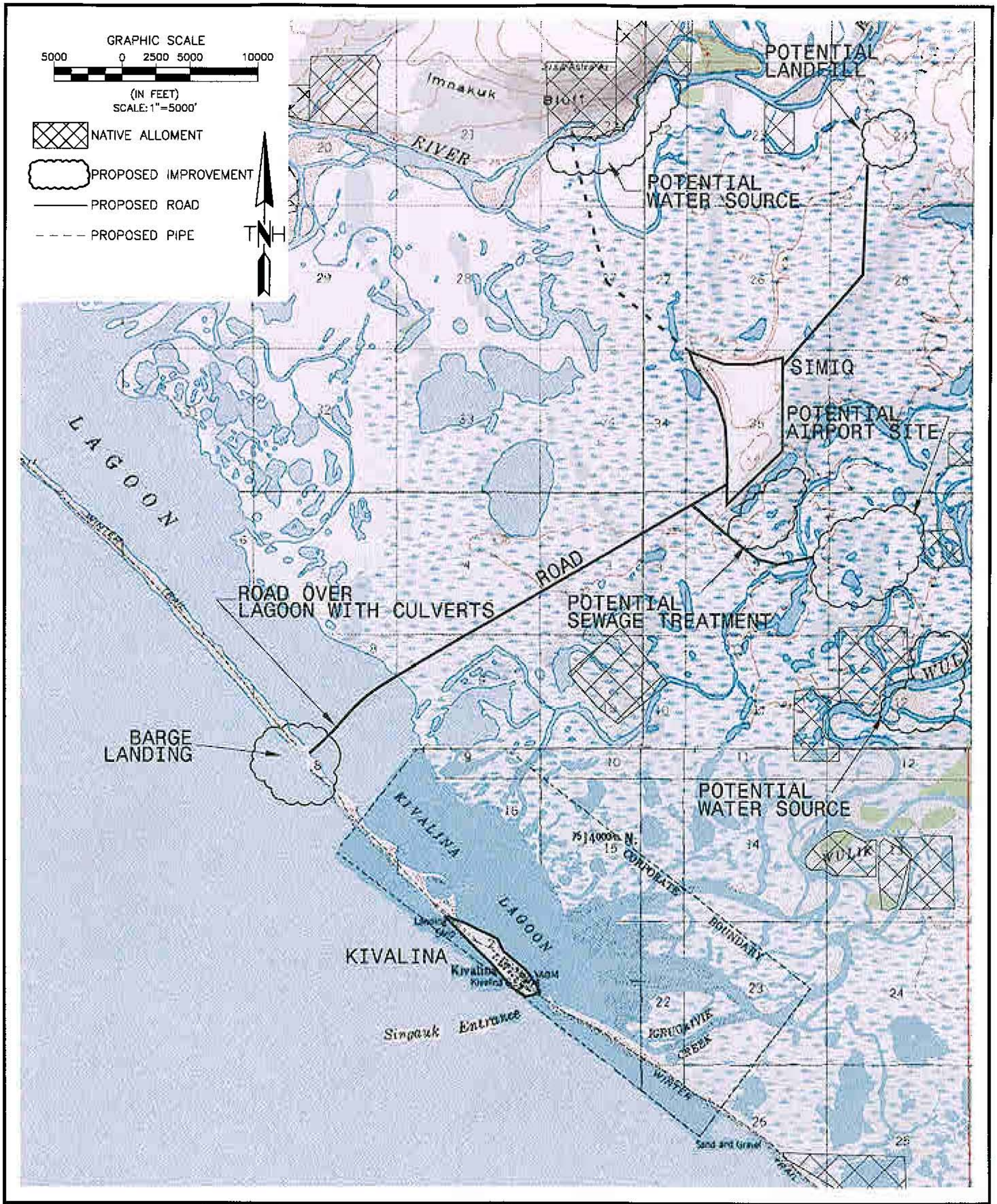

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Figure 7

SIMIQ CONCEPTUAL LAYOUT

DESIGN BY: MEW	DATE: 6/16/06
DRAWN BY: JT	PROJECT No: 03003.007
SCALE: 1" = 5000'	REV. –
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FIELD BOOK: –	SHEET 1 OF 1
GRID: –	

Imnakuk Bluff, Photo 1

View S showing stream channel emptying into River

Imnakuk Bluff, Photo 4

Limestone gravel at face at stream channel

Imnakuk Bluff, Photo 2

View N showing pond in stream channel

Imnakuk Bluff, Photo 5

View N on Imnakuk Bluff

Imnakuk Bluff, Photo 3

View downstream from Imnakuk Bluff at landing site, note shallow water depth

Imnakuk Bluff, Photo 6

Aerial view of Imnakuk Bluff area

PLOT SCALE: 1:1

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KIVALINA VILLAGE
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FIGURE 8 IMNAKUK BLUFF

PHOTOS BY TRYCK NYMAN HAYES, INC., AUGUST 25, 2004
KIVALINA, ALASKA

SHEET 1 of 1

FILE NAME KIVALINA_IMNAKUK_BLUFF.DWG

3.6 IMNAKUK BLUFF

3.6.1 Location and Site Description – Imnakuk Bluff

The Imnakuk Bluff site lies on the north side of the Kivalina River, approximately 1.5 miles east of the river's mouth. The west end of the site is 2.6 miles northeast of the Chukchi Sea and the southeast corner of the site is situated about 5.5 miles north-northeast of the existing village. It is a parcel of land 1.5 miles long by ½ mile wide, with its long axis lying parallel to the river, and its south boundary at the river.

A steep, 50 ft high bluff face that drops off to the river below characterizes the site. From the shoulder of the bluff, the site slopes upward to the north between 5-8% grade along a distance over a mile.

The soils near the shoulder of the bluff are more dry and stable than those 200+ ft north of the slope where wet, muskeg soils begin and extend beyond the north limits of the site. Reference the Geotechnical Report for a more in-depth description of the site soils.

Muskeg plants and other low arctic flora such as arctic cotton; moss, sedges, berries and grasses make up the bulk of the ground cover to within 200+ ft of the bluff. From the bluff to the north, the drier, more gravelly soils support a sparser growth of ground cover of predominantly Arctic Willow. Few scrub alder and willow bushes grow in protected depressions in the terrain.

The USACE (1998) report indicates that local residents knowledgeable about the Imnakuk Bluff site indicate winter winds can be a severe constraint to community comfort.

A stream cuts through the site, flowing north-south, about 1/3 the distance from the east boundary. This stream may provide an outlet for sewage provided it can be treated sufficiently to meet ADEC discharge standards and a permit can be obtained.

One characteristic of Imnakuk Bluff that raises safety concerns are the bluffs dropping off to the Kivalina River on the south side of the site. This presents a hazard to both vehicle and pedestrian traffic. Any design for a village at this site should require safety fencing along the top of the bluffs.

3.6.2 Site Development – Imnakuk Bluff

Reference the geotechnical report regarding the depth of gravel recommended for maintaining the thermal regime of the site after development. The depth of fill applied to the site is determined by maintenance of the existing frozen thermal regime.

The fill depth over this site will vary depending on the type of subgrade soil it is placed on. Test holes showed permafrost at the surface at this site, therefore we anticipate that fill will be a minimum of 9 ft.

Grading should maximize the utilization of swales and roadside ditching as much as possible. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

General site grades should be kept to the minimum of 2% on undeveloped (soil) surfaces as much as practicable, and less than the minimum slopes that promote scour and erosion for the soils used. Pipe grades should be a minimum of 1%. Storm drainage outfalls should be rock lined to prevent erosion and heated to maintain open flows during the colder spring nights.

Imnakuk Bluffs has native allotments on the site. The presence of native allotments presents site control issues that must be resolved prior to selection of development of this site.

3.6.2.1 Construction Considerations – Imnakuk Bluff

S&W (2005) states that soils consist of ice-rich permafrost. Residential structures could be founded on post-and-pad or pile foundations.

3.6.3 Infrastructure Development – Imnakuk Bluff

3.6.3.1 Water – Imnakuk Bluff

Based upon the water resource study (Appendix H), a surface water source is proposed for Imnakuk Bluff. For the purposes of this study, the Kivalina River is assumed to be the water source. Geotechnical investigations in 2005 (S&W 2005) showed that Imnakuk is underlain by ice lenses and has ice rich permafrost. Only above ground water and sewer systems can be considered for Imnakuk. Circulation in series among homes and buildings should be considered as a means of applying building heat to keep the system thawed in winter.

3.6.3.2 Wastewater – Imnakuk Bluff

Imnakuk Bluff has a slope between 3% to 7%, and ice-rich permafrost. A gravity collection system and aboveground utilidor would work best at this site.

A sewage lagoon system, located ½ miles south, is proposed for this site. See Section 3.2.4.2.1 on page 43 for details of a 3 cell lagoon system.

S&W (2005) states that sewer utilities would likely be above grade, as the existing solid conditions do not support buried utilities. The sewer mains would need to be constructed with arctic pipe.

Instability related to lagoon construction is an issue. On-site wastewater disposal with a leach field would not be appropriate due to shallow bedrock and frozen ground (S&W, 2004).

3.6.3.3 Solid Waste – Imnakuk Bluff

The site is situated at an elevation approximately 50 ft above the Kivalina River. At this elevation, it is not in any floodplain and the potential for surface water to enter the solid waste site does not appear to be a concern. Any solid waste site located north or east of the village site would be at a higher elevation than the village, and therefore be less susceptible to flooding. The river itself appears to be a flood plain.

Based on the September 2005 site visit, a possible solid waste disposal site could be located 1 to 1 ½ miles east of the site in the land on top of the bluff. The site appears to be high enough in elevation to avoid any flooding and may have natural soils that can be used to build a berm around the site. Additional fill may be required but could likely be obtained from the islands between the braids of the Kivalina River. Permitting of the solid waste site may be difficult as disturbance of anadromous fish habitat may occur during landfill construction and operation (August 2004 site visit).

3.6.3.4 Fuel – Imnakuk Bluff

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies to all potential sites equally.

3.6.3.5 Heating – Imnakuk Bluff

The information in 3.2.7 Heating applies equally to all sites.

3.6.3.6 Electricity – Imnakuk Bluff

The information in 3.2.8 Electricity applies equally to all sites. However, due to the site's exposure to high winds, it may be possible to utilize wind power generation.

3.6.4 Access – Imnakuk Bluff

Road access from the Imnakuk Bluff site to the lagoon may have to extend about 1.8 miles west of the site and cross Imnakuk Creek to access an area where a landing can be constructed. This road should terminate at the east side of the lagoon, making it necessary for a boat trip across the lagoon in order to reach the barrier spit. If a road were to be constructed to the Chukchi Sea beach, it would have to extend approximately 1 more mile across the lagoon.

Access to the Bluffs site by boat may be difficult. During the August site visit, we traveled to the site via a small boat piloted by Joe Swan. Finding a channel to reach the Kivalina River was difficult, and the boat grounded on a sand bar before we were able to locate a landing point. The nearest landing point was about a ½ mile upstream of the portion of the site cut by a small stream.

No barge access up the Kivalina River will be possible without dredging. The high bluffs at the river make landing and unloading a barge nearly impossible. Grades of an access road from the West are also a concern. The slope rises quickly from the lagoon to the top of the site. Road grades should have to be kept to a reasonable slope to ensure winter use is not dangerous. Slopes should be kept to less than 12%.

3.6.4.1 Access for Subsistence Activities – Imnakuk Bluff

Access to the Chukchi Sea for hunting sea mammals and fishing should be through the lagoon or from the Chukchi Sea beach.

The location of the Bluff site, inland from the lagoon, places it far enough away from the Chukchi Sea so that watching for whales from the site will not be possible, in spite of the elevation above the surrounding terrain.

The site provides direct access to the Kivalina River via a couple of foot trails from the site. Access to the village from the Kivalina River may be difficult for most of the length of the site. The high, steep bluffs make moving any game from the river to the new village site complicated. The best river access may be from the village to the lagoon, and from the lagoon to the river via boat.

The Wulik River is at the southern end of the lagoon. Access to this river should be by boat from the boat-staging pad at the end of the road from the new village to the lagoon.

Beach access from the Imnakuk Bluff site should be by boat or road across the lagoon.

Gravel roads from the new village site at Imnakuk Bluffs may be expensive to construct and maintain. The terrain to the west and east is muskeg, wet, ice-rich and poor support for roads. The terrain to the South, across the braided channels of the Kivalina River, is made up of good gravels, but the river channels impose barriers to pedestrian and four-wheeler traffic.

There are two proposed access roads from the village. One is routed 0.7 miles to the northwest to access the proposed runway, the other access road runs East to the proposed barge landing north of the Imnakuk Creek.

3.6.4.2 Goods & Supplies – Imnakuk Bluff

At the barge access site, a 1 acre staging area should be constructed for loading and unloading the barge. This staging area should allow the community to stage the materials and ferry them to the new village.

The exact location for the airstrip is unknown at this time. Additional information will be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. For the purposes of this report and the cost estimate, we have shown the airstrip runway located 0.7 miles northwest of the site as described in the USACE (1998) report.

3.6.4.3 Air Transportation – Imnakuk Bluff

The USACE (1998) report indicates that a 4,000 ft runway could be constructed approximately 0.7 miles west of the proposed community and connected to the new village by a gravel road.

The December 1997 letter from ADOT&PF indicates that ADOT&PF feels that the Imnakuk Bluff site, as described in the 1997 Corps Draft Feasibility Study, would be a good site for a new runway. ADOT&PF several available locations, good elevation and foundation condition options, no flood hazard, reduced potential for foundation degradation and upland and alluvial options for foundation material.

Additional information will be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. Refer to Section 2.1 for general recommendations.

3.6.4.4 Roads & Streets within Community – Imnakuk Bluff

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

The soil conditions of the Imnakuk Bluff site require road prism to be a minimum of 9 feet thick.

It is important to note that the bluff poses a hazard. For the safety of the community, a protective fence along the top of the bluff on the south side of the new village is recommended.

3.6.4.5 Roads Outside the Community – Imnakuk Bluff

The location of the Imnakuk Bluff site and the soil conditions of the surrounding terrain make road construction difficult and expensive. It is anticipated that there will be as few roads as possible outside the village to access the new airstrip, the solid waste facility, sewage lagoons and the lagoon boat moorage area. To reduce the amount of road development necessary, two or more of these facilities should be located along the same road.

3.6.5 □ Native Allotments

There are two Native allotments in the immediate vicinity of the Imnakuk Bluffs site that constrain the layout of a new townsite (see Figure 9). These townsites are located along the eastern half of the proposed townsite. Relocation at this site would likely require resolution of the use of these Native allotments and are a potential constraint to use of this site for relocation. In addition, two additional Native allotments are located to the east of the potential landfill site. These sites can probably be avoided, however if native allotments pose site constraints, the village location could be shifted west to avoid site control issues.

3.6.6 □ Relocation Costs – Imnakuk Bluff

Design and construction administration are not included in the construction cost estimate below. The cost estimate to build a new village site at Imnakuk Bluffs is **$248.7 million.** Detailed costs are included in Appendix A. A summary is included below:

Site Work and Airport Construction	$165,900,000
Erosion Protection	$231,000
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000

Water/Sewer System and Landfill	$19,844,807
Transportation System	$3,056,000
Total Cost	**$248,700,000**

3.6.7 Recommended Plan for Imnakuk Bluff

The Imnakuk Bluffs Site is situated approximately 6.3 miles north-northeast of the existing town site on the north side of the Kivalina River.

The area to be investigated for the runway to serve the Imnakuk Bluffs Site is located approximately 2/3 miles northwest of the town site at the lower slopes of the hills north of the site. It is anticipated that this area should provide a better subgrade on which to base the 150 ft X 4,000 ft runway. The landfill should be sited east of the site to maintain the required 10,000 feet from the runway.

The raw water source for the Imnakuk Bluffs Site has not yet been determined. Two possible raw water sources for this village option are the Kivalina River and Imnakuk Creek. Both of these potential sources are being investigated in the current water resource investigation project (2006-2007).

The landfill should be located along the access road from the barge landing to facilitate ease of transporting recyclable materials and the barge landing for shipping.

The sewage lagoon should be located below the town site on the south side, along the road to Kivalina Lagoon.

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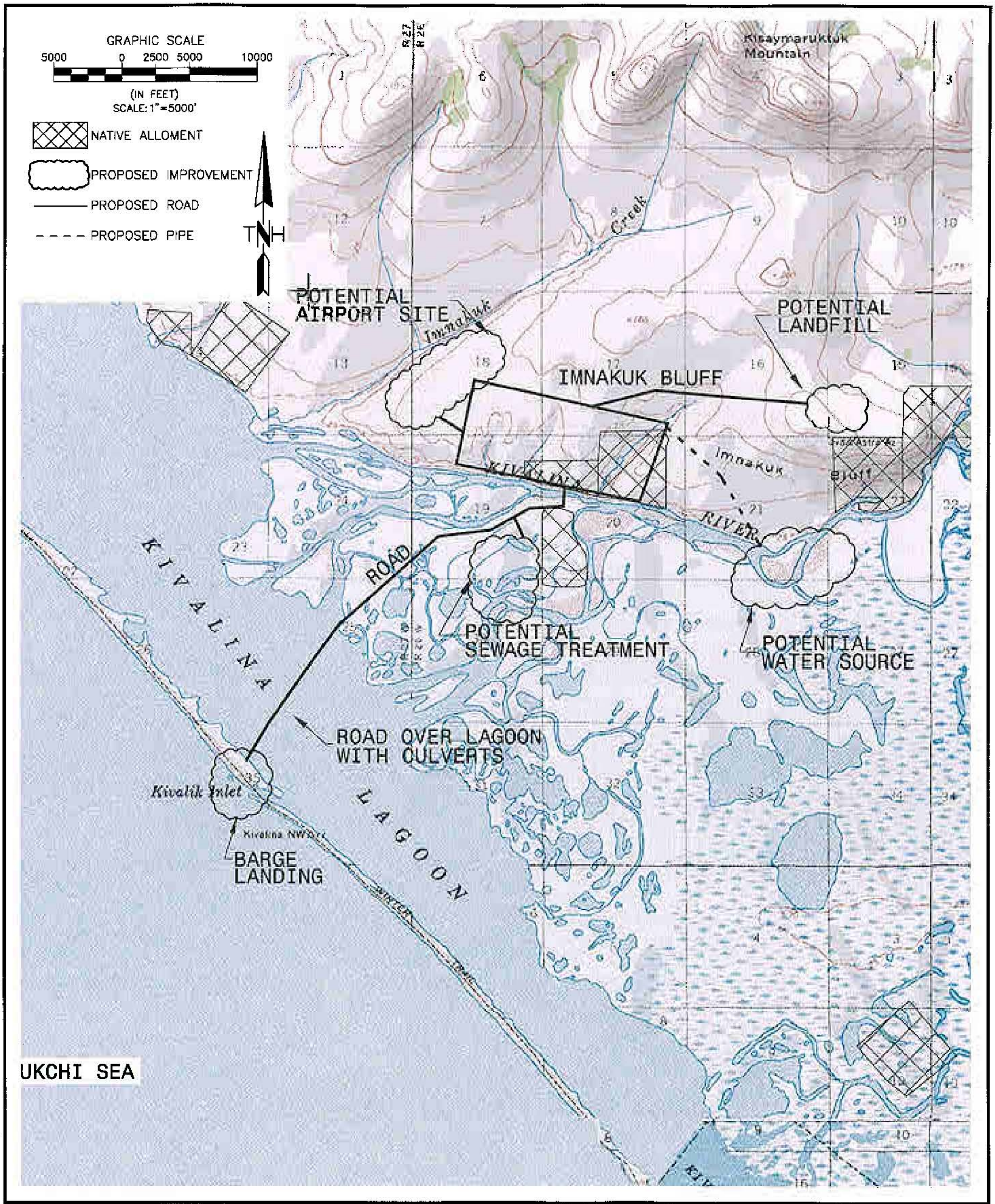

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FIGURE 9

IMNAKUK BLUFF CONCEPTUAL LAYOUT

DESIGN BY: MEW	DATE: 6/16/06
DRAWN BY: JT	PROJECT No: 03003.007
SCALE: 1" = 5000'	REV. –
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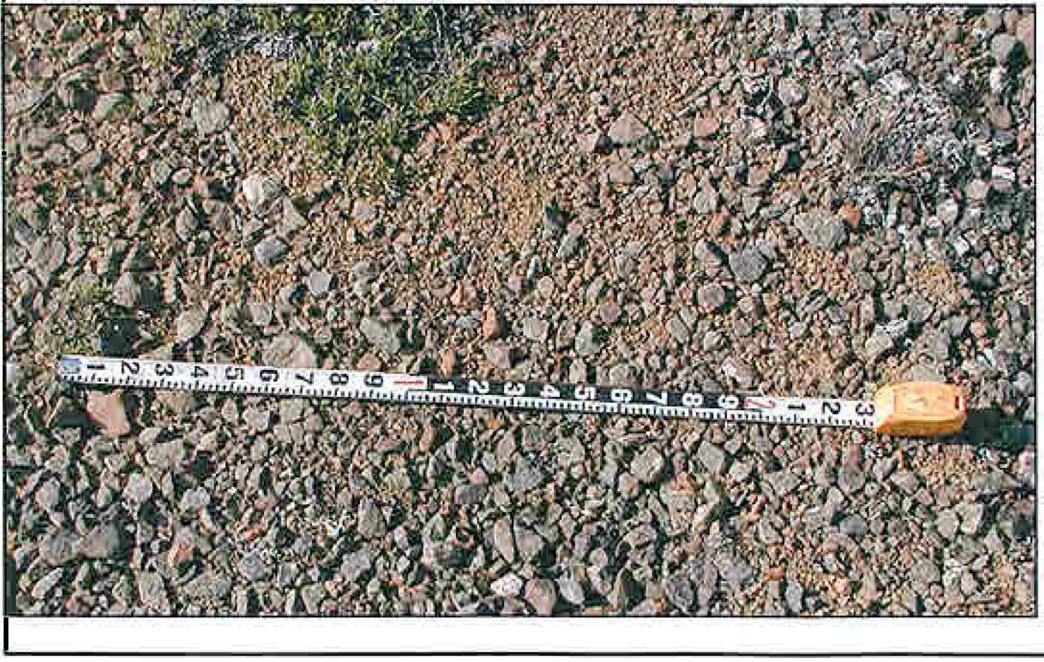
FIELD BOOK: –	SHEET 1 OF 1
GRID: –	

Tatchim Isua, Photo 1

View N from W edge of Tatchim Isua site

Tatchim Isua, Photo 2

View W from W edge of Tatchim Isua site



Tatchim Isua, Photo 3

Gravel patch at Tatchim Isua site

Tatchim Isua, Photo 4

View E from W edge of Tatchim Isua site

Tatchim Isua, Photo 5

View S from W edge of Tatchim Isua site

Tatchim Isua, Photo 6

Aerial view of Tatchim Isua site

KIVALINA VILLAGE
RELOCATION PROJECT

FIGURE 10 TATCHIM ISUA

PHOTOS BY TRYCK NYMAN HAYES, INC., AUGUST 24, 2004
KIVALINA, ALASKA

SHEET 1 of 1

FILE NAME KIVALINA_TATCHIM_ISUA.DWG

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3.7 TATCHIM ISUA

3.7.1 Location and Site Description – Tatchim Isua

The Tatchim Isua site is situated approximately 0.2 miles north of the lagoon and 9 miles north of the existing village. The site is on a bluff about 1.7 miles east of the Chukchi Sea and approximately 40 ft above the small Asikpak Lagoon located near the toe of the western slope.

The site is treeless and has little vegetative coverage. The ground within 400 ft of the bluff is dry and solid to walk on. The surface shows gravel through a thin covering of Arctic Willow.

The Tatchim Isua site is comprised of a maximum of 40 acres of the solid, dry gravelly material, which tapers out to wetter tundra on the north and west. The east and southern edges of the site are characterized by bluff faces rising gently off the lagoon below for a hundred yards, and then becoming steeper within a hundred feet of the shoulder of the site. The immediate bluff slopes rise at about a 45-degree angle for the last 35 ft.

The surface of the site slopes to the South and West over a distance of about a ½ mile. The tundra slope above the gravel site is extensive. Slopes are in the 5%-8% range with lower grades to the southeast and northwest for distances of up to 800 yards to drainage courses flowing south and west.

The faces of the bluffs on the western and southern sides are sparsely covered with scrub willow.

Reference Appendix B for geotechnical borings at the site. Eight borings were drilled in 2005. The results showed that ice rich silt was encountered 20 feet down on one of the borings, and a layer of massive ice was located on the lower bench (Shannon & Wilson, 2005).

3.7.2 Site Development – Tatchim Isua

Reference the geotechnical report regarding the depth of gravel recommended in maintaining the thermal regime of the site after development. The depth of fill applied to the site will be determined by two criteria: adequate fill to facilitate buried utilities where feasible, and the required grading to promote adequate drainage throughout the site.

The fill depth over this site will vary depending on the type of subgrade soil it is placed on. We anticipate that fill should be 3 ft, deeper in those areas of poor soils, and no fill required in the more dry, more stable subgrade soils.

Grading should maximize the utilization of swales and roadside ditching. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

A benefit of developing this site is that it is landlocked and does not require protective armor rock to ensure against erosion; however the barge landing will require erosion protection.

3.7.2.1 Construction Considerations – Tatchim Isua

If bedrock is relatively shallow and overlain by a thin layer of soil, larger structures could be founded on conventional foundation systems, and residential structures could be founded post-and–pad or conventional shallow systems (S&W, 2004).

General site preparation for structures might involve building a level pad, and then replacing the surficial frost-susceptible or thaw-unstable soils with stable nonfrost susceptible fill (S&W, 2004).

3.7.3 Infrastructure Development – Tatchim Isua

3.7.3.1 Water – Tatchim Isua

The most probable water source for Tatchim Isua is the Asikpak River (see Appendix H). Another small creek flows through the site, but it is not known if it flows year-round.

A belowground distribution system would be feasible at the Tatchim Isua site. S&W (2005) indicates that water utilities could be directly buried in the weathered rock and soil, or in a thin pad at the site.

3.7.3.2 Wastewater – Tatchim Isua

Tatchim Isua has a slope of less than 3% and large gravel pads. In the upper bench of land, and the area above the upper bench, the subsurface conditions show relatively shallow, weathered bedrock. Sewer utilities could be directly buried in the weathered rock and soil, or in a thin pad. The buried utilities would not be impacted by large differential movements due to permafrost thawing (SW 2005). If facilities are installed in the upper bench of land, a vacuum collection system and an underground arctic pipe system should be recommended. The available space allows for a sewage lagoon at this site.

Instability concerns with lagoon construction are expected to be minimal. Lakes at the base of the hill might be considered for wastewater treatment and disposal. On-site wastewater disposal with a leach field would not be appropriate due to shallow bedrock and frozen ground.

3.7.3.3 Solid Waste – Tatchim Isua

The Tatchim Isua site and its respective potential solid waste sites are well above the flood plain at an elevation of approximately 75 feet. The nearest flood plain is at the foot of the western bluff. There is minimal potential for surface water to enter the site.

A potential solid waste site is located on gently rolling hills about 0.5 to 2 miles southeast of the site. This area appears to have the capacity to support a solid waste site, but may have shallow ice. Fill soil would be needed to develop this site (TNH 2004). Drainage of the existing soil was poor during the 2004 site visit, and a visual inspection indicated silty and wet ground. Borrow material for covering landfill debris would have to be brought in from other locations.

3.7.3.4 Fuel – Tatchim Isua

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies to all potential sites equally.

3.7.3.5 Heating – Tatchim Isua

The information in 3.2.7 Heating applies equally to all sites.

3.7.3.6 Electricity – Tatchim Isua

The information in 3.2.8 Electricity applies equally to all sites.

3.7.4 Access – Tatchim Isua

Road access to the Tatchim Isua site is required to allow for barge landing and transfer of materials to the site. Figure 9 shows a proposed 1.5 mile long road from a barge landing area on the Chukchi Sea to the town site. The road would be gravel, with 5 feet of fill and 2:1 side slope shoulders. Geotextile fabric would be placed at the base of the road between the gravel fill section and the tundra.

3.7.4.1 Access for Subsistence Activities – Tatchim Isua

Access to the Chukchi Sea and its beaches for hunting sea mammals and fishing should be across a half mile of the 1.5 mile long barge landing road. All harvested game and equipment needed for subsistence activities may need to be hauled across the village access road to the barge landing area.

Access to the Kivalina and Wulik Rivers would be from the Kivalina Lagoon. The Kivalina Lagoon is reported to be very shallow in the vicinity of Tatchim Isua. To access the deeper areas of the lagoon, boat traffic would have to follow the coast from the barge landing area to one of the inlets to the lagoon, then travel up the Wulik or Kivalina Rivers.

This site is sufficiently elevated and close enough to the sea that the community can easily watch for whales that pass close by the shoreline. With a good spotting scope, several miles of coastline are visible from the western edges of the site.

The north bank of the Kivalina River should also be accessible by foot from the Tatchim Isua site by walking southeast along the west side of the lagoon and crossing Imnakuk Creek.

Constructed gravel roads from the new village site at Tatchim Isua may be expensive to construct. This high cost prohibits many roads from being built around the village. We anticipate that in addition to the Chukchi Sea access road west from the village site, that there may be one additional road of similar structural section to the east from the village to access the solid waste dumpsite. Due to lack of specific information regarding the location of these sites, no exact length for this road can be determined. However, a length in excess of 10,000 ft is anticipated because of the requirement to site any solid waste dump at least that distance from any runway accessed by turbojet aircraft. Figure 9 shows the proposed road.

3.7.4.2 Goods & Supplies – Tatchim Isua

The main source of goods and supplies for the new village should be by barge. A new barge landing and access road to the village should be designed and constructed west of the village site on the Chukchi Sea.

A barge landing on the sea may expose a moored barge to the strong wind and wave action developed over the long westerly fetch existing at the outer side of the barrier spit. This may mean that the barge may have to wait to moor and unload during bad weather.

The location of an airstrip is unknown at this time. Additional information will be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. Until a suitable location is found, the community should use the existing airstrip and ferry goods across the lagoon to utilize the new village access road.

For the purposes of this study and the cost estimate, we have assumed the runway should be located approximately half a mile west of the site.

3.7.4.3 Air Transportation – Tatchim Isua

Air transportation for the new village should be through the existing airstrip until a new airstrip is located, designed and constructed. Access to the existing airstrip requires boat travel along the beach. This may make emergency medical evacuation difficult, and in some instances necessitate the use of a helicopter to airlift injured people from the village itself.

Any future airport built specifically to serve the village should be sited considering soil conditions and required depth of gravel, distance from the new village, distance from the solid waste dump, wind conditions and flight path safety. Figure 11 shows a potential location for the new airport, but further investigation into this site will be needed.

3.7.4.4 Roads & Streets - Tatchim Isua

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

The soil conditions of the Tatchim Isua site vary with the distance east from the bluff side of the site. For approximately 400 ft, a dryer soil consisting of limestone fragments in a silt matrix provides good support for both buildings and roads. From a distance of 400 ft east of the bluffs to the east, the site gradually rises and the soils are composed of wet, clayey silt with frozen ground encountered at approximately 3 ft. These two different soil conditions may dictate two different depths of gravel for the road/building prisms. The regions near the shoulder of the bluff are underlain by more gravelly soils and are more easily utilized for installation of utilities in the roadbed than are areas underlain by silty, ice-rich soils.

The location of the Tatchim Isua site and its soil conditions make road construction difficult and expensive. It is anticipated that there should be as few roads as possible outside the village to access the new airstrip, solid waste facility and lagoon boat moorage area. Preferably, two or more of these facilities should be located along the same road, to reduce the amount of road development necessary.

3.7.5 Native Allotments

There are seven Native allotments along the northeast end of Kivalina Lagoon (see Figure 11). One of these allotments impinges slightly on the south corner of the Tatchim Isua townsite. Potential barge landing, landfill and sewage treatment sites abut against two of the Native allotments.

3.7.6 Relocation Costs – Tatchim Isua

Design and construction administration are not included in the construction cost estimate below. The cost estimate to build a new village site at Tatchim Isua is **$154.9 million.** Detailed costs are included in Appendix A. A summary is included below:

Site work and Airport Construction	$70,400,000
Erosion Protection	$231,000
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$21,521,638
Transportation System	$3,056,000
Total Cost	**$154,900,000**

3.7.7 Recommended Plan for Tatchim Isua

The Tatchim Isua area is located about 9 miles north of the existing village site, approximately ¼ mile north of the extreme north end of the Kivalina Lagoon. During investigation in August 2004, the site showed some good gravel areas on the south slopes above the shoulder of the bluff.

Figure 11 shows the recommended configuration of infrastructure for Tatchim Isua. Access to the site would be from a road and barge landing area located on the Chukchi Sea. The sewage lagoons would be located along this road. The airport facility would be located west of the townsite.

However, if wind studies show that the location is not appropriate, then an alternative locations would have to be considered. The alternative location would most likely be the same airport location as described for Imnakuk Bluff (approximately 2 miles east of Tatchim Isua, on the lower slopes of the hills north of the site). It is anticipated that this area should provide a better subgrade on which to base the 150 ft X 4,000 ft runway. An additional 10,500 lf of access road from the site may be needed. The landfill could be sited along the airport access road, and still maintain the 10,000 lf of separation between runway and landfill.

The raw water source for the Tatchim Isua Site has not yet been determined. However, the water resource report (Appendix A) recommends the Asikpak River as a source . Cost estimates will be based on this assumption.

The proposed landfill is located 1.4 miles east of the site.

The sewage lagoon should be located to the west of the townsite, along the small stream that drains into the wetlands below the site. The stream can be used as a surface discharge stream for the treated lagoon effluent. This may create a shorter length of sewage pump line than some other sites and access the best discharge route in the area, for this site.

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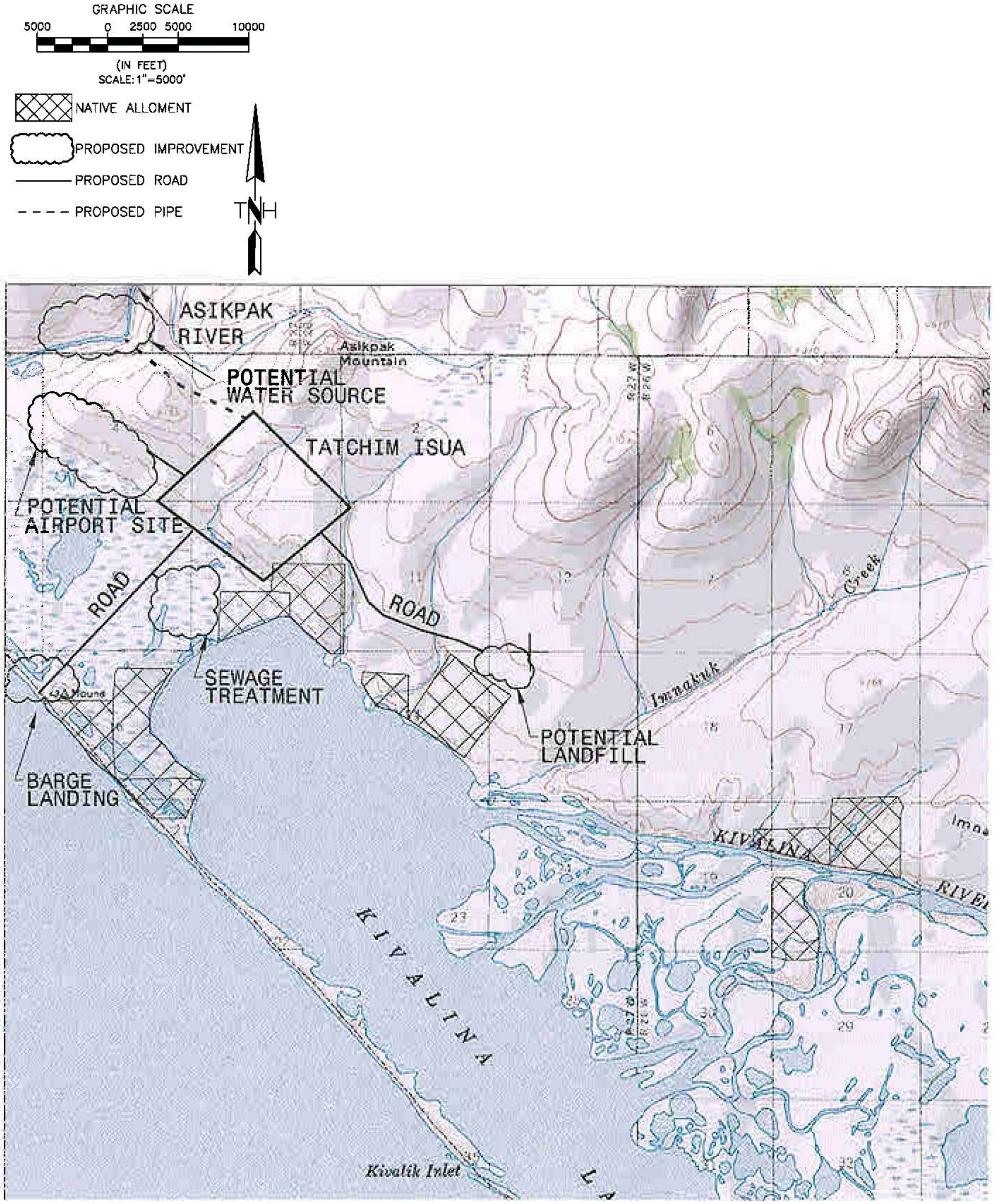

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FIGURE 11

TATCHIM ISUA CONCEPTUAL LAYOUT

DESIGN BY: MEW
DATE: 6/16/06
DRAWN BY: JT
PROJECT No: 03003.007
SCALE: 1" = 5000'
REV. –
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SHEET 1 OF 1

Kiniktuuraq, Photo 1

View of gully near beach at Kiniktuuraq

Kiniktuuraq, Photo 2

Trash on Kiniktuuraq site

Kiniktuuraq, Photo 3

View of cold storage dens at Kiniktuuraq site looking NE, Kivalina in background

Kiniktuuraq, Photo 4

Beach at W side of Kiniktuuraq looking N

Kiniktuuraq, Photo 5

View N from near landing site showing cold storage den

Kiniktuuraq, Photo 6

Aerial view of Kiniktuuraq site

PLOT SCALE: 1:1

SHEET 1 of 1

FILE NAME KIVALINA_KINIKTUURAQ.DWG

KIVALINA VILLAGE
RELOCATION PROJECT

FIG 12 KINIKTUURAQ

PHOTOS BY TRYCK NYMAN HAYES, INC., AUGUST 24, 2004
KIVALINA, ALASKA

ENGINEERING/SURVEYING & LANDSCAPE ARCHITECTURE
Tryck Nyman Hayes, Inc.

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3.8 KINIKTUURAQ

3.8.1 Location and Site Description – Kiniktuuraq

Kiniktuuraq was selected as the preferred site in 2000, prior to TNH's 2004 on-site investigation of the area. Located at the south end of the lagoon near the mouth of the Wulik River, the Kiniktuuraq site is approximately a mile southeast of the existing village. The site fronts the Chukchi Sea on its southwest side, and is separated from the lagoon by Kiniktuuraq Creek, a tributary of the Wulik River, and a small island.

This site shares many of the same characteristics of Kuugruaq and Igrugaivik. It is wet to the point of being swampy, underlain by unstable, ice-rich, fine-grained soils, and subject to destruction of the existing thermal regime without the addition of a minimum of 9 ft of gravel over the site.

This site is relatively flat, with the exception of two distinct elevations separated by a sharp incline between them. Reference the geotechnical report for discussion of these areas.

The site is essentially devoid of trees and brush. The major forms of flora are arctic plants that flourish in wet environments, such as arctic moss, sedges, arctic cotton and grasses.

3.8.2 Site Development – Kiniktuuraq

Kiniktuuraq was observed in the fall of 2004 to be flooded by storm driven tides. The site is at an elevation of 10 feet and would need to be raised above the projected storm surge elevation of 13.5 feet to facilitate development as a town site. In addition to protecting from storm surge, the site must be developed to protect the thaw unstable permafrost.

To protect against permafrost degradation, a gravel pad would have to be constructed a minimum of 9 feet thick. Reference the geotechnical report for more information about gravel requirements for the site.

Grading should maximize the utilization of swales and roadside ditching as much as possible. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

Because the Kiniktuuraq site is fronted by water on two sides, the Chukchi Sea to the west and a channel of the Wulik River on the north, the site is vulnerable to erosion and must be armored using armor rock and riprap on those sides.

3.8.2.1 Construction Considerations – Kiniktuuraq

Construction considerations for the Kiniktuuraq site can be referenced from R&M (2000) and R&M (2002). Test Borings were drilled during 1999 to investigate potential borrow material along the beach. Test Borings were also drilled in 2002 to investigate potential borrow material underlying the Kivalina Lagoon.

R&M (2000 and 2002) states that foundation soils encountered were thaw-unstable, ice-rich, fine-grained materials. Significant settlement should be expected if thawing occurs. However, very little thaw settlement should be expected along the beach areas. Permafrost was encountered within all test borings except for those drilled along the beach and those drilled under the lagoon.

In 2000 and 2002, R&M observed massive ice in test borings drilled within the upper terrace (upland) area. Many other borings encountered considerable visible ice as stratified or distinctly oriented formations. Saline groundwater was encountered as far upstream along the Wulik River as the northwest portion of Igrugaivik.

R&M (2000 and 2002) suggests use of pile foundations or a granular fill pad with a post-on-pad foundation to protect from settlement due to thawing of ice-rich soil. Insulated post-on-pad foundations can be used in this situation, but require periodic leveling due to settling. Another option would be insulated and/or refrigerated shallow foundations (thermosyphons). This method is generally used for large heavy loads such as water storage tanks and not used for light-load conditions.

R&M (2000 and 2002) states that embankments for roads and runways should be protected from settlement due to permafrost degradation. An estimated embankment thickness of 9 feet should reduce the depth of thaw penetration into the ice-rich soil to nearly zero. Rigid board insulation or allowing for some settlement can reduce embankment thickness. The settlement would occur mostly within the first few years of service. Culverts beneath the embankments are expected to settle due to permafrost degradation, and may need to be re-leveled periodically during the first few years of service. Insulation beneath the culverts may reduce the magnitude of settlement.

S&W (2004) states there is a potential for an increase in soil salinity and soil temperature due to the proximity of the site to the ocean. Increased soil salinity and soil temperatures would reduce the unit capacity of pile foundation systems in ice-rich soils. Pile foundation systems at this site could be deeper and refrigeration requirements greater than at the Igrugaivik site.

S&W (2004) also states that although the thermal integrity of the permafrost could be maintained by insulating the land surface with a thick fill, maintaining the integrity of ice-rich permafrost exposed at the coast would be more difficult. Both thermal degradation and mechanical erosion of these soils along the coast could undermine site fills unless adequately protected. In addition to mechanical stabilization, ice-rich soil along the coast would require thermal protection and protection from saline seawater.

3.8.3 Infrastructure Development – Kiniktuuraq

3.8.3.1 Water – Kiniktuuraq

No test wells have been drilled at the Kiniktuuraq site. A test well drilled about 1 mile inland at the Igrugaivik site in May 2002 produced saline water from a thaw bulb along the Wulik River (R&M 2002). Based on this finding, a well placed in similar deposits at the Kiniktuuraq site will likely produce salt water.

The Kiniktuuraq site is covered by a number of small tundra ponds a few hundred square feet in area, none of which appear large enough to provide a sustainable raw water source (TNH 2004).

Due to the lack of nearby freshwater from either surface or groundwater sources, a collection, treatment, and distribution arrangement similar to the existing Kivalina site would be required. Water would be withdrawn through a hose and pipe transmission line placed in the Wulik River and pumped to a raw water storage tank. If the Wulik River could be tapped with an infiltration gallery year round, the transmission line would have to be heated with a glycol loop to avoid freezing.

An underground distribution system is infeasible at this site due to massive ice wedges and unstable thaw conditions (R&M 2000, 2002; S&W 2004). If an aboveground distribution system were used, continuous grade adjustments would be needed.

3.8.3.2 Wastewater – Kiniktuuraq

The unstable thaw conditions at the Kiniktuuraq site present a large problem for a sewage collection system. The Kiniktuuraq site is situated on low elevation and flat terrain. Soils consist of ice-rich permafrost and large ice wedges. A vacuum collection system and an above ground utilidor are recommended for development of this site. DOWL (1994) stated a sewage lagoon could be built on this site but would require special considerations.

R&M (2000 and 2002) states that degradation of permafrost is expected beneath and around any proposed sewage lagoon placed on the perennially frozen fine-grained soils. This may result in significant thaw settlements, particularly under the lagoon dikes. The lagoon dikes should be constructed sufficiently high to account for settlement, or periodically evaluated in order to maintain the required lagoon capacity.

3.8.3.3 Solid Waste – Kiniktuuraq

No developable possible solid waste site was identified during the August 2004 fly-over. Assuming a potential site existed near the village site, great amounts of gravel fill would be required to raise the area above the flood plain. A minimum of 9 ft of gravel would be required to preserve the thermal regime under the proposed town site. Small quantities of sand and gravel could potentially be mined from the beach and along the edges of the Wulik River for small projects, as sand and gravel quantities are limited to volumes of 1,000 to 3,000 cubic yards per deposit pocked (DOWL/BBFM, 1998). Permitting a gravel mining operation in the river may be difficult. Transporting the gravel/sand cover soil to the potential landfill site would be very difficult.

Kiniktuuraq is the location of the old dumpsite, presenting permitting issues.

3.8.3.4 Fuel – Kiniktuuraq

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies equally to all potential sites.

3.8.3.5 Heating – Kiniktuuraq

The information in 3.2.7 Heating applies equally to all sites.

3.8.3.6 Electricity – Kiniktuuraq

The information in 3.2.8 Electricity applies equally to all sites.

3.8.4 Access – Kiniktuuraq

Since it is bordered on two sides by water, site access would be primarily by boat. The landward side of this site to the west and south abuts terrain that is a continuation of the wet conditions of the subject site.

3.8.4.1 Access for Subsistence Activities – Kiniktuuraq

Access to the lagoon and to the Chukchi Sea for hunting sea mammals and fishing should be direct as the site fronts the sea and abuts the lagoon. Safe boat moorage would be on the lagoon side of the site or along Kiniktuuraq Creek. The sea can be reached in less than 5 minutes from any point along the lagoon side of the parcel.

The mouth of the Wulik River is located less than a mile northeast of the north side of the site. Access to this river should be by boat from the boat-staging pad at the north side of the property, or from Kiniktuuraq Creek to the Northeast.

The Kivalina River near the north end of the lagoon can be accessed by boat from the lagoon.

Beach access from the Kiniktuuraq site is immediate along the southwest face of the site. This site affords miles of beach to the south that can be accessed by foot for beachcombing, wood gathering, hunting or more easily accessing areas inland of the beach. Beach access to the north side of Singauk Inlet should be by boat across the lagoon.

Subsistence activities such as gathering berries and greens and small game can be easily performed from the site by foot or on four-wheeler. The wet, unstable nature of the terrain should make travel by four-wheeler slow.

3.8.4.2 Goods & Supplies – Kiniktuuraq

Barge access to the Chukchi Sea can be direct from the southwest side of the site. The barge landing for this site would be a beach landing next to the village site, which would not require construction of an access road.

An airstrip could be located approximately 3.5 miles to the northeast of the village site and connected to the village via a road.

3.8.4.3 Air Transportation – Kiniktuuraq

Because the new airstrip must be located 10,000 feet from the landfill, we recommend that the airstrip should instead be located approximately 3.5 miles northeast of the village to accommodate distance requirements.

A new airport should be constructed prior to occupancy of the new village site. Refer to Section 3.1 for general recommendations.

3.8.4.4 Roads & Streets within Community – Kiniktuuraq

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

3.8.4.5 Roads Outside the Community – Kiniktuuraq

The location of the Kiniktuuraq site and the soil conditions of the terrain surrounding it make road construction difficult and expensive. There should be as few roads as possible outside the village; therefore we have recommended that the airstrip, landfill, and sewage treatment plant all be located along the same road. A 0.3 mile road to the barge landing may be necessary to facilitate loading and offloading of supplies.

3.8.5 Native Allotments

There are no Native allotments in the vicinity of the Kiniktuuraq townsite (see Figure 13). Use of this site and associated facilities are not constrained by Native allotments.

3.8.6 Relocation Costs – Kiniktuuraq

Design and construction administration are not included in the construction cost estimate. The cost estimate to build a new village site at Kiniktuuraq is **$248.2 million**. Detailed costs are included in Appendix A. A summary is included below:

Site work and Airport Construction	$163,700,000
Erosion Protection	$2,613,600
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$22,125,007
Transportation System	N/A
Total Cost	**$248,200,000**

3.8.7 Recommended Plan for Kiniktuuraq

The barge access landing and boat storage pad should be sited on the west side of the spit, on the north edge of the proposed village site. This should provide the storage and staging areas with relatively level areas, and facilitate ease of loading and unloading the barge. The road from the barge landing to the village should be less than 300 ft long.

The new runway for the village site at Kiniktuuraq should be located about 3.5 miles northeast of the site. The landfill would be located along the access road to the airport, about 7,500 feet northeast of the village and over 10,000 feet from the airport.

The most likely raw water source for the Kiniktuuraq Site is the Wulik River. Potential sources of raw water may be investigated in the water study that is currently pending publication. There are no other known sources of water in the Kiniktuuraq Site area.

The sewage lagoon may be located east of the town site between the gravel pad for the new village and the new runway (approximately 7,500 feet from the village site). A surface discharge should be established to dispose of the treated lagoon effluent onto the surrounding wetlands.

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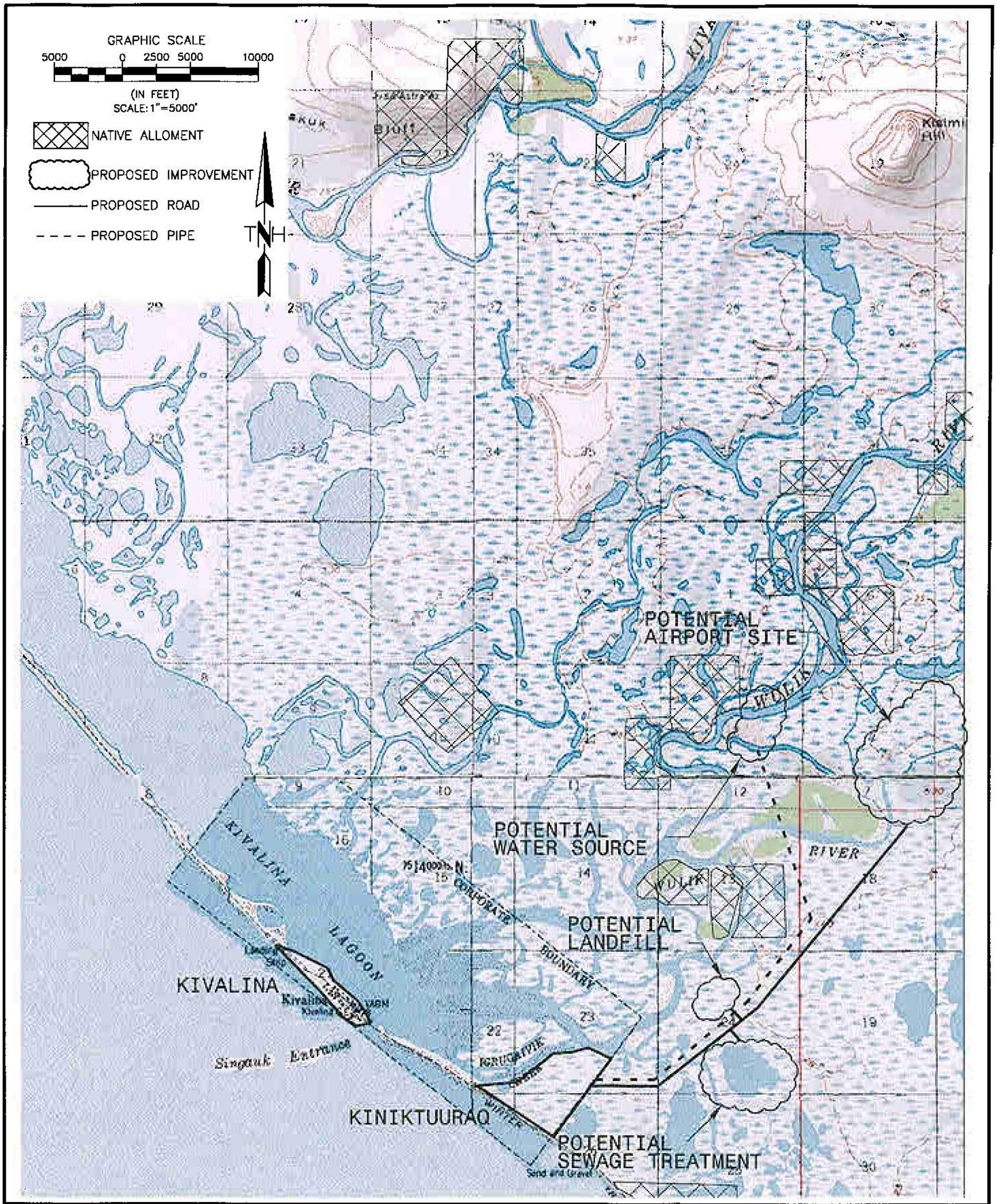

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FIGURE 13

KINIKTUURAQ CONCEPTUAL LAYOUT

DESIGN BY: MEW
DATE: 6/16/06
DRAWN BY: JT
PROJECT No: 03003.007
SCALE: 1" = 5000'
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FIELD BOOK: –
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3.9 IGRUGAIVIK

3.9.1 Location and Site Description – Igrugaivik

This site is situated adjacent to the Kiniktuuraq site, lying inland about half a mile from the northwest edge of the Kiniktuuraq. It is located approximately 2 miles east of the existing Kivalina site. The site is bounded on the west by the main channel of the Wulik River, and by sloughs or ponds on the south and north sides.

The site is essentially flat in two abutting areas with a surface differential of about 3 ft. Reference the geotechnical report for a complete description of the site.

This site is very similar to the Kiniktuuraq site, dominated by low, arctic flora such as mosses, sedges and grass. The site does not have any trees or shrubs. Any site relief is marginal and strictly local. This site appears to be basically flat. The site features small tundra ponds scattered about its area, with a large pond located on the southeast corner and an elongated pond abutting the northwest side.

No ground truthing site visit was conducted under this contract. The material presented here is a compilation of data gathered from existing literature dating back to 1994.

3.9.2 Site Development – Igrugaivik

The fill depth over this site will vary depending on the type of subgrade soil it is placed on. We anticipate that gravel fill should be a minimum of 9 ft.

Grading should maximize the utilization of swales and roadside ditching as much as possible. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

Because the Wulik River flows past the north edge of the site, the face of the site fronting the river may have to be protected with armor rock to resist erosion from river flow.

Construction considerations for the Igrugaivik site can be referenced from R&M (2000 and 2002). Test borings were drilled in 1999 to investigate potential borrow material along the beach. Test borings were also drilled in 2002 to investigate potential borrow material underlying the Kivalina Lagoon.

R&M (2000 and 2002) states that foundation soils encountered were thaw-unstable, ice-rich fine-grained materials. Significant settlement should be expected if thawing occurs. Permafrost was encountered within all test borings. Many borings encountered considerable visible ice as stratified or distinctly oriented formations. Saline groundwater was encountered as far upstream along the Wulik River as the northwest portion of Igrugaivik.

R&M (2000 and 2002) suggests the use of pile foundations or a granular fill pad with a post-on-pad foundation to protect from settlement due to thawing of ice-rich soil. Post on pad foundation are for areas with little or no massive ice, and require periodic leveling. Another option would be insulated and/or refrigerated shallow foundations. This method is generally not used for ice-rich conditions and maintenance cost could be very high.

Roads within the site are recommended to have a 9 foot gravel thickness, while access roads may be 5 feet thick. R&M (2000 and 2002) states that embankments for roads and runways may also need to be protected from settlement due to permafrost degradation. An estimated embankment thickness of 9 feet may reduce the depth of thaw penetration into the ice-rich soil to nearly zero. Rigid board insulation or allowing for some settlement can reduce embankment thickness. The settlement would occur mostly within the first few years of service. Culverts beneath the embankments are expected to settle due to permafrost degradation, and may need to be re-leveled periodically during the first few years of service. Insulation beneath the culverts may reduce the magnitude of settlement.

3.9.3 Infrastructure Development – Igrugaivik

3.9.3.1 Water – Igrugaivik

Based on the results of a geophysical survey conducted at the Igrugaivik site, Golder Associates (1997) found indications that a thaw bulb in floodplain and river terrace deposits near the bank of the Wulik River might provide an adequate year-round source of readily treatable groundwater. USACE (1998) proposed that a water supply system at this site consist of a well, pump house, water treatment building, relocation of an existing water storage tank from Kivalina, and an aboveground distribution system with forced circulation.

A test well drilled at the Igrugaivik site in May 2002, however, produced only saline groundwater. The saltwater was encountered in sand and gravel deposits at depths of 30 to 41 feet, which lay beneath a surficial permafrost layer (R&M 2002). R&M suggested the salts might be concentrating along the line of freezing/bonding at the edge of the permafrost. The source of the salt could be from a subsurface saltwater wedge effect, or from infiltration along the river during high tides or storm surges. Storm surge modeling indicates that maximum surge events can reach about 11 feet in elevation (1 foot above the highest elevation of the site) at Kivalina (USACE 1998). Further sampling of the river in various locations should be conducted to determine the extent of salt water intrusion. Additional test wells targeting potential thaw bulbs further up the river would need to be drilled in order to identify a non-saline supply of groundwater, with corresponding added costs for a longer piping distance. The location of any additional wells should take into account the inland reach of tides and storm surge.

The Igrugaivik site vicinity is covered by a number of small tundra ponds, none of which appear large enough to provide a sustainable surface water source. If a surface water source from the Wulik River were used for Igrugaivik, a collection, treatment, and distribution arrangement similar to the existing Kivalina site would be required. Water would be withdrawn through a hose and pipe transmission line placed in the river and pumped to a raw water storage tank. If the Wulik River could be tapped with an infiltration gallery year round, the transmission line would have to be heated with a glycol loop to avoid freezing.

If a year-round groundwater source is identified for Igrugaivik, R&M (2000 & 2002) and S&W (2004) suggest aboveground water utilities for the site, due to the potential for large differential settlement. The aboveground construction would thermally decouple the utilities from the subgrade and allow grade adjustments if necessary.

3.9.3.2 Wastewater – Igrugaivik

The unstable thaw conditions at the Kiniktuuraq site present a large problem for a sewage collection system.

Because of the flat terrain and permafrost at Igrugaivik, a vacuum collection system and above ground arctic pipe is recommended. USACE (1998) discusses that wastewater treatment could be accomplished by the development of a settlement lagoon at the 6 acre tundra pond near the proposed beach access road. Discharge of effluent after settlement of sludge could be directed to a minor channel of the Wulik River by the pond.

Aboveground sewer utilities are suggested by R&M (2002) due to the potential for large differential settlement. Direct burial of settlement-sensitive gravity, pressure, or vacuum sewer systems might be risky due to the settlement potential.

R&M (2000 and 2002) mentions that massive ice wedges and large differential settlement would affect sewage lagoons. High lagoon dikes need to be constructed to account for settlement or periodically regraded as necessary to avoid causing a membrane liner to rupture. In an unlined lagoon, a piping type of failure could occur along lenses or wedges of massive ice. A sewage lagoon constructed with earthen dikes should be sited in an area without massive ice if possible, or a tundra pond could be used. Septic tanks and a package treatment plant would also eliminate some of the potential problems with a constructed lagoon.

USACE (1998) proposed a sludge disposal site by the road near the proposed sewage treatment lagoon.

3.9.3.3 Solid Waste – Igrugaivik

S&W (2004) assumed that the site is underlain by potentially highly thaw-unstable soils based on its 2004 site investigation. Since at least 9 feet of gravel would be required to preserve the thermal regime under the proposed town site, construction of a solid waste landfill would be difficult and expensive.

3.9.3.4 Fuel – Igrugaivik

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies to all potential sites equally.

3.9.3.5 Heating – Igrugaivik

The information in 3.2.7 Heating applies equally to all sites.

3.9.3.6 Electricity – Igrugaivik

The information in 3.2.8 Electricity applies equally to all sites.

3.9.4 □ Access – Igrugaivik

The Igrugaivik site, like the Simiq site, provides only one direct avenue of access. This site is surrounded by muskeg type soils that are saturated, thermally unstable and provide poor structural support for vehicles, including four-wheelers. Access from the main channel is the most direct access to the site.

A road will need to be constructed to provide year-round access to this site. The best route appears to be to the southwest along the Wulik River, across the Kiniktuuraq site to the sand spit on the south side of the Singauk Inlet near the river’s mouth. While this one mile long route presents additional design problems over a straight route to the Chukchi Sea along a southwest course, it benefits from accessing the south end of the lagoon, where a protected barge landing can be constructed. Bridges would have to be constructed and culverts installed to cross channels and streams along the route. This is the same route as described in the USACE (1998) study. A total of 1.3 miles of road (west to the Singauk Entrance and east to a potential runway location) is required.

It is important to note that to stabilize the sand spit comprising the south side of the Singauk Inlet, the spit may have to be armored against wave and storm erosion on all sides.

We have not been able to discover any existing data regarding the depth of the south end of the lagoon. The action of the flow of the Wulik River in conjunction with the tidal influences on the Singauk Inlet make the entrance to the lagoon and flow channels at the south end difficult to determine. To understand what engineering considerations are necessary at the south end of the lagoon, a study specific to the river and tide actions may have to be conducted if this site is selected as the preferred new village location.

It is possible for boats to navigate up the channel of the Wulik River to access the west side of the Igrugaivik site. This would provide an additional boat tie-up point near the village.

3.9.4.1 Access for Subsistence Activities – Igrugaivik

Access to the lagoon, rivers, and the Chukchi Sea for hunting sea mammals and fishing should be at the proposed barge landing site. The location of the site, inland from the lagoon, places it far enough away from the Chukchi Sea so that watching for whales from the site will not be possible.

The 1 mile road from the northwest end of the site to the lagoon may allow foot and vehicle traffic to easily access the barge and boat staging pads and the lagoon.

Beach access from the Igrugaivik site may be either by foot or four-wheeler over the muskeg to the southwest of the site or by the road from the village pad to the south end of the lagoon, and then west to the south side of the Singauk Inlet. Access to the beach on the north side of the inlet may be by boat from the lagoon only.

Subsistence activities such as gathering berries and greens and small game hunting can be easily performed from the site by foot or on four-wheeler. The wet, unstable nature of the terrain may make travel by four-wheeler slow. The very high cost of constructing roads across the muskeg may require that roads from the village be limited to an access to the airstrip and solid waste dump facility and barge landing. It is anticipated that this road may be at least 1.3 miles long.

3.9.4.2 Goods & Supplies – Igrugaivik

A road to the beach is the most likely access to the barge landing. At the barge landing site, a one acre staging area should be constructed to enable loading and unloading of the barge. This staging area should allow the community to stage the materials and ferry them to the new village.

The location of an airstrip is unknown at this time. Additional information should be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. Until a suitable location is found, the community should use the existing airstrip and ferry goods across the lagoon to utilize the new village access road.

The USACE (1998) study describes a 4,000 ft long runway site northwest of the site. No distance is given, but for the purposes of a cost estimate for this study we have located it about 1 mile east of the east end of the site. If the solid waste dumpsite is located along the gravel road to the barge landing, it should easily be outside the 10,000 ft runway exclusion zone (see Figure 12).

3.9.4.3 Air Transportation – Igrugaivik

The December, 1997 letter from ADOT&PF to Dr. Orson Smith, USACE Project Manager regarding location and logistics for a new runway indicates that ADOT&PF feels the Igrugaivik site has moderate ability to support a new airstrip. The letter cites ice-rich soils, potential foundation degradation, possible river erosion and heavy reliance on river resources for foundation material.

Additional information will be gathered during the Stage II study to determine the best location and design considerations for a new airstrip. For the purposes of this study, we have selected a location approximately 1 mile east of the site on a low ridge. A new airport should be constructed prior to occupancy of the new village site. Refer to Section 3.1 for general recommendations.

3.9.4.4 Roads & Streets within Community – Igrugaivik

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

The poor soil conditions and unstable thermal regime of the Igrugaivik site may necessitate the construction of a thick gravel pad to protect the existing conditions. This pad should also serve to raise the new village above the level of the anticipated storm surge.

3.9.4.5 Roads Outside the Community – Igrugaivik

The location of the Igrugaivik site and the soil conditions of the terrain surrounding it make road construction difficult and expensive. It is anticipated that there should be as few roads as possible outside the village to access the new airstrip, solid waste facility and lagoon boat moorage area. Preferably, two or more of these facilities should be located along the same road, to reduce the amount of road development necessary. A total of 2.3 miles of road outside the village proper is assumed for this site.

3.9.5 Native Allotments

There are no Native allotments in the immediate vicinity of the Igrugaivik townsite (see Figure 14). However, there is a Native allotment to the south of a potential sewage treatment plant.

3.9.6 Relocation Costs – Igrugaivik

Design and construction administration are not included in the construction cost estimate. The cost estimate to build a new village site at Igrugaivik is **$246.1 million**. Detailed costs are included in Appendix A. A summary is included below:

Site work and Airport Construction	$164,800,000
Erosion Protection	$1,045,440
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$20,521,057
Transportation System	N/A
Total Cost	**$246,100,000**

3.9.7 Recommended Plan for Igrugaivik

The Igrugaivik Site is the southernmost of the three village sites on the south side of the Singauk Entrance. It is located south of the Kiniktuuraq site and is accessible to the Wulik River by a side slough.

The new runway for the village site at Igrugaivik may be located about at the same location as described for the Kiniktuuraq Site. It is about 1 mile west of the proposed Igrugaivik Site. It is anticipated that this area may provide a poor subgrade on which to base the 150 ft X 4,000 ft runway, and a geofabric base may be required to provide support and separation for the muskeg below. The short length of village to runway road and the close routing of the barge landing to village road mean that siting the landfill along either may be difficult.

Siting the landfill at the same location proposed for the Kiniktuuraq Site, on the base of the gravel spit, adjacent to the dredged channel should provide the required separation from the new runway, as well as a close location to the village for ease of use and to the barge landing for transport of recyclable materials, batteries and hazmat for shipping.

The most likely raw water source for the Igrugaivik Site is the Wulik River. Potential sources of raw water will be investigated in the water study that is currently pending publication. There are no other known sources of water in the Igrugaivik Site area. It is anticipated that a raw water intake structure should be constructed in a thaw bulb, to furnish a year round water supply.

The sewage lagoon should be located south of the town site to allow surface discharge to flow southward, away from the proposed village pad. A surface discharge should be established to dispose of the treated lagoon effluent onto the surrounding wetlands.

XREF's/IMAGES USED FOR THIS DWG:

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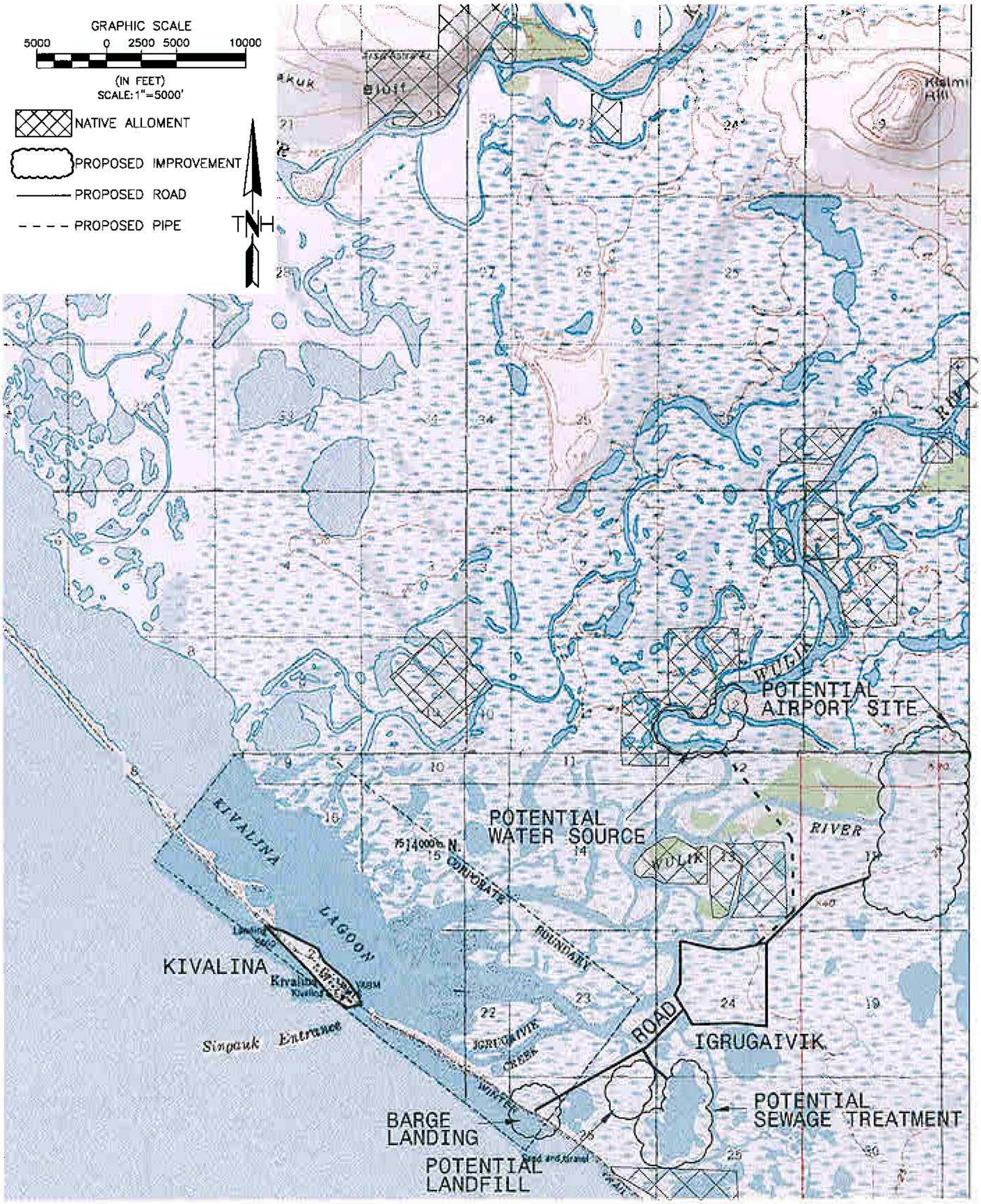

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FIGURE 14

IGRUGAIVIK CONCEPTUAL LAYOUT

DESIGN BY: MEW
DATE: 6/16/06
DRAWN BY: JT
PROJECT No: 03003.007
SCALE: 1" = 5000'
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FIELD BOOK: –
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SHEET 1 OF 1

3.10 KUUGRUAQ

3.10.1 Location and Site Description – Kuugruaq

The Kuugruaq site is several hundred yards directly north of the Igrugaivik site and about 2 miles east of the existing Kivalina town site. From the air, the three sites on the south side of the Wulik River, including Kuugruaq, all appear to have the same characteristics: low, wet, ice-rich soils with numerous tundra ponds, sloughs and channels in and around the indicated areas.

No ground truthing site visit was conducted under this contract. The material presented here is a compilation of data gathered from existing literature dating back to 1994. From geotechnical reports, and from aerial photos, the site has both thaw stable soils with gravel and sand, plus ice rich permafrost soils. The Wulik River has undercut the permafrost areas leaving part of the village site thawed with gravel benches and willows. The undisturbed parts of the site have classical polygonal ground indicated ice rich permafrost.

When the Wulik River was at flood stage in 1993, approximately half the Kuugruaq site was inundated with floodwater (DOWL, 1994). Approximately 100 acres of site land was left above the 1993 flood level. Further investigations of flood levels should be conducted for this site before it is chosen.

Any consideration of this site as the new village site should take this information into account when laying out the new site.

3.10.2 Site Development – Kuugruaq

The fill depth over this site can vary depending upon the use of insulation placed below the fill to reduce the thickness of gravel. We anticipate that fill may be a minimum of 9 feet.

Grading should maximize the utilization of swales and roadside ditching as much as possible. Where lengths of grade and slopes combine to make swales and ditches too deep, drainage structures such as culverts, manholes, catch basins and subsurface piping shall be employed.

The full length of the north and west sides of the site may have to be protected with armor rock to protect against erosion from the Wulik River. Approximately 9,000 lf of erosion protection may be required.

3.10.2.1 Construction Considerations – Kuugruaq

Golder (1997) reports the active and abandoned floodplain portions of the site may be underlain by relatively thaw-stable soils. A thaw-stable subgrade would greatly simplify and reduce construction cost of structures and infrastructure. Commercial, municipal, and community structures could be founded on conventional foundations or pile foundations, and residential structures could be founded post-and-pad or on more conventional foundation systems. Road sections in town could be thinner. General site preparation for structures might involve replacing surficial frost-susceptible soils and raising the site grade above flood level with a nonfrost-susceptible fill. The area of potentially thaw-unstable soils for development is limited, and some facilities such as runway and access roads would have to be constructed over ice-rich, thaw unstable ground.

3.10.3 Infrastructure Development – Kuugruaq

3.10.3.1 Water – Kuugruaq

Based on the results of a geophysical survey conducted at the Kuugraaq site, Golder Associates (1997) found indications that a thaw bulb in abandoned floodplain deposits near the Wulik River bank might provide an adequate year-round source of readily treatable groundwater. A test well drilled in 2002 at the nearby Igrugaivik site produced only saline groundwater (R&M 2002). The recommended Kuugraaq test well is located about ¼ mile further inland from the coastline than the Igrugaivik well. If the Kuugraaq well also proves to be saline, additional test wells targeting similar deposits and thaw bulbs further upstream along the river would be needed to identify a non-saline supply of groundwater, with corresponding added costs for a longer piping distance. The location of any additional wells should take into account the inland reach of tides and storm surge as a possible source of saline groundwater.

The Kuugruaq site is covered by a number of small tundra ponds, none of which appear large enough to provide a sustainable surface water source. If a surface water source from the Wulik River were used for Kuugruaq, a collection, treatment, and distribution arrangement similar to the existing Kivalina site would be required. Water would be withdrawn through a hose and pipe transmission line placed in the river and pumped to a raw water storage tank. If the Wulik River could be tapped with an infiltration gallery year round, the transmission line would have to be heated with a glycol loop to avoid freezing.

If a groundwater source is proved up for the Kuugruaq site, the proposed water supply system would likely consist of a well, pump house, water treatment building, relocation of an existing water storage tank from Kivalina, and an aboveground distribution system with forced circulation. S&W (2004) suggests that aboveground water and sewer utilities would be required for the eastern portion of the Kuugruaq site, due to the potential for differential settlement in old terrace deposits. Utilities could be directly buried in the western portion of the site, which is covered by floodplain deposits and relatively thaw-stable soils.

3.10.3.2 Wastewater – Kuugruaq

Because of the flat terrain and permafrost at Kuugruaq, a vacuum collection system and above ground arctic pipe system is recommended. DOWL (1994) stated the land area and construction materials are available to construct a sewage disposal system.

As stated above, S&W (2004) suggests that aboveground sewer utilities would be required for the eastern portion of the Kuugruaq site. For the western portion of the site, sewer utilities could likely be directly buried, and instability concerns with lagoon construction could be minimal. A leach field could be considered for wastewater disposal (S&W, 2004).

3.10.3.3 Solid Waste – Kuugruaq

There is a limited potential area of thaw-unstable soil available for development. Some facilities would have to be constructed over fine-grained, ice-rich, and highly thaw-unstable soil (S&W 2004). The area appears to represent an unstable thermal regime with very poor soils. Construction of a solid waste landfill would be difficult and expensive.

3.10.3.4 Fuel – Kuugruaq

Except for the location of marine headers and fill pipeline routings, the information in 3.2.6 Fuel applies to all potential sites equally.

3.10.3.5 Heating – Kuugruaq

The information in 3.2.7 Heating applies equally to all sites.

3.10.3.6 Electricity – Kuugruaq

The information in 3.2.8 Electricity applies equally to all sites.

3.10.4 Access – Kuugruaq

The Kuugruaq site can be made accessible using the same road design for Igrugaivik shown in the USACE (1998) report. The 1998 report has a road design consisting of a 3 feet of fill, with 2 to 1 side slopes. The road width is 20 feet wide. The close proximity of the Kuugruaq site to the Igrugaivik site would necessitate only a short road extension to access the Kuugruaq site.

The proposed barge access road shown in Figure 15 would provide access to the Chukchi Sea for residents of a new community developed at Kuugruaq. The road should provide community access to both the sea and the lagoon.

The location of the site, inland from the lagoon, places it far enough away from the Chukchi Sea so that watching for whales from the site will not be possible.

The Wulik River makes up the west boundary of the Kuugruaq site. Access to the river can be direct from the site. If a gravel boat staging pad is not constructed at the barge landing at the Singauk Inlet, it could be built at the site to provide a more protected moorage for the community's boats.

Beach access from this site could be by foot or four-wheeler over the proposed gravel road to the Singauk Entrance, or by boat from the Wulik River, downstream to the entrance.

Constructed gravel roads from the new village site at Kuugruaq may be expensive to construct and maintain. A 1.47mile long Singauk Entrance access road cost is required. Additional road length may be required to reach the new runway and the Kuugruaq village site.

Road access to subsistence sites from the Kuugruaq site may be limited to the corridor between the Singauk Entrance barge landing and the new runway north of the Igrugaivik site, a maximum of approximately 3 miles. Access to areas to harvest greens, berries and hunt small game along the river or coastal beach is good. Traveling inland to the east or south from this site may be difficult over the soft soils and wet ground cover.

3.10.4.1 Goods & Supplies – Kuugruaq

A barge landing could be located on the beach southwest of the Kuugruaq site. Access to the barge landing to offload goods and supplies may be via a 1.75 mile long access road.

At the barge access site a 1 acre staging area should be constructed to enable loading and unloading of the barge. This staging area should allow the community to stage the materials and ferry them to the new village.

Goods and supplies can also be delivered via air. The location of the new airstrip is discussed in the following section.

3.10.4.2 Air Transportation – Kuugruaq

The location of the new airstrip would be at the same site as the Kiniktuuraq airstrip; approximately 7,500 feet northeast of the Kuugruaq village site. The relatively close proximity of the airstrip to the village would make it convenient for residents to access. Access to the airstrip would be over an approximately 1.75 mile long access road. A new airport should be constructed prior to occupancy of the new village site. Refer to Section 3.1 for general recommendations.

3.10.4.3 Roads & Streets within Community – Kuugruaq

The road layout within the community is expected to closely reflect the plan in Appendix G for the Phase I study report. Roads should be designed on a grid system to maximize flow of traffic and access to all portions of the new community.

The road system would be constructed on top of the gravel pad installed to protect the thermal regime of the underlying soils. An estimated minimum of 9 feet of gravel may be required for a structural roadbed for community streets.

3.10.4.4 Roads Outside the Community – Kuugruaq

The location of the Kuugruaq site and the soil conditions of the terrain surrounding it make road construction difficult and expensive. It is anticipated that there should be as few roads as possible outside the village, accessing the new airstrip, solid waste facility and lagoon boat moorage area.

The USACE (1998) report describes a total of approximately 2 miles of road for the Igrugaivik site with the airstrip located at the Northeast end of the road, the barge landing at the West end of the road and the solid waste dump site situated between the new village and the barge site, a minimum of 10,000 ft from the runway. Because of new setback requirements for the airstrip, we recommend approximately 3 miles of road to reach all the facilities and still allow for proper distance between the landfill and the airstrip.

3.10.5 Native Allotments

There are two Native allotments in the immediate vicinity of the Kuugruaq site that constrain the layout of a new townsite (see Figure 13). These townsites are located along the northern half of the proposed townsite. Relocation at this site would likely require resolution of the use of these Native allotments and are a potential constraint to use of this site for relocation.

3.10.6 Relocation Costs – Kuugruaq

A construction cost estimate to relocate to this site has been prepared. Design and construction administration are not included in the costs. The cost estimate to build a new village site at Kuugruaq is $245.6 million. Detailed costs are included in Appendix A. A summary is included below:

Site work and Airport Construction	$164,800,000
Erosion Protection	$2,961,750
Construction Camp	$606,000
Power and Fuel	$5,292,000
Move Buildings	$1,125,000
New Buildings	$52,690,000
Water/Sewer System and Landfill	$18,146,638
Transportation System	N/A
Total Cost	**$245,600,000**

3.10.7 Recommended Plan for Kuugruaq

The Kuugruaq Site is the easternmost of the three village sites on the south side of the Singauk Entrance. It is located north and west of the Igrugaivik Site and abuts the Wulik River along its northern edge.

Access to this site should be from the beach barge landing near the Kiniktuuraq site.

The new runway for the village site at Kuugruaq may be located about 1.75 miles northeast of the site. It is anticipated that this area may provide a poor subgrade on which to base the 150 ft X 4,000 ft runway, and a geofabric base may be required to provide support and separation for the muskeg below.

Siting the landfill is more difficult for this site than most of the others because the best location, which is the same as for Kiniktuuraq and Igrugaivik puts it too far away from the proposed village site to ensure it will be properly utilized year round. Locating the landfill on the west side of the new village gravel pad may provide the required 10,000 lf of separation from the new runway, as well as make access to it by the community convenient. This location will place the landfill farther away from the barge landing, but transportation of recyclable materials, batteries and hazmat to the barge landing for shipping can be accomplished by 4-wheeler and trailer or snow machine and sled.

The most likely raw water source for the Kuugruaq Site is the Wulik River. Potential sources of raw water will be investigated in the water study that is currently pending. There are no other known sources of water in the Kuugruaq area. It is anticipated that a raw water intake structure wick be constructed in a thaw bulb, to furnish a year round water supply.

The sewage lagoon may be located east of the town site on the east side of the road to the new airstrip. A surface discharge may be established to dispose of the treated lagoon effluent onto the surrounding wetlands.

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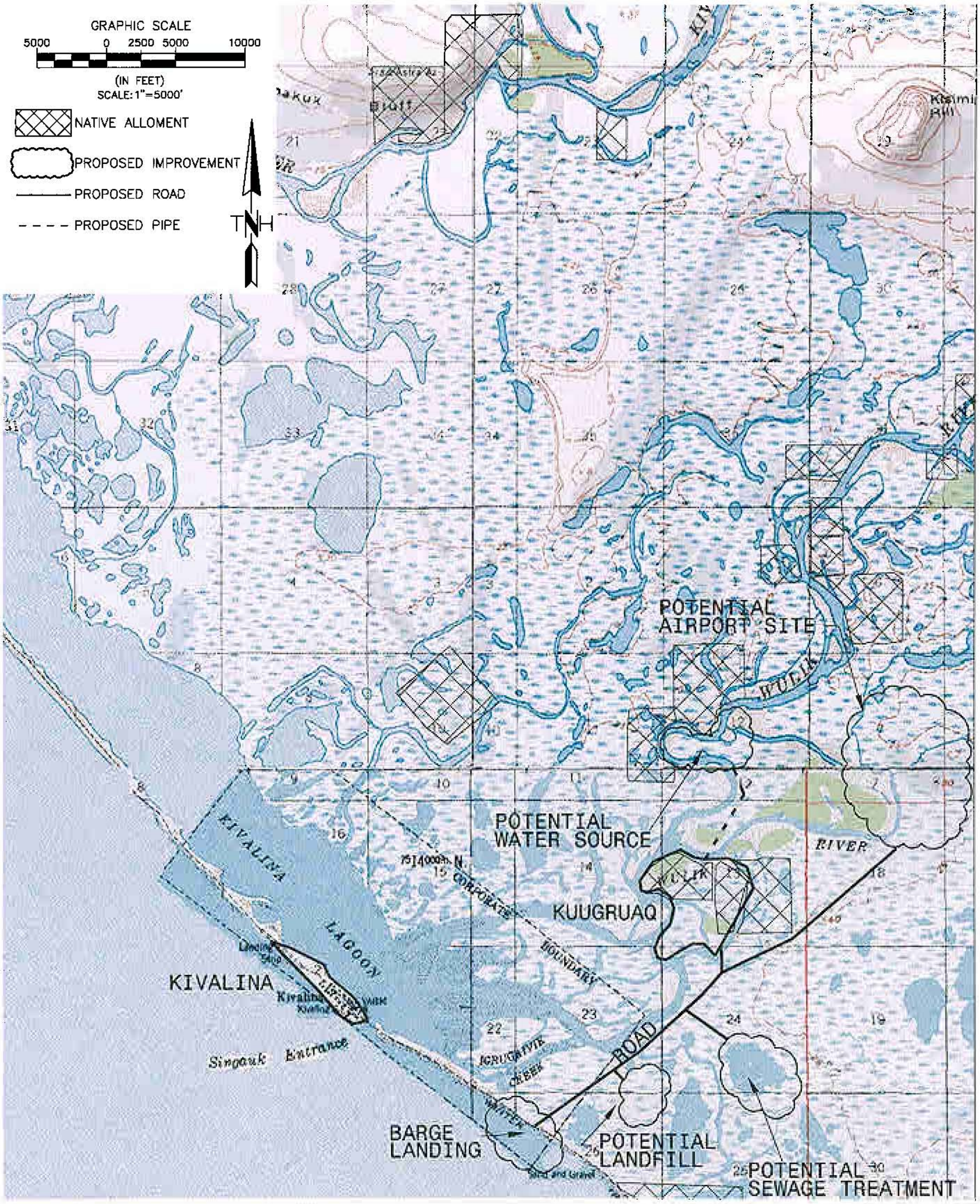

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FIGURE 15

KUUGRUAQ CONCEPTUAL LAYOUT

DESIGN BY: MEW	DATE: 6/16/06
DRAWN BY: JT	PROJECT No: 03003.007
SCALE: 1" = 5000'	REV. -
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FIELD BOOK: -	SHEET 1 OF 1
GRID: -	

3.11 COMPARISON OF ALTERNATIVE SITES

The planning team developed a site comparison matrix to help the community of Kivalina compare the strengths and weakness of the seven sites. The site comparison matrix is qualitative in nature and shows the relative strengths and weaknesses of each site. The 31 siting criteria that are being suggested for site comparison include physical environment factors, construction and utilities factors, social and access factors, and cost implications. These siting criteria are summarized in Section 1.5. These factors are included in a site comparison matrix shown in Appendix D. These factors have been presented to the community for initial consideration on the December 7, 2004 meeting, and were updated with their input from meetings on September 15, 2005 .

3.11.1 Criteria Values and Weighting

The planning team has assigned values to the siting criteria for each site. With the exception of estimated costs, it is not possible to assign a quantitative value to each criterion at this time. For each factor, under the four criteria factor, a qualitative value of 1 to 5 has been assigned. These values have been assigned given the relative strengths and weaknesses of each site; 5 as the highest value showing the greatest benefit/least risk and 1 having the least benefit greatest risk. A value of 3 is considered neutral.

Depending on the perspective of the public and agency stakeholder, not all criteria are of equal importance in selecting a relocation site. For example, subsistence access may not be as crucial to an agency responsible for public utilities as vulnerability to storm surges or erosion hazards. Local residents may feel that the impact of site location on everyday life, such as access to subsistence, cost of travel, and comfort with a site is equally as important as relocation costs.

In the case of some siting criteria, design measures and extra funding can mitigate potential concerns. Of the 31 siting criteria, 8 fall into this category:

- Soils and ice content,
- Sewage disposal availability
- Ease of water storage and distribution
- Solid waste disposal availability
- Gravel requirements to develop the site
- Site for an airport with a crosswind runway
- Site preparation costs
- Access road development costs

Six criteria have been identified as critical to site suitability, and may not be easily mitigated by design and funding. These criteria include:

- Storm surge vulnerability
- Shoreline erosion vulnerability
- Water supply source and quality
- Community expansion potential
- Land status
- Operation and maintenance costs

Finally, the importance of social and access factors to local residents should not be underestimated. Sites that result in higher transportation and utility costs can create economic hardships.

3.11.2 Siting Criteria

A summary of the 31 siting criteria are presented below:

3.11.2.1 Physical Environment

Storm Surge Vulnerability – whether the site is vulnerable to storm surge and flooding, based on the site location, site elevation, and historic observations of flooding. This affects the safety of the site and site preparation/structural design costs.

River Flooding Vulnerability – whether the site is vulnerable to spring breakup and fall flooding, based on the site location, site elevation, and historic observations of flooding. This affects the safety of the site and site preparation/structural design costs.

Shoreline Erosion Vulnerability – whether the site is vulnerable to coastal or riverine erosion, based on the site location, site elevation, soil characteristics (fine grained, ice-rich), aerial photograph analysis, and historic observations of erosion. This affects the safety of the site and site preparation/structural design costs.

Site drainage and wetlands – whether the site has standing water when temperatures are above freezing, has particular drainage issues or problems, and whether the site has jurisdictional wetlands, based on aerial photograph analysis and historic observations of erosion. This affects the site preparation/structural design costs and permitting relocation.

Soils/Ice content – whether the site has soil characteristics such ice-rich, high organic, or water content, which affects the stability of the site given climate change. This affects the amount of gravel needed for site preparations and can affect the site preparation/ structural design costs.

Vulnerability to High Winds – whether the site has exposure to high winds, which can affect snow drifts around buildings and roads, and affect heating bills

Water Supply Source and Quality – location, quantity available, and quality of water supply. This affects the viability of a good town site, and costs involved in pumping, storing, and treating water.

3.11.2.2 Construction and Utilities Factors

Sewage Disposal Availability – whether the site has a pond or other suitable area for sewage disposal and treatment, and other factors such as soil and drainage conditions. This affects the site preparation/structural design costs, permitting, and health considerations

Ease of Water Storage and Distribution – whether site topography and soils lend themselves to water storage and distribution systems. This affects the site preparation/structural design costs.

Solid waste disposal availability – whether the site has a suitable area for landfill, and other factors such as soil, drainage conditions, and separation from an airport site. This affects the site preparation/structural design costs, permitting, wildlife nuisance, and health considerations

Gravel Requirements to Develop the Site – how much gravel the site requires for community development, including soil conditions and need to insulate permafrost, and elevation needs to get out of flood areas. This is one of the primary cost factors in site preparation/structural design costs.

Barge Access Distance to the Site – whether the site has good barge access for unloading construction material, fuel, and freight, and whether an access road to deep water along the coast is required**.** This affects site preparation costs and operation and maintenance costs for a community.

Site for an Airport with Crosswind Runway – whether the site has a suitable location for an airport with a crosswind runway, including orientation to prevailing winds and adequate separation from a community landfill. This affects overall site relocation costs.

Community Expansion Potential – whether the community has an adequate and suitable area for community growth and expansion. Lack of adequate space for community expansion may not solve many of the problems that the community is currently facing.

Ease of Maintaining Two sites during Construction/relocation – whether a site can be easy accessed during construction and for moving facilities between the existing and new town site. This affects relocation costs and schedule.

Permitting Obstacles – whether a site has issues affecting obtaining state and federal permits, including wetlands and sensitive fish and wildlife species. This affects relocation costs and schedule.

3.11.2.3 Social and Access Factors

Distance from Current Village Site – The distance between the community and a subsistence harvest site is both an economic and safety factor. An increase in distance increases fuel cost for ATV, snowmachine, and boat access. An increase in distance also increases travel time, which can be a safety issue in bad weather.

Access to the Ocean – Kivalina residents utilize the ocean for hunting marine mammals and access to traditional use areas. Proximity is a factor in people's comfort with a new town site, and has implications for fuel costs and safety

Access to the Wulik River – the Wulik River is an important area for subsistence fishing, access, and traditional camps. Proximity is a factor in people's comfort with a new town site, and has implications for fuel costs and safety.

Access to the Kivalina River – the Kivalina River is an important area for subsistence access, and traditional camps. Several families have Native Allotments and traditional camp sites along the Kivalina River, and use them for subsistence and cultural purposes.

Proximity is a factor in people's comfort with a new town site, and has implications for fuel costs and safety.

Access to Kivalina Lagoon – the Kivalina Lagoon provides protected boat access for subsistence activities. Proximity is a factor in people's comfort with a new town site.

Access to Subsistence Camps and Traditional Use Areas – whether a site has easy and safe access to subsistence camps and traditional use areas, and has implications for fuel costs and safety**.**

Location of Boat and Gear Storage – whether a site has nearby, adequate, and safe storage areas for boats and subsistence gear. Proximity is a factor in people's comfort with a new town site.

Potential for Ice Cellar Construction – Ice cellars have traditionally been used for food storage. The ability to use existing or construct new ice cellars is a factor in people's comfort with a new town site.

General Comfort with Site – whether the site is one where people would be comfortable living. A site where people are uncomfortable may not make a successful relocation site.

Land Status – whether the site has appropriate ownership availability of land for relocation. A site with native allotments of other potential encumbrances may complicate relocation and add to cost.

3.11.2.4 Cost Implications

Site Preparation – site preparation is potentially the highest cost associated with relocation. A site that requires a substantial amount of gravel may be extremely costly for relocation.

Access Road Development Costs – a site may need access roads to airports, boat access areas, landfills, and to a barge landing. The length of access roads required for a new community site are a factor in construction and O&M costs

O&M Costs – Operations and maintenance costs can affect the viability of a relocation site. Typical costs are associated with roads, utilities and public facilities.

Fuel Costs – Fuel costs can affect the viability of a relocation site. Higher fuel costs are associated with access roads, and increased power generation and space heating needs due to climate.

3.11.3 Preliminary Site Ranking

Of the seven alternative sites, Tatchim Isua receives the highest overall point value, and highest value in all four categories except for Physical Environment (primarily due to uncertainty regarding water supply). Imnakuk Bluff scores relatively high in second place, with resolution of land status being the primary outstanding issue. Simiq scores in the middle range, but there are many unknowns regarding the site, and the community has not previously considered it. The four southern sites, and particularly the two coastal sites (Kiniktuuraq and Existing) receive lower values primarily due to continued long-term vulnerability to flooding and erosion, construction and utility factors. However, these sites score much higher with regard to social and access factors.

Figure 16 **Master Relocation Matrix** **Matrix Criteria**

🟩	site has generally positive attributes associated with this specific criteria
🟨	**site has mixed positive and negative attributes with specific criteria; or criteria is neutral**
🟥	site has generally negative attributes associated with this specific criteria

	Site						
	Tatchim Isua	Imnakuk Bluff	Simiq	Kuuruaq	Igrugaivik	Kiniktuuraq	Existing Site
PHYSICAL ENVIRONMENT							
Storm surge vulnerability	5	5	5	3	3	1	1
River flooding vulnerability	5	5	5	2	2	3	3
Shoreline erosion vulnerability	5	5	5	2	2	1	1
Site drainage and wetlands	4	3	2	3	1	1	5
Soils - ice content	3	3	2	3	1	1	5
Vulnerability to high winds	1	1	3	3	3	3	3
Water supply - source and quality	4	5	2	2	2	1	1
Subtotal Physical Environment	27	27	24	18	14	11	19
CONSTRUCTION & UTILITIES FACTORS							
Sewage disposal availability	5	3	5	3	2	2	1
Ease of water storage and distribution	4	4	2	3	2	1	1
Solid waste disposal availability	5	5	3	1	1	1	1
Gravel requirements to develop site	3	3	2	2	2	1	2
Barge access/distance to site	3	2	1	2	2	5	5
Site for an airport with crosswind runway	4	3	4	3	3	3	2
Community expansion potential	5	5	4	2	2	2	1
Ease of maintaining two sites during construction	1	1	1	3	3	4	3
Permitting Obstacles	4	4	3	2	2	2	3
Subtotal Construction and Utilities	34	30	25	21	19	21	19
SOCIAL AND ACCESS FACTORS							
Distance from current village site	1	2	3	4	4	5	5
Access to the ocean	3	2	1	4	4	5	5
Access to the Wulik River	1	1	1	5	5	5	4
Access to the Kivalina River	3	5	1	2	2	2	2
Access to the Kivalina Lagoon	4	3	1	4	4	5	5
Access to subsistence camps and traditional use areas	2	2	1	4	4	5	5
Location of boat/gear storage	2	2	1	5	5	5	5
Potential for ice cellar construction	3	3	5	5	5	5	2
General comfort with site	2	3	2	3	3	3	3
Land Status	5	2	5	1	5	5	3
Subtotal Social and Access	*26*	*25*	*21*	*37*	*41*	*45*	*39*
COST IMPLICATIONS							
[1] Site preparation costs	5	1	1	1	2	1	3
Access road development costs	4	2	2	3	3	4	5
[2] O&M costs	4	4	3	2	2	1	1
[3] Cost of living (heat, power)	2	2	2	3	3	3	3
Fuel costs for access to subsistence areas, airport, dock	1	2	2	3	3	4	4
Subtotal Cost Implications	16	11	10	12	13	13	16
COMPARATIVE TOTAL	103	93	80	88	87	90	93
RANK	1	2	7	5	6	4	3

[1] **Site preparation cost estimates range from $155 to 252 million**

[2] **O&M costs reflect differences in costs per village, mostly for maintaining errosion and flood barriers**

[3] **Costs for heat and power are assumed to be higher in areas where terrain is subject to higher winds (hillside sites)**

4 PUBLIC INVOLVEMENT

4.1 PUBLIC INVOLVEMENT OVERVIEW

Public involvement for the project includes public, KRPC, and agency meetings, and the collection of public opinion and comment. Public meetings will be held in the village of Kivalina and may involve a combination of presentations and open house format. Residents of the village will be given the opportunity to comment on the project through other means as well.

4.2 PUBLIC INVOLVEMENT PURPOSE AND NEED

It is crucial to receive public input to successfully complete this project in part because of the need for community acceptance of a new town site and the controversial nature of the project itself. The task of site selection ultimately falls to the residents of the village, who must consider issues such as physical environment, social factors, construction and utilities, cost factors, and access to subsistence areas while making their decisions. Public meetings for this project are particularly important not only because of the project's significance, but because of its time frame and the potentially contentious nature of the site selection process.

Public involvement is an important part of the site selection process. It includes meetings with the KRPC, public meetings, house-to-house visits, discussions with community leaders and facility operators, and meetings with classes at the McQueen School.

4.3 PUBLIC INVOLVEMENT ACTIVITIES

4.3.1 Public Meetings

Village suggestions on site comparison factors and characteristics were solicited during three meetings: a public meeting in December 2004, an Elders Council meeting in September 2005, and a public meeting in December 2005. Given the amount of information presented at the December meeting, it was difficult to obtain comments on the strengths and weaknesses of specific sites. Consultation with the Native Village of Kivalina resulted in the suggestion to use the Kivalina Elders Council to provide their knowledge and experience with regard to the alternative relocation sites.

An Elders Council Meeting was held on September 15 at 6 pm. Approximately 25 elders were present. The intent of the meeting was learning from the elders any traditional knowledge they have about the six proposed sites for village relocation, specifically with regards to the physical environment and subsistence activities.

Elders were asked to help answer a series of questions for each of the relocation sites under consideration. Information learned on each of the sites is summarized in "Strengths" and "Weaknesses" table below.

Site	Strengths	Weaknesses
Kivalina (no action)	Good subsistence access.	Extreme erosion taking place – has become a public safety issue.
Imnakuk Bluff	No flooding around this site.	Rocky shoreline along the river that is hard on boats.
	No known erosion problems.	Water has potential to be salty below the bluff due to tidal influences.
		Wind is much stronger at this site.
		Subsistence access is a problem due to the shallow lagoon and preferences to use the Wulik River over the Kivalina River.
		Barge access would be a problem; a road would have to be built from the site.
		Higher cost of living due to increased transportation (gas) needs.
Kuugruaq	Gravel is in the area, but is on a Native allotment.	Area floods during spring breakup.
	Existing water source is near Kuugruaq	
Tatchim Isua	Above flood levels.	Water supply would have to be pumped from further up the Kivalina River or a different creek.
	No known erosion problems.	Wind and snowfall is stronger than at Kivalina.
		Area would not be good for subsistence due to difficulty of transport through the shallow lagoon.
		Higher cost of living due to increased transportation (gas) needs.
Kiniktuuraq	Water supply would be similar to Kivalina (pumping from a source upriver).	Site is sinking – would have to add gravel every year.
	Original relocation site chosen by the people.	Lots of erosion along the coast.
	Would result in the least amount of cultural change for the community.	Soils are just mud and ice – very swampy; Deep drainage ditches on site

Site	Strengths	Weaknesses
		Not as much water access for subsistence.
Kiniktuuraq		Area was flooded during recent storms Gravel pad would have to be put in place to raise the site above flood level.
Igrugaivik	Doesn’t flood that often.	Soils are a mixture of silt/ice or gravel/ice. Higher areas are mostly ice.
	Not a lot of erosion – primarily during the high waters in the spring.	
	Subsistence access is good.	
Simiq		No community support for this site.

The strengths and weaknesses of the existing Kivalina site were not discussed in any detail. Most community members in attendance felt that the Kiniktuuraq site was very similar to the current Kivalina village site. They were concerned with the potential for the same levels of erosion and flooding, however felt that Kiniktuuraq would get much calmer weather. The subsistence access from Kiniktuuraq was felt not to be quite as good as from around Kivalina.

August 2004 Community Visit and Public Meeting: Members of the planning teams from COE, URS, and TNH took part in a community visit and public meeting on August 23, 2004. The purpose of the visit was to hold the public meeting, conduct an agency meeting, and conduct site visits to the potential town sites.

Members of the planning team attended a joint meeting (the KRPC, the City of Kivalina, NVK, and NWAB) held at the city hall offices on August 23, 2004. Attendees discussed the current status of the project. Issues involving project progress and community concerns were also discussed.

The community public meeting was held at 7pm at McQueen School. The meeting presented the scope of work, introduced representatives from involved agencies, and presented plan objectives to the community. The meeting also included discussion of planning efforts and tasks for the current phase of planning.

December 2004 Community Visit and Public Meeting: The second meeting was held on December 7th, 2004 and was comprised of a review of the October 28th agency meeting in Anchorage, review of steps in the relocation process and schedule, a site comparison workshop, and a discussion of the next steps in relocation. A KRPC meeting was held at City offices prior to the public meeting. A National Environmental Policy Act training workshop was held the morning following the public meeting.

December 2005 Community Visit and Public Meeting

On December 12, 2005, a community meeting was held at 7 pm at McQueen School. The meeting presented the draft report and recommendations.

4.3.2 Agency Meetings

October 2004 Agency Meeting: On October 28, 2004, the USACE, TNH, and URS held an agency meeting on the Kivalina Relocation Plan studies. Attendance generally included representatives of various state and federal agencies that would likely have a role in relocating the community of Kivalina, and included representatives of the Kivalina IRA, the City of Kivalina, the KRPC, and the Northwest Arctic Borough (NWAB) (see attached sign-in sheets).

The intent of the meeting was to provide a briefing on the progress of studies associated with the relocation of Kivalina, specifically initial considerations regarding the phasing and schedule for relocation. Given the potential funding resources, program jurisdictions and requirements, and expertise of the agency participants, it was felt that they could provide important review and feedback regarding the information being presented. There were four items that were listed as agenda items:

- Overview of Project and Current Scope of Work
- Review of Phasing and Funding Considerations for Master Schedule Development Items
- Presentation of Draft Master Relocation Schedule for Discussion
- Suggestions and Revisions for Draft Master Relocation Schedule

4.4 SUMMARY OF COMMENTS

4.4.1 Public Comments

Among the most significant concerns brought forth by the people of Kivalina are the following:

4.4.1.1 Gravel

The residents of Kivalina are concerned about the amount of gravel necessary to construct a new town site. During past public involvement activities, residents were advised that the gravel requirements for a new town site make the move barely feasible. The need for large amounts of gravel has led to significant community distress.

4.4.1.2 Costs

The costs of the project are daunting. Availability of funding is questionable, and residents are concerned that if there is no funding, they may not be able to move their village regardless of the problems they have with the current site.

4.4.1.3 Time frame

Some residents have worked on the relocation project for over ten years. The current schedule shows that completion is not possible within the next seven years. Lack of progress on the project is an enormous concern for residents.

4.4.1.4 Sanitation, Health, Water and Sewer

Currently the village of Kivalina has no water and sewer. Sanitation and health are difficult for residents to maintain while using honey buckets and dumpsites. Residents have expressed their strong desire for more efficient sanitation for the village

5 CONCLUSIONS

Steady erosion has threatened the Village of Kivalina for nearly two decades. The potential loss of the town site to the encroaching sea is a dire concern for the community. Storms in the winter of 2004 caused the erosion of the beach near the school and fuel farm. One occupied house was undercut by erosion and had to be evacuated. In 2005, storms have threatened the airport runway, school housing, and the fuel farm, and the season for fall storms is not yet over. With each new storm, the threat of erosion continues.

The existing town site is already limited in land, as it is surrounded by water on all sides. Sanitation is insufficient and presents a serious health issue for residents. Recent projects to upgrade sanitation have been cancelled because the funding agencies will not fund projects that are threatened by erosion. Funding agencies are also reluctant to fund improvements to the existing town site, since the community may have to be relocated. Ongoing housing shortages, a general lack of community sanitation systems, and a pressing situation with ongoing erosion have led the community to pursue relocation of the village.

5.1 Challenges With All Sites Currently Under Consideration

Any of the sites under consideration for Kivalina relocation that are analyzed in this report can be technically constructed. However, the analysis conducted for this report, including siting criteria and site evaluations, indicate that none of the sites currently under consideration are ideal for relocation. Previous and recent geotechnical investigations indicated that soils are ice-rich under all the sites being considered except the current Kivalina site and Tatchim Isua. No potential town sites rank high in all four of the major site evaluation criteria categories: physical environment, construction and utilities factors, social and access factors, and cost implications. This is best illustrated by a comparison of Kiniktuuraq and Tatchim Isua.

Kiniktuuraq was chosen by referendum as the community's preferred site for relocation in 2000. It is favorable in terms of location near the existing site and location for subsistence access. The site requires minimal access roads and has good barge access. It also ranks high in terms of subsistence-related and O&M costs, and many in the community are comfortable with the site. However, Kiniktuuraq is subject to coastal erosion and flooding, and is underlain by permafrost. Site preparation may require a substantial amount of gravel (a minimum of 9 feet) to elevate it above flood levels and insulate the permafrost. Given current trends in climate change, this and all other low-lying coastal sites are likely to prove infeasible.

Tatchim Isua is not particularly good for access to subsistence resources. Its general location makes access to subsistence resources problematic, and shallow water depth at the end of the Kivalina Lagoon limits boat access. For this and other cultural reasons, the community does not appear to be comfortable with the site. The site may also require access roads to both barge landings and boat launch areas, and the location of water supply has yet to be identified. However, the site is above any coastal or riverine flood elevations, and has the best soils of any of the sites under consideration. The site may likely require the least amount of gravel of any of the sites under consideration.

As shown above, Kiniktuuraq, selected by the community as the preferred site, and Tatchim Isua, the best site from a construction standpoint, both present difficulties. The other sites under consideration are even more problematic. Coastal sites are the most susceptible to erosion and flooding. Some coastal and riverine sites are also underlain by permafrost. Gravel pad and other site preparation requirements would be extensive, and could still be subject to erosion, flooding, and other storm damage over time. Low lying sites are likely to experience problems with sewage disposal, landfills, and water supply. Sites that are located above areas prone to flooding and erosion are less likely to have good coastal and river access for subsistence activities or barges that supply fuel and freight. They may require longer access roads to areas that provide boat and barge access. There is less community comfort with these sites compared to coastal and river sites, and they may entail increased costs associated with subsistence activities due to longer travel times.

The comparison of those two sites also shows that even sites with good coastal and riverine access for subsistence and traditional use purposes may be insufficient to support the new village immediately. Both the new site and the existing town site must be maintained during relocation.

5.2 Rapidly Changing Environmental Conditions

There is ample evidence that environmental conditions in the Arctic, including the Kivalina area, have been changing rapidly. These changes may be linked to long-term climate change, and include:

- **More severe fall storms** – fall storms on the Chukchi Sea are more severe and can occur later in the fall/winter season.
- **More severe erosion and flooding** – the severity of fall storms, coupled with delays in ice formation on the Bering Sea, have increased the frequency and severity of erosion and flooding events at Kivalina.
- **Accelerated permafrost melting** – communities throughout the Alaskan arctic are seeing an increase in permafrost melting and subsequent ground settlement.

These changes have significant ramifications in selecting a relocation site that will be safe and can be maintained over the long term. They also have significant implications for construction design and costs of sites that are subject to these climate change-related events. Even if designed properly, long-term trends make it difficult to maintain integrity and could entail continual O&M costs. Based on the increasing threats to low-lying sites along the coast and rivers, and to ice-rich sites in general, further consideration of the existing Kivalina site, Kiniktuuraq, Kuugruaq, Igrugaivik, and Simiq are not recommended for further consideration. Only Imnakuk Bluffs and Tatchim Isua should remain under consideration.

Due to the challenges with existing sites, it may be appropriate to consider additional sites. Any consideration of additional sites should include consideration of long-term climate changes. Potential sites include a higher rocky area behind the Simiq site, and a location that could access both the Wulik River and the Red Dog road system. It cannot be over-emphasized that any sites for future consideration should be subject to geotechnical investigation to determine the presence and nature of ice in the soil.

5.3 Cost Considerations

Appendix A indicates that while there is a wide range in the total relocation costs between the sites, given the assumptions identified for this study, the least expensive site is over $150 million (Tatchim Isua), and the most expensive site is nearly $252 million (Simiq). Site preparation and construction is by far the major cost element of relocation, ranging from approximately one-third to over two-thirds of total relocation costs, and gravel for site pads and roads is the most significant component of site preparations. Because of the need to elevate sites above flooding levels and/or insulating ice-rich soils, cost estimates included an assumption of a gravel pad at least 9 feet thick due to the substantial amount of gravel required to prevent melting the permafrost. Part of the high cost was an assumed need to import the volume of gravel required.

New approaches to the volume and source of gravel are needed. Alternative design assumptions such as aboveground utilities, flush and haul systems, boardwalks, pile building foundations, and use of gravel capped pads could reduce the amount of gravel required. Local sources of gravel, such as Tatchim Isua and the mountain behind Simiq could also reduce gravel costs, if the volume and characteristics of the gravel on those sites are suitable for construction purposes.

Costs associated with site and facility operations and maintenance, access to airports and ports, and additional travel time for subsistence and other traditional activities are vital considerations. Longer distances to airports, ports and subsistence areas can substantially increase fuel costs and raise safety concerns.

Sites with continued exposure to flooding, erosion, and permafrost melting may have ongoing and potentially costly maintenance requirements.

Finally, initiating and sustaining Kivalina relocation activities will require a large infusion of funding. Such an amount is beyond the normal program capacity of state and federal agencies, and would likely require a combination of specific funding actions by Congress and the Alaska State Legislature.

5.4 Schedule Considerations

Appendix C addresses the master schedule for relocation. Given the number of agencies involved, necessary approvals, facility requirements, and complexity of Kivalina relocation in addition to design, permitting, NEPA compliance requirements, and construction timeframes would result in a schedule of at least 10 years. Relocation of Kivalina cannot wait 10 years, given current conditions and threats to safety and property. A streamlined emergency response approach needs to applied to shortening the schedule, with a single agency involved as overall lead for relocation. All participating agencies must recognize the severity of the risk to Kivalina, and work together to shorten program and regulatory requirements. This type of approach could shorten the schedule for relocation to three to five years. In the meantime, some form of effective emergency erosion and flood protection needs to be installed at Kivalina to protect lives and property.

5.5 The Community Situation Is Dire

As indicated throughout the report and in preceding sections of the conclusions, the current situation in Kivalina is dire. Fall storms are increasing in severity and frequency, and a significant amount of shoreline has been lost in the last two years alone. Erosion is threatening to damage the airport runway, school and associated housing, and the fuel farm. Should this occur, it could become difficult to maintain a functioning community. While an emergency evacuation plan has been completed, plans for an emergency evacuation road are under way, and some limited local erosion protection has been put in place, more immediate and coordinated action is needed. Without action, Kivalina does not have even five years for relocation.

5.6 New Relocation Solutions Are Needed

More work is needed prior to taking the next step of design or construction, and this involves some new thinking. Ongoing water source studies and geotechnical investigations may confirm the suitability of certain sites for construction. Site control for the selected relocation site may have to be obtained. Native allotments overlap or border Tatchim Isua, Imnakuk Bluff and Kuugruaq.

Relocation Schedule. Based on uninterrupted steady progression of funding, design, and construction, it would take 10 years to completely move the village to a new site. Maintaining a 10-year schedule is optimistic under current regulations. A key feature of maintaining schedule is to obtain funding for the master planning stages; detailed feasibility studies; environmental studies; and seed money to start construction of major components such as airports, roads, harbors, and site grading/pad. The community of Kivalina, Northwest Arctic Borough, and participating state and federal agencies need to develop an accelerated schedule that protects the public interest in environment and expenditure funds while expediting response to an emergency situation.

Relocation Costs. In 2005 dollars, construction cost estimates to move the village range from $123 million to $249 million. Costs need to be adjusted during progression of the project to account for inflation and to add engineering and construction management costs. New approaches and assumptions for gravel requirements and source, site design, and facility design can reduce relocation costs, as potentially can the consideration of a limited number of new sites. These items need to be investigated immediately

Agency Coordination. In order to move Kivalina, agency coordination is critical. Currently, the Corps of Engineers is assisting with the initial planning stages. However, it does not have funds and specific authority to lead the project past the planning stages. Other agencies such as ANTHC have a strong role in the community, but they do not have the authority or technical expertise to lead a village relocation project. A strong "lead" agency may be needed to keep the project moving, coordinate with other funding agencies, and to assist the community through the process.

Emergency Erosion Protection. Immediate action is needed to design and construct emergency erosion protection to protect critical community facilities. A system must be funded, designed, and constructed prior to next fall's storm season(2006).

Finally, while this study has a relocation matrix that shows factors for selecting a site, the initial rankings for a village site may need to be reviewed and updated during public involvement steps between the 95% and 100% reports. At that stage, a recommendation and conclusions can be made about selecting a village relocation site. This final report incorporates the views of the community and other interested agencies, and provides objective information for the community to consider while deciding which alternative plan is most appropriate, affordable, and sustainable.

5.7 Next Steps

The next steps in the relocation process involve three sets of activities.

<u>Pursue Temporary Erosion Protection Measures.</u> Temporary measures are needed to protect the school and fuel facilities from erosion. The community of Kivalina, working with the Northwest Arctic Borough,

Alaska District Corps of Engineers, and other entities such as the Denali Commission should work cooperatively to obtain funding, design and construct suitable erosion protection structures.

Confirm Community Selection for Relocation Site. The community needs to carefully review this report and the advantages and disadvantages associated with each sites, including relative risk and likelihood of receiving addition funding. The choice of a site for relocation should then be confirmed in a formal referendum.

Initiate Next Steps in Implementing Community Relocation. The Master Relocation Schedule in Appendix C lays out the estimated phases and specific steps to proceed from site confirmation to completion of relocation. The next steps in Phase Three, Planning, are as follows:

- Obtain funding for selected site planning and design activities
- Initiate comprehensive master planning for the selected site
- Complete specific infrastructure and utility feasibility studies and initiate grant applications for design and construction
- Identify agency to lead future funding, design and construction efforts associated with relocation
- Acquire design and permitting phase funding

Completion of these steps will lead to initiation of project design phase (Phase 4).

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