Quinhagak
Hazard Impact Assessment

City of Quinhagak

February 10, 2012

Prepared by

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To Whom It May Concern:

The Quinhagak City Council and the Native Village of Kwinhagak recognize the need to make informed decisions about future planning and long term sustainability for the community. To that end, in February 2009 the city applied to the Alaska Climate Change Impact Mitigation Program administered by the Division of Community and Regional Affairs for funding to complete a plan focusing on natural hazards, particularly those related to the impacts of climate change. In May 2011, the City hired POWTEC, LLC and sub-consultant Tetra Tech, Inc. to perform a Hazard Impact Assessment for the community.

On January 30, 2012 the Quinhagak City Council reviewed the *Quinhagak Hazard Impact Assessment* report and took public comment on the report. Recognizing the potential threat of climate change to the community, it is the City Council's wish to be proactive in addressing hazards. The Council finds the assessment of potential impacts presented in the *Quinhagak Hazard Impact Assessment* to be accurate and useful and accepts this report as an approved planning document for the community of Quinhagak, subject to additional edits and changes made by the consultant following the Public Hearing and City Council review.

Sincerely,

Willard Church, Mayor
City of Quinhagak

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Executive Summary and Plan Purpose

The Quinhagak (QUINN−uh−hawk); var. Kwinhagak; Hazard Impact Assessment plan documents local climate change impacts and vulnerability, identifies knowledge gaps, and presents mitigation and adaptation activities in the form of recommendations to help the State prioritize climate impact investments.

This Quinhagak Hazard Impact Assessment identifies the nature of climate-change related impacts from erosion, flooding, storm surge, and thawing permafrost that could result in one or more of the following hazards to the community, and provides recommended actions for response to the identified impacts listed below.

The climate-change impacts of erosion, river and stream flooding, coastal storm surge, and thawing permafrost[1] threaten residential dwellings and community infrastructure. All four of the State of Alaska's impacts are concerns in Quinhagak.

1. **Risk to life or safety during storm or flood events:**
   - Two homes are at particular risk from river erosion and are both less than 50 feet from experiencing loss or damage.
   - Two additional homes received some flood waters inside, with a total of four homes surrounded on three sides during the November 9th &10th, 2011 coastal storm surge flooding.

2. **Loss of critical infrastructure**:
   - Shoals in front of the City Dock caused by siltation, sedimentation, and shifting river channel disrupt access.
   - The length of the old airport runway, the runway apron, and the east end of runway are impacted by river erosion.
   - The Clinic/Washeteria Building has differential settling caused by melting permafrost.

3. **Threats to public health:**
   - The deteriorating condition of the clinic building has a failing foundation system with which puts the overall building at risk of condemnation;
   - Surface and groundwater contamination from the Footprint Lake landfill/sewage lagoon, while not directly related to climate change, are public health threats.

4. **Loss of 10% or more of residential dwellings:**
   - Water infiltration was at or surpassed 40% moisture content in 55 of the 165 occupied houses, which means more than 33% of the Quinhagak housing stock, has been determined to be beyond repair and facing imminent collapse due to extensive dry-rot and deterioration.

Each of the climate impacts are discussed in more detail in **Chapter 3** with recommended actions included in **Chapter 4**.

[1] Wildfires were not included as a climate impact because of the location of Quinhagak and low probability of tundra

Chapter 1: Introduction

The City of Quinhagak applied for, and was awarded, a grant to fund the development of a Hazard Impact Mitigation Assessment plan. The City applied under the Alaska Climate Change Impact Mitigation Program (ACCIMP) administered by the Alaska Department of Community and Economic Development, Division of Community and Regional Affairs (DCRA). This Hazard Impact Assessment plan is intended to document climate-related changes impacting the community and include recommendations for immediate, mid-term and long-term studies, projects, and other actions.

Preparation of the City of Quinhagak Hazard Impact Assessment is the first step in the ACCIMP process. The Hazard Impact Assessment identifies and defines the climate change-related hazards, establishes current and predicted impacts, and provides recommendations on studies, projects, and other actions to mitigate the hazard impacts. Prioritized needs, urgency of actions and funding possibilities including through additional ACCIMP grants, other funding sources, or local actions are included in Chapter 4.

Public Involvement

Three meetings were held when public input was provided with tribal and city council leaders involved, and good comments were obtained each time.

The Native Village of Kwinhagak (NVK) maintains a Community Development and Special Projects Site on the internet at http://kwinhagak.org/. This web site is owned by the NVK, and according to the home page, is intended to support collaboration among NVK Tribal departments, NVK Tribal contractors, partner agencies and other project stakeholders. This site was used to obtain additional information from community sources.

The City of Quinhagak prepared a compelling application for, and received an Alaska Climate Change Impact Mitigation Program (ACCIMP) legislative appropriated grant to fund the development of this Hazard Impact Mitigation Assessment Plan.

During the preparation of this plan, Christy Miller with Tetra Tech, traveled to Quinhagak to hold public meetings. She met with city council and staff, NVK, corporation, and residents to discuss the local hazards and climate impacts they were witnessing in the community and region. Most areas impacted by hazards were inspected. Meetings to collect input for this plan were held: August 9th and10th, 2011, and January 30th and 31st, 2012. A final city council meeting was held February 14th, 2012 to review the plan without the consulting team present.

Appendix A includes details of public involvement meetings, interviews, and a list of agencies or individuals contacted in the preparation of this Hazard Impact Assessment.

Community Description

The majority of community services in Quinhagak are provided by NVK. NVK is the community entity responsible for a variety of public and community services, including

health and social service, community development programs, environmental, land and natural resources, and housing. The City of Quinhagak is owner of many of the public facilities.

Qanirtuuq Inc., which is the village corporation, has a vital role in the community. They own and operate the native store and manage a fuel facility which supplies fuel to homes.

The Lower Kuskokwim School District (LKSD) has a K-12 school in Quinhagak with 150 students and 12 teachers.

Location

Quinhagak is on the south bank of the Kanektok River, on the east shore of Kuskokwim Bay, less than a mile from the Bering Sea coast. Quinhagak (pronounced QUINN-uh-hawk, also known as Kwinhagak) is 71 miles southwest of Bethel and lies at approximately 59° 45' North Latitude, 161° 54' West Longitude (Section 17, Township 005S, Range 074W, Seward Meridian). Quinhagak is located in the Bethel Recording District. The city limits of Quinhagak encompass 4.7 square miles of land and 0.6 square miles of water.[2] The community is 420 air miles southwest of Anchorage.

Topography and Vegetation

The land surrounding Quinhagak is characterized by intertidal areas, wetlands, and swampy floodplains. The topography of the area ranges in elevation from less than six feet to approximately 22 feet above mean sea level. Numerous shallow lakes, ponds, and streams of various sizes dominate the landscape. Sedges, tundra grasses, mosses, and cotton grass blanket the upland terrain. Gently rolling, treeless upland plains extend from the Kanektok River floodplain eastward to the Kilbuck Mountains and southward toward the Arolik River floodplain. Patches of brush are present in the river floodplain. Alluvial deposits of sand and gravel underlie the inactive and active floodplain along the Kanektok River. The dominant landform in the upland areas is re-transported fluvial and eolian deposits overlying fluvial and/or glacial outwash deposits of sand and gravel. Along the coast to the south and west of Quinhagak are marine beach and tidal deposits. Lacustrine deposits are associated with tundra lakes in the upland areas. Tundra grasses, sedges, and mosses blanket most of the upland natural terrain. The lower floodplain of the Kanektok River supports thick willow growth and grass cover. Quinhagak is at the southern extent of the zone of discontinuous permafrost. The upland terrain in the region is typically underlain by permafrost. However, permafrost is locally absent beneath bodies of water and beneath the Kanektok River floodplain.[3]

JOA Surveys, LLC, an Alaska based surveying company specializing in tides and water level measurement, vertical datum's and geodetic networks, collected tidal data during the summers of 2010-2011 along the Bering Sea Coast including Quinhagak to update Nautical Charts for the National Oceanic and Atmospheric Administration (NOAA). In addition to updating Nautical Charts the tidal monitoring data collected during 3-4

[2] Department of Community, Commerce, and Economic Development (DCCED), Division of Community and Regional Affairs (DCRA) on-line community profile (2011).

[3] Duane Miller Associates LLC, 6/15/2009 Geotechnical Exploration and Data Report- DRAFT Material Source Assessment Quinhagak, Alaska.

months during the two-summer project will also serve NOAA's effort to bring "Datum" to Alaska. Datum was first introduced to support a seamless bathymetric - topographic digital elevation model (DEM). Datum allows transformation of bathymetric and/or topographic elevation data among different orthometric, ellipsoid/3-D, and tidal datum's. Expansion of VDatum to Alaska, when completed, is expected to enable NOAA and other agencies and institutions collecting coastal and offshore spatial data to seamlessly integrate that data despite different vertical datum's used.

Geologic Setting

Marine beaches characterized by coastal delta deposits of interlayered alluvial and sediments are along the coast to the south and west of Quinhagak. The dominant landform in the upland area is re-transported fluvial and eolian deposits overlying glacial outwash deposits. Lacustrine deposits are associated with the tundra lakes in the upland area.

Materials underlying Quinhagak are typical of the area and include coastal deposits of inter-layered alluvial and marine sediments and coastal delta deposits. The old airport rests on alluvial deposits in the floodplain of the Kanektok River. To the south of the community are marine beach and thawed lacustrine deposits.

Groundwater

Groundwater can be found at fairly shallow depths within thawed areas of the floodplain, and at depths of 150 feet or more in areas with permafrost. There are no known operational wells in Quinhagak other than the three Water Treatment Plant wells drilled beneath the Kanektok River. All previous wells drilled in the area were either dry, or produced considerable iron and color, according the CRW Engineering Group.

History and Archaeology

Quinhagak's Yup'ik name is Kuinerraq, which means "new river channel." Quinhagak is a long-established village whose origin has been dated to 1000 AD. It was the first village originally located on the lower Kuskokwim to have sustained contact with Europeans. Gavril Sarichev reported the village on a map in 1826. After the purchase of Alaska in 1867, the Alaska Commercial Company sent annual supply ships to Quinhagak with goods for Kuskokwim River trading posts. Supplies were lightered to shore from the ship and stored in a building on Warehouse Creek. A Moravian mission was built in 1893. There were many non-Natives in the village at that time; most were waiting for boats to go upriver. In 1904, a mission store opened, followed by a post office in 1905 and a school in 1909. Between 1906 and 1909, over 2,000 reindeer were brought in to the Quinhagak area. They were managed for a time by the Native-owned Kuskokwim Reindeer Company, but the herd had intermingled with migrating wild caribou and scattered by the 1950s. In 1915, the Kuskokwim River was charted, so goods were barged directly upriver to Bethel. In 1928, the first electric plant opened; and the first mail plane arrived in 1934. The city was incorporated in 1975 as a second class city in the Unorganized Borough.[4]

[4] DCRA, Quinhagak community profile (2011).

In 2001, Walking Dog Archaeology conducted a preliminary archaeological review of the Quinhagak area that was included in CRW Engineering's 2002 Water and Sewer Feasibility Study. The findings and conclusions of that review are as follows:

- A search of the Alaska Historical Resource Survey maintained by the State Office of History and Archaeology revealed that there are no known historic properties in the immediate vicinity of Quinhagak. There is one known site, GDN-010, located 3.6 miles to the south-southeast. This was the Village of Arolik (Agaligamute) that was abandoned in the first part of the 20th Century.

- There have been two archaeological surveys in Quinhagak itself. The first survey was conducted in 1978 in conjunction with a Public Health Service water and sewage disposal project. The second survey was conducted in conjunction with a Bureau of Indian Affairs roads project that investigated not only areas within the community, but also the road right-of-way and material sources to the south. Neither of these surveys revealed any historic properties. An additional survey required in response to a fuel spill 0.6 miles west of the community also yielded no historic properties.

Population

The community is primarily Yup'ik Eskimos who fish commercially and are active in subsistence food gathering. Over 97% of the residents recognize themselves as Alaska Native. The 2000 census reported a population of 555 and by 2010 the census population was at 669[5] but in 2009 Department of Labor and Workforce Development population estimate was 680. Over half of the current population is between 20 and 54 years of age. The American Community Survey estimated 135 households, with the average family size of 5.21 persons, although household size was slightly less at 4.53 persons per household.[6]

Most of the employment in Quinhagak is with the school, government services, or commercial fishing. Trapping, basket weaving, skin sewing, and ivory carving also provide income. Subsistence remains an important part of the livelihood; subsistence upon salmon, seal, walrus, birds, berries, moose, and bear is an integral part of the lifestyle.[7]

Local officials have also indicated the 2010 population figures are low with current populations estimated at 757 [8] residents, and a significant influx of summer transients.

Table 1. Quinhagak Population by Decade (US Census Data)

Year	1950	1960	1970	1980	1990	2000	2010
Population	194	228	340	412	501	550	669
% Change	-	17.53%	49.12%	21.18%	21.60%	10.78%	20+%

[5] April 2010 Census.
[6] American Community Survey 2005-2009, 5-year estimates.
[7] Quinhagak Climate Impact project application.
[8] DCRA population estimate 2010.

Housing

NVK operates its own housing department and administers a range of funding, including Native American Housing Assistance and Self Determination Act of 1996 (NAHASDA) Indian Housing Block Grants, Indian Community Development Block Grants, and U.S Department of Housing and Urban Development (HUD) Imminent Threat funding.

Economy

Quinhagak residents are highly dependent upon fishing for their incomes. In 2010, 83 residents held commercial fishing permits for salmon net and herring roe fisheries. Coastal Villages Seafood LLC (CVS) no longer processes halibut and salmon in Quinhagak due to the siltation at the City Dock area. The CVS plant only produces ice having moved processing to Platinum according to the Kwinhagak Tribal administrator. The population increases by 40 during the fishing season. Quinhagak is inundated with tourists attracted to the fishing on the Kanektok and Arolik Rivers, known for their abundance and numerous variety of fish (rainbow trout, Arctic char, Dolly Varden, grayling, pike, all five species of Pacific salmon - kings, sockeyes, chums, pinks, and silvers). Most of the tourists go through several fishing guide companies in the area. However, according to the Mayor and other community members only one resident is employed by the guide companies and the visitors contribute very little to the overall economy of the community.

Table 2. Income[9]

Per Capita Income	$8,127
Median Household Income	$25,156
Median Family Income	$38,281

Table 3. Poverty

Percent Below Poverty: 26.1%

Quinhagak was included in the 2011 annual update of the distressed community list prepared by the Alaska Department of Labor and Workforce Development (DOL&WD), Research and Analysis Section. The DOL&WD uses the most current population, employment and earnings data available to identify those Alaska communities considered "distressed". The distressed status is determined by comparing average income of a community to full-time minimum wage earnings, the percentage of the population earning greater than full-time minimum wage earnings and a measure of the percentage of the population engaged in year-round wage and salary employment.

Climate

Some sources consider Quinhagak to be located in a marine climate[10], while others classify the climate as a transitional climate between maritime and continental conditions[11]. Continental conditions are the prevalent winter climate, whereas Quinhagak summers are maritime, thus the maritime continental zone. Alaska's

[9] US Census 2000, as reported in the *Dock and Marine Infrastructure Improvements Technical Report.* Prepared by USACE and Denali Commission, (June 2010).

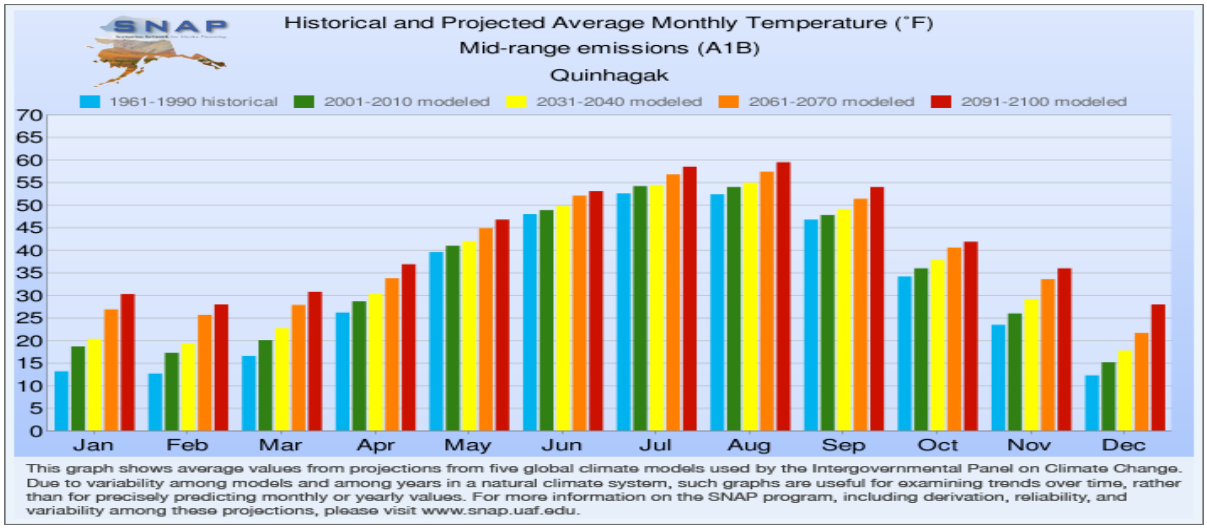
[10] DCRA Quinhagak community profile.

[11] Alaska Climate Research Center, Geophysical Institute, University of Alaska Fairbanks.

maritime continental zone includes the western portions of Bristol Bay and west-central zones. In this zone the summer temperatures are moderated by the open waters of the Bering Sea, but winter temperatures are more continental in nature due to the presence of sea ice during the coldest months of the year. Precipitation averages 22 inches a year, with 43 inches of snowfall. Summer temperatures average 41 to 57 °F, and winter temperatures average 6 to 24 °F. Extremes have been measured from 82 to -34 °F. The prevailing winds in Quinhagak come from the south and southwest during summer months, changing to predominantly from the north and northeast from September through March. The winter months also receive the high percentage of winds from the east and southeast. Winds during the spring are variable.

The Scenarios Network for Alaska Planning (SNAP) is a collaborative organization linking the University of Alaska, state, federal and local agencies, and non-governmental organizations. The primary products of the network are (1) datasets and maps projecting future conditions for selected variables, and (2) rules and models that develop these projections, based on historical conditions and trends. The Quinhagak Historical and Average Monthly Temperature graph that follows, depicts five scenarios for global climate including historical temperatures from 1961-1990. This modeling is useful for looking at trends over time. This graph can be examined for certain key changes and threshold values. For example, mean monthly temperatures shifting above freezing in spring and fall are of particular interest for Quinhagak, signifying a loss of ice and/or frozen ground needed for travel or food storage, or a shift in precipitation from snow to rain, and longer periods of warmer soils. All models show warming which will lengthen the months above freezing expanding to November in the fall and March, even April by the 2091-2100 models. Warmer temperatures across all seasons may impact permafrost and land-fast ice.

Table 4. Quinhagak Historical and Average Monthly Temperature
Source: UAF, SNAP http://www.snap.uaf.edu/about



It is important to note that uncertainty associated with each of these graphed values. Uncertainty stems from the modeling of atmospheric and oceanic movements used to create the GCMs, from the PRISM downscaling process, and from the assumptions made regarding greenhouse gas levels for each emission scenario. Variability between the

five GCMs is generally in the range of 0-4°F for temperature and 0-0.7 inches for precipitation. In general, a higher percentage of uncertainty is associated with precipitation values than with temperature values.

How the Community Charts Data Was Derived

SNAP climate models rely on output from Global Circulation Models (GCMs) used by the Intergovernmental Panel on Climate Change (IPCC). Each model was created by a different research team using slightly different data and assumptions. Model output for past years was compared to actual climate data for the same time period, and selected five GCMs (from a total of fifteen) based on their accuracy in Alaska and other northern regions. SNAP then scaled down outputs to the local level using data from Alaskan weather stations and PRISM, a model that accounts for land features such as slope, elevation, and proximity to coastlines. Information for each community is based on the closest 2km by 2km grid square from SNAP's statewide datasets.

Table 5. Total Change in Mean Seasonal and Annual Temperature (°F), 1949 – 2009 Bethel First Order Weather Station

Region	Location	Winter	Spring	Summer	Autumn	Annual
West Coast	Bethel	6.6	4.8	2.3	0.0	3.5

Source: Alaska Climate Research Center, Geophysical Institute, University of Alaska Fairbanks http://climate.gi.alaska.edu/ClimTrends/Change/TempChange.html .The date for first-order weather stations, with Bethel being the nearest to Quinhagak, show actual warming trend data based on longer period records and more detailed records. However Quinhagak has temperature variants that are more dramatic due to the warming effects.

Quinhagak's clinic/washeteria building was designed based on the values presented in the *Environmental Atlas of Alaska* by Hartman and Johnson (University of Alaska, 1978). Based on the charts in Hartman and Johnson, Quinhagak has winters that are about 10°F- days warmer than Bethel and summers that are only slightly warmer according to Duane Miller Associates[12].

Transportation

Quinhagak relies on air transportation for passenger mail and cargo service. A state-owned 4,000 foot long by 75 foot wide gravel airstrip is available. Float planes land on the Kanektok River. A harbor and dock serves barges with deliveries of heavy goods at least twice a year. Boats, ATVs, snow machines, and some vehicles are used for local transportation. Winter trails are marked to Eek (39 mi) and Goodnews (39 mi), all according to the DCRA community profile for Quinhagak.

The Quinhagak/Kwinhagak airport is managed by NVK and is a non-state airport.

[12] Duane Miller Associates, *Foundation Movements Washeteria Building, Quinhagak, Alaska,* letter to David Nairne & Associates, Ltd. (June 30, 2006).

The new airport at Quinhagak was opened in November 2004. The USACE reported in 2010 that frost heaving has resulted in an uneven runway surface, including a large heave that has restricted takeoff and landing weights, causing inefficiencies.

The old airport was decommissioned in 2004. The rate and magnitude of erosion at the old airport site is exacerbated during the spring months when the river is at its highest levels. Also, during the summer of 2011 river stages remained high continuing to exacerbate bank erosion.

Unreliable access from the open water of Kuskokwim Bay at the mouth of the Kanektok River to Quinhagak hinders the delivery of fish products, fuel, and other goods to the City Dock. Insufficient water access also hinders the export of processed seafood, results in lower quality and lost fish product, and limits search and rescue operations according to a U.S. Army Corps of Engineers (USACE) June 2010 technical report on the dock and marine access problem.[13] The USACE further reported that vessels from surrounding villages almost exclusively deliver their catch to a tender in Kuskokwim Bay as they are unfamiliar with the changing channel of the Kanektok River. However, local boats need to access the river in order to return home. The fish processing plant near the City Dock is no longer used for processing (only ice making) because of the problems in accessing the dock. Boats including the fuel and supply delivery barges have become stuck on sandbars or are forced to stay out of the mouth of the Kanektok River until the tide rises to a point that allows them to return to port. Vessels are often damaged, necessitating the repair or replacement of motors and hulls.

[13] USACE, Dock and Marine Infrastructure Improvements Technical Report, Quinhagak, Alaska (June 2010)

Chapter 2: Identification and Description of Hazards and Climate Impacts

Climate Impacts

> ***"Climate Impacts:*** *consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts. Potential impacts: All impacts that may occur given a projected change in climate, without considering adaptation. Residual impacts: The impacts of climate change that would occur after adaptation."* *Definition Earth System Science Partnership (ESSP)* www.essp.org

Climate models show that Arctic regions are most sensitive to global warming. Recent scientific findings indicate that physical characteristics of the Arctic atmosphere, ocean, and land have been changing since the 1970s. Precise records of the 1990's show acceleration of these changes. Detailed documentation of accelerating climate impacts is difficult without established baseline data and analysis of impacts over time.

Hazard Identification Process

Two of the 10 fundamental principles for the framework and objects of the nation's mitigation strategy are:

- All mitigation is local
- Hazard identification and risk assessment are the cornerstones of mitigation

Mitigation means sustained action taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Hazards are identified through collection of historical information and local knowledge, and review of existing plans and studies.

Analysis of Identified Hazards

Flooding

The developed areas of Quinhagak are adjacent to the floodplain of the Kanektok River. The U.S. Army Corps of Engineers (USACE) rates flood hazards in Quinhagak as high, noting that the Kanektok River is subject to constantly changing channels and severe bank erosion.

Because of its close proximity to the Kuskokwim Bay on the Bering Sea, Quinhagak is also subject to storm surge (coastal flooding) as well as a backwater effect during tides up river adjacent to the village during these coastal events. Storm surge is an abnormal rise of water generated by a storm, over and above the predicted tide level.

The Kuskokwim Bay at Quinhagak is completely exposed to storms from the Bering Sea. The November 1974 Bering Sea Storm, and the floods along the Yukon-

Kuskokwim Delta from the November 8th through10th, 1979, brought extensive damage to the many coastal communities. The Yukon-Kuskokwim Bay from Quinhagak to Pastol Bay slopes very gently into the sea and is totally exposed to Bering Sea coastal storms.[14]

Table 5. U.S. Army Corps of Engineers, Flood Plain Management Services Quinhagak Flooding

Comments: The following information is based on a temporary benchmark (TBM) with an assumed elevation of 100 feet. The TBM is located on the front porch of the new Quinhagak School, out from the center of the door.

SURVEY INFORMATION AS OF JULY 1994	
1978 Flood Level (Flood of Record)	86.5'
Recommended Building Elevation	88.5'
First Floor of the Clinic	95.4'
Front Doorsill of the City Office Building	94.4'
Front Porch (1st Floor) of the City Power Plant	95.1'
Bottom of Fuel Tanks (Near Power Plant)	92.7'
Center of Doorsill of the Old Moravian Church	90.7'
Tidal Float Debris from the Fall, 1993, Storm	88.5'
Spring breakup generally does not cause flooding. However, river levels rise significantly three to four weeks after spring breakup due to snow melt in the mountains. The river at times floods the airport road due to this rise.	

The 1978 flood was considered by the USACE to be the flood of record with the 1978 flood approximately 9.0 feet above sea level. The USACE recommends building levels in the flood prone areas of Quinhagak to be at least two feet above the 1978 flood level – that is 11.0 feet above mean sea level.

The November 2011 coastal flooding did not reach the elevation of the 1974 flood but did cause damage to fish drying racks.

The Seward Peninsula, Norton Sound, and Lower Yukon area are identified as having the greatest frequency of reported storms in the now historical, but still useful report: *Storm Surge Climatology and Forecasting in Alaska*[15]**.** The objective of this study was to

[14] Living with the Coast of Alaska, Owen K. Mason, William J. Neal, and Orrin H. Pilkey, Duke University Press (1997).
[15] *Storm Surge Climatology and Forecasting in Alaska,* Wise, J., Comiskey, A. and Becker, R., Arctic Environmental Information and Data Center (AEI&DC), University of Alaska, (August 1981).

improve the quality of life and the security of property in coastal areas susceptible to flooding by enhancing the decision-making process for human activities and development by compiling historical climate data to develop a surge forecast regression equation.

There is only one stream gage on the Kanektok River and it is maintained by the U.S. Fish and Wildlife Service on the right bank, 7 river miles downstream from the confluence with Takshilik Creek, 19 river miles upstream from the Togiak Wildlife Refuge wilderness boundary, and 28 air miles east of Quinhagak (Latitude 59 E 46.66' N., longitude 161 E 05.10' W., in SW ¼ SE ¼ Sec. 35, T. 4s., R.69W on Goodnews D-6 quadrangle). The Kanektok River has a drainage area of 767 square miles, of which 761 square miles is located within the Togiak National Wildlife Refuge, all within the Wilderness Area of the Refuge.

Drainage

Localized drainage and stormwater accumulation is a problem in Quinhagak particularly during spring break up and the summer. Water flows generally from the south-southeast crossing to the north-northwest, passing through the community to drain into the Kanektok River. The drainage pattern flows through large wetlands and lake complexes including the old Footprint Lake Sewage Lagoon, then narrowing to a small stream that passes under Qunirtuuq Drive (See Appendix B Photo Log Figure 3 and 4) between the Moravian Church and the old Quinhagak Subdivision, passing under a small wooden bridge before entering the Kanektok River.

The local roads overtop in several locations, including the Quinirtuuq Drive culverts which at 24 inches each are undersized, and the small wooden bridge constricts flows causing water resulting in localized flooding. Some erosion occurs from this drainage running into the river, but the majority of the erosion problems are from the river itself and coastal erosion. Contamination with high e coli and fecal coliform is also reported along this drainage way during open water seasons and many children in the village play in and around these waters.

Erosion

Erosion has been and continues to occur along the banks of the Kanektok River and the Kuskokwim Bay coastline. The old airport was decommissioned in 2004 because of the rate and magnitude of erosion. This situation is exacerbated during the spring months when the river is at its highest and swiftest levels. The City Dock and harbor area also show signs of erosion, although siltation in this area is the most series hazard to the utility of the City Dock. The peninsula of land between the harbor and the Kuskokwim Bay continues to narrow due to erosion. Should this peninsula fail, likely in the area of an old gravel extraction site near its point, the City Dock and harbor will not be sheltered from open coastal waters. Additionally, more materials from erosion will fill the harbor rendering it non-navigable, which is currently nearly the case. On the right bank of the harbor is the "Old Village" which in impacted by high tides and storm surges. In the past 40 years the old cemetery has been lost and houses have had to be moved to escape loss into the river. Fish drying racks and fish-smoking sheds, located a little further up

the river have been lost or moved due to erosion, all according to the Quinhagak Community Development Plan (March 9, 2010).

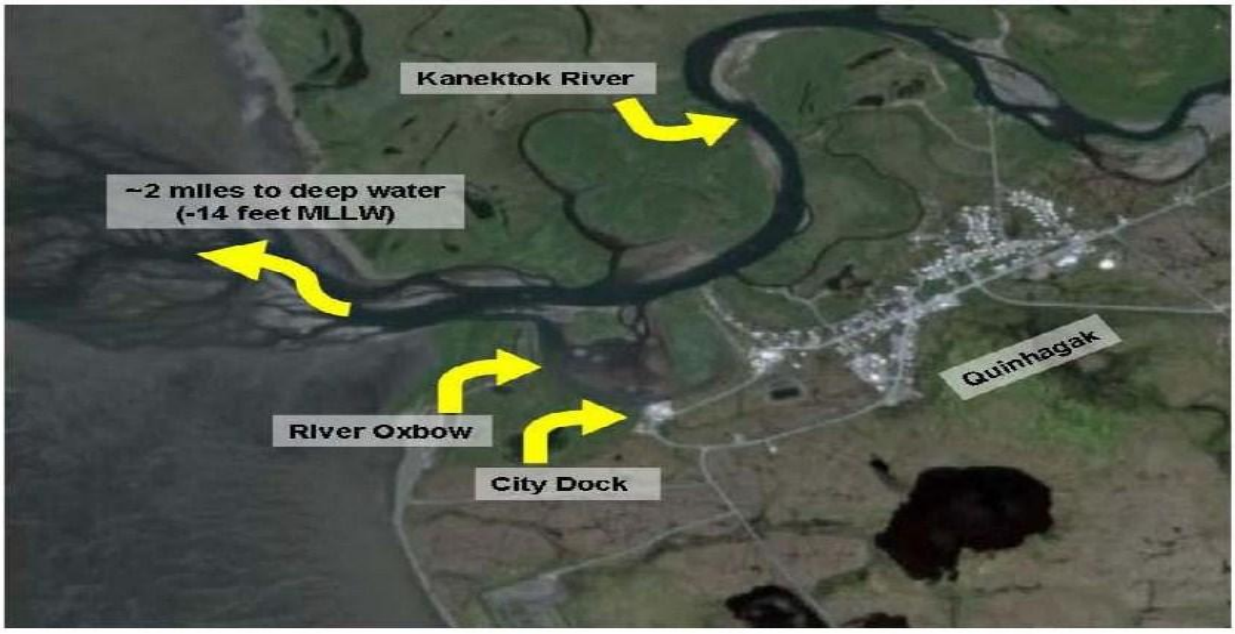
There are approximately 22 people in five residences and approximately 20 essential fish camps located in areas exposed and historically prone to erosion. Two of the five residences could be lost within 1 to 5 years if not moved or replaced based on visual inspections for this Hazard Assessment in August 2011 by a Certified Floodplain Manager (CFM).

Shifting River Channels and Sedimentation

The Kanektok River can be described as having actively migrating meanders, the kinds of are both incremental channel shifts from meander migration and episodic channel shift (avulsion) that occurs when a meander bend is cut off. Predicting hazards related to episodic or avulsed channel shifts is beyond the scope of this project. However, incremental channel shifts from incremental meander migration appear to be having adverse impacts and are documented by the U.S. Army Corps of Engineers (USACE), and others.

The USACE reported in their 2010 *Technical Report of Dock and Marine Infrastructure Improvements* that vessels from surrounding villages almost exclusively deliver their catch to a large tender in Kuskokwim Bay as they are unfamiliar with the changing channel of the Kanektok River and allows fishermen to avoid traveling to the City Dock thereby avoiding the risk of grounding. Due to the navigational conditions the tender is not able to come to the City Dock. However, local boats need to access the river in order to return home. The Coastal Villages Seafood's (CVS) fish processing plant near the City Dock is no longer used for processing, only ice making, because of the problems in accessing the dock according to updates provided by the City Mayor and Tribal Administrator. Boats including the fuel and supply delivery barges have become stuck on sandbars or are forced to stay out of the mouth of the Kanektok River until the tide rises to a point that allows them to return to port. Vessels are often damaged, necessitating the repair or replacement of motors and hulls.

The Quinhagak City Dock is located in a bend of the Kanektok River that is slowly silting in and will eventually form an oxbow lake. The channel from this oxbow exits into the Kanektok River near its confluence with the Kuskokwim Bay. Silty conditions and large tidal action in Kuskokwim Bay have left multiple deposits at the mouth of the Kanektok River leading to these challenging navigational conditions for vessels trying to access the City Dock (USACE, 6/2010). In the last 20 years, navigational conditions at Quinhagak have deteriorated from local fishermen being able to utilize 26 foot boats equipped with outboards. To the current situation in which fishermen must use shallow draft boats equipped with jet motors according to local residents interviewed.



Map showing Kanektok River and City Dock on river oxbow is from the ***Dock and Marine Infrastructure Improvements Technical Report***, USACE & Denali Commission, (June 2010).

Permafrost and Ground Failure

Permafrost is permanently or perennially frozen ground. Defined by temperature only, it is a combination of soil, rock, water, and other buried materials that has been frozen naturally at 0 degrees Celsius (32 degrees Fahrenheit) or less for two consecutive years or more.[16]

"The average annual temperature of the ground surface, thermal properties of the subsurface materials, and geothermal gradient of the earth primarily determine the thickness of permafrost. Other factors that affect the occurrence and thickness of permafrost include the vegetation layer, snow cover, slope and aspect of the surface, surface water, and groundwater. Removing vegetation and its insulating effect usually causes the surface temperature to rise and underlying permafrost to thaw during summer months. The insulating effect of deep snow tends to prevent the formation of permafrost. Southward-facing slopes receive more solar radiation and are less likely to be underlain by permafrost than are northward-facing slopes. Warming effects of streams, rivers, lakes, and oceans can cause permafrost beneath these water bodies to be thin or absent." [17]

The relationships between climate and permafrost surface temperature are exceedingly complex. Even the case of warming air temperatures is not straightforward. Warming of annual mean air temperatures can be a result of a general shift in all seasons or seasonal shifts such as warmer or longer summers (defined here as the period when the ground is snow free) or warmer or shorter winters (when snow is on the ground).

[16] Alaska Department of Environmental Conservation definition, 1999.
[17] Magee, Gregory; William, Rice "Rethinking Landfill Development and Operation in Permafrost Regions", 2002.

Since winters are longer than summers in permafrost areas, cooler summer temperatures can be offset by warmer winter temperatures resulting in a net warming.[18]

Permafrost is impervious to infiltration of water and affects the movement and discharge of surface water and groundwater. Sand and gravel deposits may contain flowing groundwater that conducts sufficient heat to melt the permafrost or keep permafrost from forming. Soil type and water content affects the presence of permafrost, as different types of soils and rocks conduct heat at different rates. In discontinuous permafrost areas, silt in alluvial and glacial deposits is more likely to contain permafrost than sand and gravel embedded in silt.

As described by University of Alaska researchers in permafrost studies in the Seward Peninsula (also applicable to the area around Quinhagak) "Ice-rich permafrost maintains a relatively low permeability, greatly restricting infiltration of surface water to the subsurface groundwater and vice versa. Wetlands and numerous tundra ponds exist. These ponds are sustained above the permafrost, or perched, due to the limited internal drainage. As the climate warms in summer and winter, the permafrost will become warmer. The active layer (the layer of soil above the permafrost that freezes and thaws every year) will become thicker and the bottom of the permafrost will become closer to the ground surface (Figure 1). When the permafrost thaws, unfrozen channels develop between and below ponds allowing subsurface drainage to occur throughout the year. Talik formation (a patch of unfrozen ground in an area of permafrost) can also occur."[19]

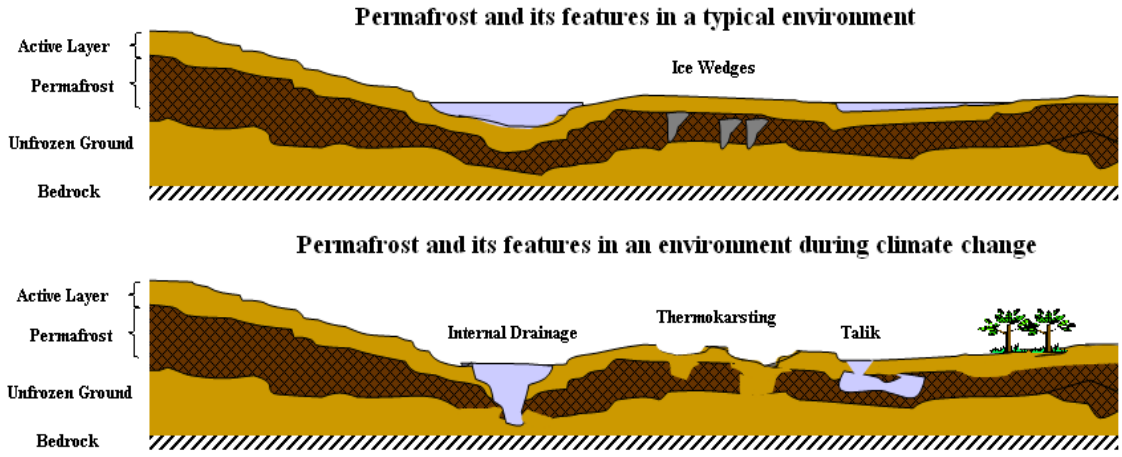


Figure 1. Consequences of a climate warming on permafrost and hydrology. Thawing of permafrost result in drainage of ponds, thermokarsting where ice rich soil and ice wedges degrade, talik formation and deepening of the active layer.

A Quinhagak resident described in his own words "There is an underground current of water that travels from the lake south of Qanirtuuq Drive, surfaces and floods over little

[18] Osterkamp, T.E. Geophysical Institute, UAF, Characteristics of the recent warming of permafrost in Alaska, Journal of Geophysical Research, Vol. 112, (2007).
[19] Hinzman, Larry; Liljedahl, Anna; Busey, Bob, "Permafrost, Hydrology & Climate Change on the Seward Peninsula" International Arctic Research Council, University of Alaska Fairbanks, website: http://www.iarc.uaf.edu.

bridge and causes overflow flooding."[20] Other than this resident's local knowledge of the groundwater flows, it is unknown if this is a talik formation.

Soils

The delta tundra soils within the community are characterized by organic material over saturated silts, with shallow discontinuous permafrost. A typical soil sample in the Quinhagak area has a foot or more of peat overlying saturated silts and permafrost. The areas permafrost is typically ice rich and relatively warm (31°F). The depth to permafrost varies depending on soil type and other localized factors, but can usually be found within 4 feet of the surface and may extend for several hundred feet. When thawed, the soils are typically saturated. The results of a December 2000 soils investigation for the sewage lagoon located southwest of Quinhagak showed a soil profile of tundra/peat underlain by organic silt according to CRW Engineering Group. The organic mat varied from a few inches thick to as much as 1-foot thick. The underlying organic silt extended to an average depth of about 2 feet.[21]

The geotechnical investigations for the new airport prepared by Duane L. Miller, P.E. reported in a July 17th, 1996 report that previous investigations in the upland areas of the Quinhagak area found peat and organic silt over silt to depths as great as 17 feet and underlain by sand and gravel deposits. The three borings for the high school were drilled to depths of 20 to 30 feet and showed icy organic silt and silt to depths of 10 to 17 feet and sand and gravel below those depths. Ground temperatures at depth were 31°F.

For the exploration of the runway alignment and borrow sites the Department of Transportation and Public Facilities (DOTPF) drilled 43 borings. Most of the borings were in the river floodplain area and showed unfrozen conditions in the 10 to 25 feet depths that were explored. The soil underlying the Kanektok River and its most recent meanders are well drained thawed sands and gravels. Qanirtuuq Corporation has designated several of these areas as material borrow sites. The Kanektok River floodplain is typically capped by silt and underlain by sand and gravel with varying amounts of silt.

By contrast the typical delta tundra soils are susceptible to thawing from thermal disturbances and are soft and highly compressible when thawed. Near surface frozen soils degrade rapidly when the overlying vegetative mat is disturbed.

Summary of Borings

Boring	Boring Description	Date	Total Depth	Organic Base	Top of SP/GP	Permafrost	Temp at depth
1	Near existing runway	4/8/95	10.0'	0.5"	0.5'	No	n/a
2	Upstream floodplain	4/8/95	12.0"	Trace	10.0'	No	n/a
3	Upstream floodplain	4/9/95	29.0'	Trace	8.0'	No	n/a
4	Upland Drainage	4/9/95	20.5'	6.0"	11.5'	No	35.1ºF at 15.5'
5	Upland Tundra	4/9/95	19.3'	4.0'	12.0'	Yes	31.5ºF at 16'
6	Upland Drainage	4/9/95	20.5'	4.0'	12.5'	No	33.8ºF at 15.5'
7	Upland Tundra	4/10/95	19.5'	3.0'	12.0'	Yes	31.5ºF at 19'
8	Upland Tundra	4/10/95	19.0'	2.0'	12.0'	Yes	31.5ºF at 10'
9	Upland Tundra	4/10/95	19.5'	1.5'	12.5'	Yes	30.9ºF at 19'
10	Upland Tundra	4/10/95	20.5'	3.0'	17.0'	No	32.8ºF at 20'
11	Upland Tundra	4/11/95	19.0'	3.0'	12.0'	Yes	32.0ºF at 19'
12	Upland Drainage	4/11/95	15.5'	3.0'	9.0'	No	33.5º at 14'
13	Upland Tundra	4/11/95	30.0'	4.5'	11.0'	Yes	31.9º at 25'

[20] John Sharp, Quinhagak resident describing underground current, January 31, 2012, plan comments.
[21] Native Village of Kwinhagak Piped Water & Sewer Feasibility Study, CRW Engineering Group, (May 10, 2002).

Hydrology

There is only one stream gage on the Kanektok River and it is maintained by the U.S. Fish and Wildlife Service on the right bank, 7 river miles downstream from the confluence with Takshilik Creek, 19 river miles upstream from the Togiak Wildlife Refuge wilderness boundary, and 28 air miles east of Quinhagak (Latitude 59 E 46.66' N., longitude 161 E 05.10' W., in SW ¼ SE ¼ Sec. 35, T. 4s., R.69W on Goodnews D-6 quadrangle).

The Kanektok River has a drainage area of 767 square miles, of which 761 square miles is located within the Togiak National Wildlife Refuge, all within the Wilderness Area of the Refuge.

Counting salmon escapement in the Kanektok River has been attempted by biologists since the 1960s, by use of sonar, a counting tower and starting in 2001, a weir on the Kanektok River. All previous attempts have failed, partially due to the high water flow and unstable gravel banks of the Kanektok River. For these reasons, the floating weir is located approximately 42 river miles upstream of Kuskokwim Bay, in an area where the river runs in a single channel and has relatively stable banks.

Storm Surge Climatology

Communities in low-lying areas such as the Yukon-Kuskokwim Delta are likely to face increased flooding and changing storm surge and storm tracks. Overall, decreasing sea ice extent and resulting increasing wave surge will have greater impact on coastal erosion than will sea level rise per the Arctic Climate Impact Assessment.

The US Army Corps of Engineers (USACE) indicated wave measurements have not been recorded in the area of Quinhagak. The city is located on the Kanektok River, so waves at Quinhagak are not a navigation issue at the barge landing area with the approach to Quinhagak over the Kuskokwim River Delta where a river channel cuts through the delta. A depth limited wave at mean higher high water level (MHHW) over the mudflat with an elevation of 0 feet would be 9.75 feet high.[22] Wind can be extreme at Quinhagak. A wind study was performed by V3 Energy LLC to determine if Quinhagak was a viable candidate for wind turbines. Quinhagak winds are directional from the north-northwest to north-northeast with a lesser south to southeast wind component.

In a telephone conversation with Ruth Carter, DOTPF coastal engineer, she indicated a coastal storm analysis had not been performed for Quinhagak but would be needed to determine storm surge risk to the community.

The coastal area is generally of low relief. The Wise report (et al)[23] indicates the shape of the sea floor is conducive to the formation and enhancement of storm surges. From

[22] USACE and Denali Commission, *Dock and Marine Infrastructure Improvements Technical Report*, (June 2010).
[23] *Storm Surge Climatology and Forecasting in Alaska,* James L. Wise, Albert Comiskey, Richard Becker, Jr., Arctic Environmental Information and Data Center, University of Alaska Anchorage, research funded by the Alaska Science Council on Science and Technology as part of the Alaskan Natural Hazards Research. (August, 1981).

Goodnews Bay northward an adequate fetch can be generated, and east of Goodnews Bay, west-southwest through west is the only directions from which an adequate fetch can develop.

Autumn and late summer are the seasons, now extended through November, for destructive storm surge flooding according to the *Storm Surge Climatology* report published in 1981. The historical record through 1981 indicated two storms accounted for most of the reports of storm surge flooding (November 1979 storm caused storm surge flooding from Cape Newenham to Scammon Bay, unclear were the impacts at Quinhagak.)

Chapter 3: Infrastructure and Climate Impacts

Risk to life or safety during storm or flood events; loss of critical infrastructure and the current impact to infrastructure; threats to public health; and loss of 10% or more of residential dwellings are discussed in this chapter.

Table 7. Summary List of Community Infrastructure

Infrastructure	Description	Owner/Operator
Airport	3,200' gravel runway	COQ / NVK
Bulk Fuel	36 tanks, 380,000 gallons	various / various
Commercial Facilities	Grocery store, small businesses, fish processing plant, sport fishing	various / various
Communications	Local, long distance internet	UUI/GCI
Electric Utility	Diesel generators, overhead distribution system	AVEC / AVEC
Health Care Clinic	Clinic	YKHC / YKHC
Kuinerrarmiut Elitnaurviat School	K-12, 150 students, 12 staff	LKSD / LKSD
Roads	Gravel, fair condition	COQ / NVK
Solid Waste Landfill	New facility	COQ / NVK
Wastewater collection	Honey bucket, haul tanks, piped system	COQ / NVK
Wastewater treatment	Sewage Lagoon	COQ / NVK
Water storage tank	Bolted steel tanks	COQ / NVK
Washeteria	Laundry, shower, sauna	COQ / NVK
Water Treatment Plant	Filtration and chlorination system	COQ / NVK

COQ – City of Quinhagak
NVK – Native Village of Kwinhagak
UUI – United Utilities Inc.
GCI – General Communications Inc.
YKHC – Yukon Kuskokwim Health Corporation
LKSD – Lower Kuskokwim School District (State of Alaska)

Community Sanitation Overview

Based on the findings of a 1993 water and sewer master planning study, the community built a new water treatment plant and washeteria, and installed an initial 30 small haul water and sewer systems. Both the water treatment plant and washeteria are operating as designed, but the small haul system has been difficult and very expensive to operate.

In March 2001, a community survey was performed to determine whether the residents of Quinhagak wanted to continue with the installation of additional haul units or stop and evaluate the feasibility of a piped water and sewer system. Over 60% of the respondents indicated that the NVK, who under joint agreement with the City operates the existing haul system, should “Stop and Study Pipes.” In July 2001, NVK authorized the completion of this study to evaluate the feasibility of a piped water and sewer system, all according to the piped water and sewer study prepared in 2002.[24]

[24] CRW Engineering Group, *Native Village of Kwinhagak Piped Water and Sewer Feasibility Study*, (May 10, 2002).

Based on the community's decision, currently under construction or completed is: 1) an above ground piped water and sewer system, 2) improvements to the existing water treatment plant, 3) a new utility building to house water distribution and sewage collection equipment, 4) a 250,000-gallon water storage tank, 5) a new sewage lagoon, 6) a pump station, and 7) a force main to the lagoon. The DCRA, Rural Utilities Business Advisor (RUBA) program's February 2012 status report summarized the community water and wastewater system as follows, "Quinhagak has a population of 669 with 89 homes connected to the piped water and wastewater system, 28 homes on a flush and haul system, and 58 residences haul water and dump waste in hoppers. There is a watering point at the water treatment plant where residents fill containers free of charge. The community's school is the only commercial customer on the piped water and wastewater system. Water is hauled upon request to the Head Start building and the Qanirtuuq, Inc. Store, the other two commercial customers. The IRA council (i.e. NVK) manages the water and wastewater facilities and employs two water operators and a wastewater operator which are supervised by the Public Works Director. The tribe has been in Alaska Native Tribal Health Consortium's (ANTHC's) billing assistance program since June of 2010. ANTHC bills only residential customers on piped water and wastewater. The water and wastewater department is subsidized significantly by the City of Quinhagak through a memorandum of agreement which closely ties city and tribal governments' day to day business. The tribe owns the lagoon, the utilities building, distribution mains, and the 250,000 and 45,000 gallon water tanks. The city owns the washeteria, water plant, the transmission line from the water plant to the utilities building, and the infiltration gallery. The joint tribal/city council also operates the trash haul and landfill services and the community washeteria. Currently, more than half of the residences are connected to the piped system. Necessary core infrastructures such as the utilities building, two large capacity water storage tanks, distribution lines, and wastewater lagoon have been built to serve the entire community on piped water and wastewater."[25]

Water Infrastructure

The interim water intake system serving the entire community is a 36-inch corrugated metal pipe installed when a slant well was washed out during 2005 flooding that resulted in a State and Federally-declared disaster. The Department of Environmental Conservation, Village Safe Water (VSW) indicates the main climate-related water resource factors for Quinhagak include water quality and hydraulic changes due to a shift in the river channel away from the water infiltration gallery.[26] Decreased efficacy of the source water intake gallery has been documented due to changes in the river course over the years. (IWRA)

Wastewater Infrastructure

A low pressure sewer system is currently under construction. Homes that have not yet been served by the piped sewer system are served by a small haul system or are on honey buckets. The community has a new lagoon that is serving the piped sewer system. The old lagoons for

[25] RUBA Status Report updated February 3, 2012, by Fred Broerman, online at: http://www.commerce.state.ak.us/dca/ruba/report/Ruba_public_report.cfm?rID=661&isRuba=1.

[26] Imperiled Community Water Resources Analysis, for Immediate Action Work Group, An Advisory Group of the Governor's Subcabinet on Climate Change (June 30, 2010).

the school, washeteria, and honey bucket haul are to be abandoned these include: Quinhagak School sewage lagoon, the Washeteria Lagoon and the sewage disposal site "Qemirrayagaak Nanvaak" used for the honey bucket haul, also known as Footprint Lake. CRW Engineering Group has a draft closure plan for the Footprint Lake Lagoon, and is assisting the community in seeking funding to close the lagoon. The new sewage lagoon had not been used as of August 2011, but according to CRW's project manager could be used at any time and is designed to accommodate the honey bucket haul system.

The southwest corner of the new sewage lagoon fence is approximately 294 feet from the Kuskokwim Bay according to measurements taken August 9th, 2011. Coastal erosion is advancing the bluff line along the Kuskokwim Bay but poses no immediate or mid-term threat to the facility. The Public Works Director assisted the planning teams Certified Floodplain Manager in taking the measurements in August and estimated that an additional 50 feet may have eroded along the coastline adjacent to the lagoon during November 2011 coastal storms and high tides.

City Dock and West Docking Area

"*An additional seven communities were identified as possibly benefiting from more involved dredging in order to maintain safe, all-tide access to the sites or to eliminate the need for lightering to shore. One of these sites, Quinhagak, was cited by one operator as needing immediate emergency dredging in order to allow continued fuel deliveries. While one-time boulder/hazard removal may well be practical in the Commission transportation program funding, dredging improvements need to be carefully considered for their long-term stability. Routine or repeat maintenance dredging is not practical under the Commission's funding parameters."*[27]

Siltation and erosion are both taking a toll on the City Dock and harbor area. The peninsula of land between the harbor and the Kuskowim Bay has had dramatic erosion. Should this fail, the City Dock will be no longer be sheltered and chances are the harbor will become non-navigational as a result of discharge materials as the peninsula erodes. This will pose a major hardship for Quinhagak as this is the only functioning dock in the village. It is at this dock that fuel and other cargo is received.[28]

The City Dock is on the inside bend of a meander of the Kanektok River that float planes had landed cross wises in the harbor/river area but no longer can because of the heavy siltation in the meander bend. Also the sediment infill is causing large fuel barge operations such as Crowley Marine Services' fuel barge to become stuck for a full tide cycle once per delivery. Conditions sometimes dictate that fuel be flow in when barge is unable to make a delivery. The USACE estimated that a full fuel load would have to be flown in once every 10 years. Northland Barge Services, which delivers freight to Quinhagak, uses landing craft to lighter freight in and, while rare, Northland sometimes becomes grounded for several days, resulting in costly delays.[29]

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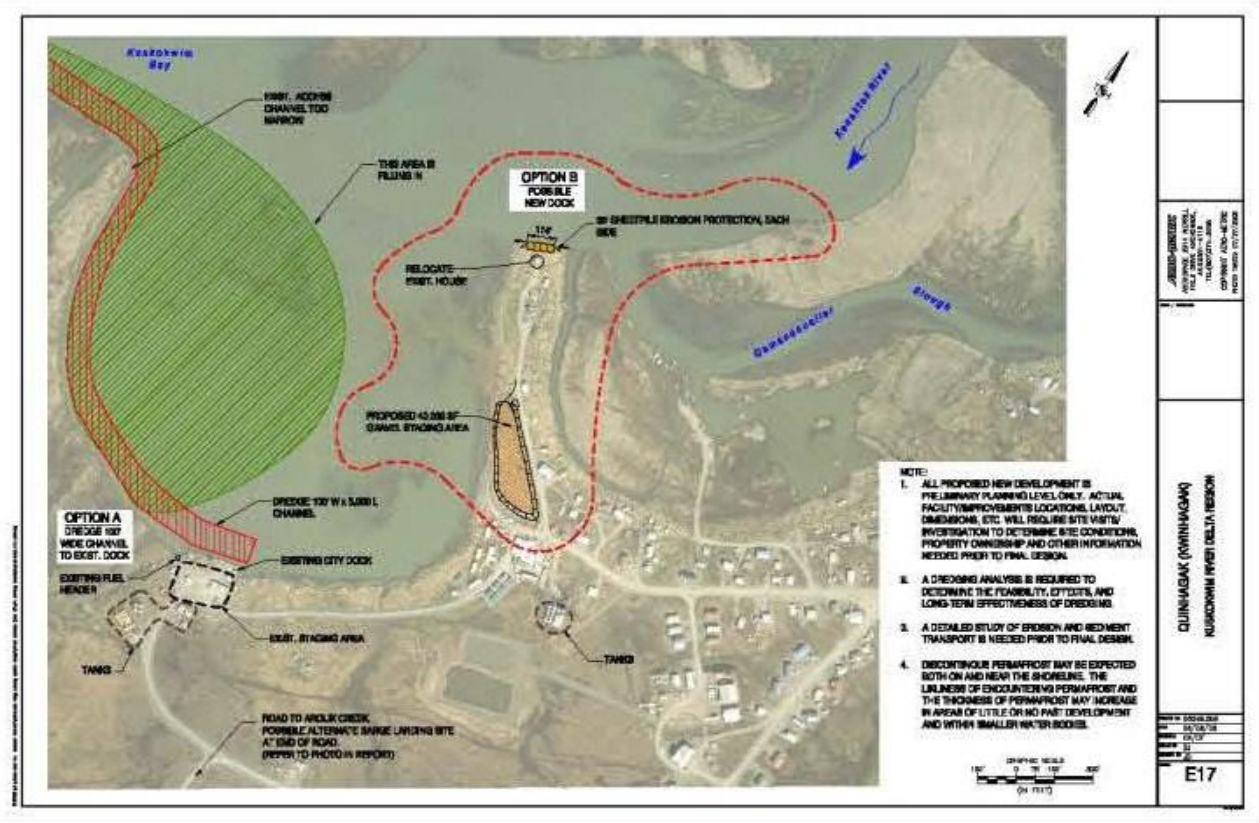
[27] Alaska Barge Landing System Design Study Report, by Tryck, Nyman, Hayes, Inc. for USACE in partnership with Denali Commission (2007).

[28] Alaska Climate Change Impact Assistance Program (ACCIAP) grants application from City of Quinhagak.

[29] USACE, Dock and Marine Infrastructure Improvements Technical Report Quinhagak, Alaska (June 2010), page 3.

The fish plant had served as the regional processor for the Kuskokwim and Goodnews Bay fishing districts. During the season of 2000, the plant produced over 400,000 pounds and employed about 40 people. In subsequent seasons, the plant has produced 1 million to 2 million pounds of high quality headed, gutted, and filleted fish and employed about 100 local people. However, the plant currently only produces ice and is no longer accessible as a processing facility as a result of the siltation that plagues the ox bow where City Dock is located with the plant nearby.



North Docking Area and Boat Harbor

Barging is the dominant re-supply method for Quinhagak as well as communities throughout the Kuskokwim Bay, Alaska Peninsula, the Yukon, Kuskokwim and Kobuk Rivers, and the Bering, Chukchi, and Beaufort Sea coasts of Alaska.

On the right bank of the harbor was the “Old Village.” The old section of the village was impacted by high tides and storm surges. In the past 40 years an old cemetery has been lost and three houses moved. Fish drying racks and fish smoking sheds have all been lost or relocated due to erosion. The elders say the land is sinking. Only seven houses remain. One of these homes is approximately 50 feet from the Kanektok River where rapid erosion is occurring. Another area of concern is the traditional fish drying rack area. The area has seen considerable erosion. It is upstream of the point in the old village but still in the intertidal zone. This area has eroded approximately 30 feet in the last 20 years.

Fuel Storage Areas

Seven different owner/operators of the different tank farms in Quinhagak include:

NVK is co-managing Alaska Village Electric Cooperative's (AVEC) tank farm; Lower Kuskokwim School District (LKSD), manages the school tank farms; Qanirtuuq, Inc., the local village corporation, along with fuel sales, owns and operates the Native Store; the Moravian Church, A & C Market, and the National Guard Armory own tanks with significantly less capacity than the first three providers.

The only contaminated site involved Qanirtuuq, Inc.'s fuel tank, where approximately 4,200 gallons of gasoline were released on June 13th, 1992. The tank farm was then relocated to a lined, bermed area in late summer, 1992. Cleanup was completed the end of summer 1992 with approximately 300 cubic yard area of contaminated tundra remaining in a lined containment cell.

Electricity and Communication Infrastructure

Power poles in the community have in many cases taken on a comical list with repair a continual need. Permafrost and ice jacking create maintenance needs.

The communication infrastructure is a different case with United Utilities, Inc. a wholly owned subsidiary of GCI, building Terra-Southwest, a project to build a next generation communications network in Southwest Alaska. This project is jointly funded with $44 million coming from the USDA Rural Utilities Service and the American Recovery and Reinvestment Act and $44 million in the form of a loan to UUI. In 2012 new consumer broadband offerings to homes and businesses in the 65 communities in Southwest Alaska will be connected on a week-by-week basis. When completed Quinhagak will be included with the total of 9,000 households and 750 public and private institutions in the region that will have access to high-speed broadband internet connections.

Housing

Quinhagak is faced with what has been deemed "a housing crisis" not only as a result of growth in the community and the lack of available safe, sanitary, and affordable housing, but as a result of a series of inspections, most recently by the Cold Climate Housing Research Center (CCHRC), it has been determined that more than 55 public housing homes constructed in 1979 have been deemed unfit for human occupancy and are at risk of imminent collapse.[30] The 10 year housing needs in Quinhagak exceed 150 units, overcrowding is rampant according to the Quinhagak Community Development Plan; 30% of Quinhagak housing needs replacement.

Housing workgroup goals from the Quinhagak Community Development Plan include:

1. Replace all 55 homes included in Kwinhagak's disaster declaration;
2. Plan and implement affordable mortgage program with down payment assistance for families currently living in the homes included in Kwinhagak's disaster declaration to contribute to the financing for housing development;
3. Improve the livability of the occupied homes included in the Kwinhagak's housing declaration until the homes are replaced;
4. Develop an emergency plan and emergency facilities;

[30] Native Village of Kwinhagak Community Development & Special Projects site http://kwinhagak.org/.

5. Plan and develop facilities to demolish and dispose of the 55 homes included in Kwinhagak's disaster declaration;
6. Plan and develop infrastructure to support the above goals.

Architectural Analysis - Summary:

The initial 1970's era construction assembly of the housing stock analyzed in Quinhagak was insufficient to handle the climatic, heating, and occupancy loads of rural Western Alaska. As a result, the exterior envelopes of the buildings have been completely compromised, the sites are experiencing significant subsidence, mold and rot have infiltrated the homes, and they are too difficult to heat effectively. The retrofit of the 1990's that was meant to rectify this situation instead compounded the problem. Water infiltration and mold are extensive, air quality is poor, and the buildings are failing their inhabitants thermally, structurally, and economically. We conclude that the widespread use of these homes has created a problem of crisis proportions for the village: they are for all practical purposes unsalvageable, yet to condemn them all would leave roughly one third of the village without shelter.

Cold Climate Housing Research Center
Architectural Analysis of 70s Era Homes in Quinhagak
September 3, 2009

Community residents interviewed describe presence of mold in the exterior, interior, and wall cavity of older homes. The CCHRC report agreed that mold is found to be most prominent on the northern façade of the homes, as that side receives the least light and has the least ability to dry. The combination of the double vapor barrier, lack of eaves, high occupancy load, high Delta-T (difference between outdoor and indoor temperatures), and wet climate prohibit the building from ever drying. In the winter, there is too much humidity and not enough heat to allow the building to dry from the inside. The wet climate and double vapor barrier prohibit drying from the outside.[31]

Another problem with older homes in Quinhagak is the soil surrounding the homes has subsided from under the building, creating standing water around the base of the building, typically at the south side. According to the CCHRC report, subsidence occurs when heat begins to melt the frozen ground around the pilings, causing the level of grade to fall away from the building. The homes analyzed in Quinhagak have subsidence issues on the south face of the property. Of the ten homes analyzed, six were experiencing significant subsidence issues. In the buildings experiencing subsidence, the difference in grade height between the north pilings and south pilings averaged 19.5 inches.

[31] Housing Analysis in Quinhagak, prepared for NVK by Cold Climate Housing Research Center, Rural Community Development Consultants & PDC Engineering, (September 3, 2009).

Clinic

The Denali Commission, Alaska Native Tribal Health Consortium (ANTHC), and Yukon Kuskokwim Health Corporation (YKHC) conducted a "Code and Condition Survey" in November 18th, 2004 that resulted in the recommendation that a new large clinic be construction. Major issues include:

- Structural – major settling and foundation problems.
- Sanitary problems - recently the settling has caused problems with the sanitary sewage system.
- Size - the clinic size is very small for the population served.
- Cost of renovation and upgrade to the existing clinic was evaluated and it was determined that a new clinic was more economically feasible.

The community website http://www.kwinhagak.org/ paints a dire picture stating, "Another crisis looming on the horizon for the residents of Kwinhagak is the imminent structural failure of the foundation system supporting the Quinhagak Health/Sanitation Building. This facility is a critical facility for Kwinhagak, housing the clinic, washeteria/laundromat, and various tribal programs. Constructed in 1999, the foundation system utilizes thermosyphons to ensure the ground underneath the concrete foundation system remains permanently frozen. However, some basic design assumptions may have been flawed, as they were based on old climate data and assumed colder summers than has been the average in recent years. Through a combination of poor drainage and warmer temperatures, the permafrost beneath the building has begun to degrade, resulting in settlement. One side of the concrete foundation perimeter has cracked and is migrating away from the main pad, bringing the southwest wall with it, and causing severe cracking throughout the building, and in particular in the clinic exam rooms." [32]

In 1997 Duane Miller Associates, LLC submitted a report for the geotechnical aspects of the foundation design for the Washeteria/health clinic building showing icy soils, and concluded "the soil under the site is not thaw stable and will experience large total and differential settlements if it thaws."[33] The Duane Miller letter reported that two thermoprobes on the westerly side during a site visit August 8th-9th, 2005, showed a temperature of 31.5°F, the other eight probes showed temperatures of 31.3°F. The pressures measure in August 2004 showed a temperature of 31.3°F. Arctic Foundations measured the pressures in the thermal siphons in April 1998 and found temperatures in the range of 26.4° to 29.4°F.

The climate conditions assumed for the design in 1995 and 1997 for the clinic were based on values presented in the Environmental Atlas of Alaska by Hartman and Johnson (University of Alaska, 1978). Since the clinic was constructed the winters have been both colder and warmer, but the summers have all been warmer and generally longer. The Duane Miller Associates report concludes, "A warming climate manifested through longer summers appears to be the primary culprit in the building's settlement. If

[32] Native Village of Kwinhagak Community Development Site, http://kwinhagak.org/.

[33] *Foundations Movements Washeteria Building, Quinhagak, Alaska,* Duane Miller Associates (DMA), letter to David Nairne & Associates, Ltd. (June 30, 2006).

nothing is done, the settlements are expected to continue in warm years. Sine remedial work could be done to reduce the risk of future thaw settlement."

Roads and Culverts

The community currently has 20 major roads to access housing and community facilities. The roads are in fair condition. Additional transportation arteries consist of minor foot and snow machine / ATV paths, and boardwalks, which provide pathways between the major arteries and community facilities. The roads are constructed primarily of pit-run material. A major concern identified by NVK with the current road system is dust created from gravel surfaced roads. Potholes have also been a recurring problem appearing on roads, which help to drive up maintenance costs beyond operation and maintenance funding according to the Quinhagak Community Development Plan.

Improved drainage to prevent the road subgrade from becoming saturated, to direct the drainage away from the development area, and to improve public safety, were expressed by the community during a 2007 community planning workshop.

According to George Johnson, City of Quinhagak Public Works Director, two culverts across Quinhagak Airport Road (Qanirtuuq Drive) have heat trace lines, however at least one additional is needed. Also along Carter Road drainage culverts are misplaced, and/or three additional culverts across are needed to move water under Carter Road.

Airports

Quinhagak has two airports, an old airport adjacent to the Kanektok River that is no longer in commercial use, and a new airport.

The old 2,600-foot gravel airstrip continues to have erosion along the length of the north side and east end despite placement of super sacks along the Kanektok River bank.

The new 3,000 foot runway that was opened in November 2004 is well away from the river and completely avoids river erosion. However, frost heaving has resulted in an uneven runway surface including a large heave that has restricted takeoff and landing weights, causing inefficiencies.[34] The airport is owned and managed by NVK.

[34] Dock and Marine Infrastructure Improvements Technical Report Quinhagak, Alaska, USACE.

Chapter 4 Recommendations

In addition to describing the hazards and climate impacts, recommended actions in response to the identified impacts are needed. This chapter includes recommendations for 1) Projects, 2) Studies and 3) Immediate and Ongoing Actions. Many of these projects, studies or actions will require obtaining additional funding, authorizations and permits, and consensus building before they are undertaken. A time frame for completion of each project or study, either short-term (immediately or 1-5 years), mid-term (5-10 years) or long term (more than 10 years)

Table 8. Recommended Projects

Project	Hazard(s) Addresses	Possible Resources Agencies and/or Funding Sources	Estimated Time Frame
1. Dredging at City Dock	Shifting River Channel, sedimentation and erosion	ACCIMP USACE ANTHC Legislative Appropriation	Short Term
2. New City Dock	Shifting River Channel	USACE DOT/PF Legislative Appropriation	Long term
3. Move or replace Residential Structures most at risk	Erosion & Flooding	ACCIMP NAHASDA HUD, USDA Legislative Appropriation	Short Term
4. Replace Undersized Culverts & Install Additional Culverts	Flooding, Drainage	BIA IRR, State, NVK, COQ	Short-Term
5. Replace Undersized Wood Bridge	Flooding	BIA IRR, State	Short-Term
6. Install Culvert Thawing Devices	Flooding, Drainage	NVK/COQ	Short-Term
7. Erosion Control	Erosion, Flooding, Shifting River Channel	COQ/NVK Other	Short-Term

ACCIMP, Alaska Climate Change Impact Mitigation Program
ANTHC, Alaska Native Tribal Health Consortium
BIA, IRR Bureau of Indian Affairs, Indian Reservation Roads
DOT/PF, Alaska Department of Transportation & Public Facilities
HUD, U.S. Department of Housing and Urban Development
NAHASDA, Native American Housing Assistance and Self Determination Act of 1996
USDA, U.S. Department of Agriculture
NVK, Native Village of Kwinhagak
COQ, City of Quinhagak

Description of Recommended Projects

1. **Dredge Channel to City Dock –** Because of the continued shifting channel and sedimentation of the Kanektok River the ox bow area where the City Dock is located needs dredging, or sediment removed by use of a suction dredge, or an excavator as was done in the 1990's, per the Tribal Administrator. Qanirtuurq Corporation General Manager indicated to the USACE in 2009 that the Corporation counts on fuel barges being able to access Quinhagak for deliveries twice per year.

Channel conditions have created a situation where it is cheaper to fly goods into the community rather than barge them. The USACE Planning Assistance to the States (PAS) Program is a possible source of funds to provide detailed plans for dredging/excavating the City Dock channel and ascertaining a suitable storage area, most likely the gravel pit on the downstream bend of the oxbow below the dock. The USACE could also monitor and measure the effectiveness of the sediment removal project.[35] The USACE reported "The Village indicated they were not interested in doing the small project, a "Band-Aid fix", and that they were going to push for what they wanted. They also had concerns about accepting a small fix and then being ineligible for further project funding."[36]

2. **New City Dock –** Replacement of the City Dock is preferred by the community, however interim dredging may be required until plans and funding for a replacement facility can be obtained. Dock replacement was included in recommendations by the USACE *Dock and Marine Infrastructure Improvements Technical Report Quinhagak* study and the USACE *Statewide Barge Landing Assessment*. For this new dock and the dredging alternative, detailed survey and mapping of the project area(s) would need to be conducted; wind, wave, and sediment transport analyses would be needed of a new location.

3. **Move or Replace Residential Structures Most at Risk –** Homes most at risk from river erosion include the end of Old Village (also known as Nuuk Point) end home is approximately 50 feet from the river as of August 2011; Cleveland Home (Meqsarturyaraq Area) **Katie** Cleveland home was 43 feet 7 inches from the bluff edge of the Kanektok River (as of 10/10/2011). Stakes were placed in 10 foot intervals from the home to the edge of the river to assist in gauging rates of erosion at the Cleveland home site. Mrs. Cleveland is elderly, and lives alone in the 40 ft. x 20 ft. structure that is also difficult to heat.[37] Cleveland home is also situated in an area that has seasonal flooding.

4. **Replace Undersized Culverts & Install Additional Culverts –** Improved drainage to prevent the road subgrade from becoming saturated, to direct the drainage away from the development area and to improve public safety were expressed during interviews in the community and during an August 2007, NVK Northern Management and CE2 Engineers hosted community planning workshop in Quinhagak. A drainage plan for Quinhagak addressing localized runoff problems and needs has been completed by David Nairne & Associates. The amount of water running through the community during spring break up and heavy periods of prolonged rainfall can cause failures to road embankments, and fill pads for structures. As development in the community continues to increase, so will the drainage runoff problems that can aggravate and accentuate permafrost melt.

5. **Replace Undersized Wood Bridge –** Replace undersized bridge on Petmilleq Heights road between Moravian Church and Quinhagak Subdivision; this area

[35] Telephone conversation with Bruce Sexauer, Alaska District, US Army Corps of Engineers (USACE).
[36] USACE Trip Report from a June 3, 2010 trip to Quinhagak, by Pat Fitzgerald and Lorraine Cordova, USACE.
[37] Interview with Katie Cleveland through her daughter Stella Cleveland, P.O. Box 8, Quinhagak, who acted as interpreter during October 10, 2011 visit to her home to inspect erosion risk and take measurements.

floods annual at Spring break up and flooded during the November 2011 coastal storm. Bridge was constructed approximately 30-years ago and is of insufficient size or strength for large vehicles, and is currently used primarily by 4-wheelers, snow machines and pedestrians. When Qanirtuuq Drive floods, this is the only other road to get through the community from east to west, and it too can be flooded coinciding with Qanirtuuq Drive floods/washout at the upstream culverts.

6. **Install Culvert Thawing Devices (heat traces) –** Twenty-four inch culverts that provide drainage under the Old Quinhagak Airport Road (Qanirtuuq Drive) generally from the south/southeast large wetland areas adjacent to the community across the village into the Kanektok River and generally frozen during spring brea kup. One heat trace has been installed and an additional heat trace is needed. Along Carter Road drainage culverts are in the wrong locations in the area of the new housing according to the Public Works Director.

7. **Erosion Control –** Address Erosion Control along the length of the old airport runway and the airport apron, is listed as a short-term (1-5 year) priority in the community's Transportation and Waterfront Development priorities.

Table 9. Recommended Studies

Project	Hazard(s) Addresses	Possible Resources	Estimated Time Frame
1. Channel Migration Zone Study	Shifting Channel, Flooding	State, USGS	Short-Term
2. Erosion and Sedimentation	Sediment, Accretion, Erosion	State, USACE	Short-Term
3. Coastal Storm Surge Analysis and River Flooding	Coastal Flooding	DOT / PF, USACE	Short-Term
4. New City Doc Location	Channel Migration, Erosion Flooding	Legislative appropriation	Mid-Term
5. Community Health Impact Assessment	Public Health; Environmental Health	ANTHC, State	Mid-Term
6. Improved Baseline Mapping	Climate Change	State, USGS	Mid-Term

Description of Recommended Studies

1. **Channel Migration Zone Study –** Common tools used to assess flood hazards are based on fixed-bed hydraulics and do not characterize areas susceptible to channel erosion either within or outside of the areas prone to flooding. The principal goal of delineating the Channel Migration Zone (CMZ)—the area where the Kanetok River would be susceptible to channel erosion—is to predict areas at risk for future channel erosion due to fluvial processes. CMZ delineations help reduce risks providing information to guide future development in and along the river; reduces the costs of repairing or replacing infrastructure and major civil works that might otherwise be threatened or damaged by channel migration.

2. **Erosion and Sedimentation Study –** There are various approaches to measurement of river bank erosion and channel change, such as the Channel Migration Zone described above. The movement of the Kanektok River would be

difficult to accurately predict throughout the community unless more complete channel migration analysis is conducted, or erosion is monitored where structures and infrastructure is at risk as is recommended, (i.e. old airport, Meqsarturyaraq Nuuk Point, etc.). The sedimentation/accretion in the area of the City Dock and North Docking area should also be included. Coastal land loss and thermokarst lake expansion and drainage could be analyzed in the close proximity to the new landfill, new sewage lagoon and at the mouth of the Kanektok River adjacent to the community.

3. **Coastal Storm Surge Analysis and Riverine Flood Analysis –** No analysis of coastal storm surge at Quinhagak is known to have been performed. This should be conducted and analyzed with the old river flood hazard and depths from the USACE. Coincident coastal storm surge and high river water may cause more extreme flood depths than are currently anticipated.

4. **New City Dock Location –** A study is needed for siting a new dock to serve Quinhagak.

5. **Community Health Impact Assessment –** Impacts of continued poor waste disposal within the community, to regional-scale resource development projects, recreational fishing or hunting within the watershed, and the availability of subsistence resources that are central to Quinhagak's well-being all may be impacts to the local health and economy of the community. Donlin Creek Mine, recreational fishing on the Kanektok River, and spill potentials on Kuskokwim Bay may impact the local economy and employment, culture, infrastructure, air and water quality, and access to subsistence resources, all of which influence community health. Housing quality has already been assessed and been deemed in imminent need of replacement. Large-scale mining projects have been shown to have significant health impacts on local communities—especially among indigenous populations. The main health impacts expected to occur as a result of this mine, include changes to health determinants such as employment and income, exposure to environmental contamination, diet and nutrition, and psychosocial health issues. A Health Impact Assessment would aim to ensure health is considered in decisions that affect Quinhagak.

6. **Improved Baseline Mapping -** The ability to predict changes due to climate change is dependent upon being able to define the status quo. Unfortunately, few baseline maps of key environmental variables are available for Alaska. Improved baseline mapping and associated data collection is a critical need.[38] The current May 2004 community maps prepared by Global Positioning Services, Inc. and funded by the Coastal Villages Region Fund in cooperation with DCCED using funds from HUD, ANTHC, the Denali Commission (USDA, DOT/PF) and the City could be updated to show new facilities.

[38] *Recommendations on Research Needs to Implement an Alaska Climate Change Strategy.* Alaska Climate Change Research Needs Working Group, 2009. Accessed at *www.climatechange.alaska.gov/docs/rn_12jun09_dftrpt.pdf*.

Table 10. Immediate and Ongoing Actions

Project	Hazard(s) Addresses	Possible Resources
1. Establish Measurements and Monitor Erosion at Key Threat Points	Channel Migration Erosion	State USACE Local: NVK, COQ, Corporation
2. Footprint Lake Lagoon Discontinue Sewage Bunker Dumping	Environmental Health	NVK, COQ
3. Major Construction Projects to Install Thermistors	Climate Change Monitoring Soil Temperatures	COQ, NVK – Add to Construction RFP's and Contracts
4. Erosion Control	Erosion, Flooding, Shifting River Chanel	COQ, NVK Other?

Some climate, hazard, and environmental impacts demand immediate and ongoing action, thus the community has or should try to accommodate these recommendations in their local procedures and contracting.

Description of Immediate and Ongoing Actions

1. **Establish Measurements & Monitor Erosion at Key Threat Points -** The Public Works Director measured some distances from infrastructure to the coastline but a regular schedule (suggested twice per year) should be established at these locations at a minimum:
   - Old Airport - east end, northside, downstream curve
   - Old Village (Nuuk Point)
   - Sewage Lagoon (new)
   - Landfill (new)

   Available information of erosion loss will assist with other recommended studies, projects and assisting the community for documenting the erosion hazard impacts when making application for additional assistance.

   Table 11. Example of Local Erosion Monitoring Information to Collect

Date of Measurement or Distance Estimated from Aerial Photo	Katie Cleveland Home (Meqsarturyarag Area)	Adolf Pleasant Home (Nuuk Point)	Sewage Lagoonoff Arolik Road
8/10/11	43ft. 7in. (measured)	50ft. approximately	294ft. from SW corner of fence to coastal bluff line
7/08/07 Google Image	85ft (estimate from aerial photo image)	95ft. (estimate from aerial photo image)	375ft. from SW corner to coastal bluff (estimate from aerial photo image)

2. **Footprint Lake Lagoon Discontinue Sewage Bunker Dumping** – Discontinue dumping sewage bunkers at the Footprint Lake Lagoon and begin using the new sewage lagoon.

3. **Install Thermistors to Monitor Soil Temperature –** Changes in the ground temperature with time can be documented by installing thermistors in casings. This

requirement could be included in proposal requests for any new publicly funded building construction.

4. **Erosion Control –** Continue to provide erosion control locally, if affordable, and where the control structures are effective.

5. **Community adoption of floodplain development and erosion policy –** The City of Quinhagak has adopted a floodplain development and erosion policy so as to demonstrate local commitment to wise development that avoids loss from flooding and erosion.

Table 12. Quinhagak Floodplain Development & Erosion Policy
Avoid new construction and other development in the floodplain areas of the Kanektok River as depicted by the USACE on (show map), and below Mean Sea Level elevation (either 9 ft. or 11 ft. which is 2 ft. above the 9 ft. flood level reached in 1978)
Require new development along Arolik Road to consider coastal erosion and document erosion rates and setback new construction inland of the estimated 30-year erosion line. This line shall be estimated prior to construction using aerial photography analysis or other acceptable means to determine historic and ongoing erosion rates along the Kuskokwim Bay.
Development that is allowed in the river and coastal flood-prone areas include fish drying racks, boat tie-up and storage, boat docking facilities, and other development that has taken into consideration in design and construction the forces and effects of flooding and erosion, or that is designed to control erosion and/or flooding.
Dredging and gravel extraction shall be allowed if determined by a professional engineer and/or other water resources specialist to avoid or minimize flooding impacts on adjacent developed lands.
Note: Floodplain Management Policy was approved by City Council March 13, 2012

Broad Recommended Research Needs

The Research Needs Work Group of the Governor's Sub-Cabinet on Climate Change emphasized several needs, four of the eight broad research needs identified are included here because they support the recommended studies needed at Quinhagak:

1. Revise flood risk maps.
2. Develop sea level rise projection maps for coastal areas throughout Alaska, accounting for local isostatic rebound in conjunction with global sea level rise predictions.
3. Use the SPOT satellite data system or others to track changes in permafrost extent and work to develop projection maps for changes in extent over the next 100 years, based on climate change projections.
4. Assess the degree and rate of thawing of submarine permafrost deposits in coastal areas due to warming sea temperatures.

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Appendix A: Public Involvement

Comments from Quinhagak Community Development Plan

- New sewage lagoon will be impacted by Kuskokwim Bay erosion
- Evacuation Route A: Upriver Borrow Source
- Address Erosion Control, Old Airport (East End=High Erosion Area), along length of old runway; Airport Apron, Pump-house
- Channel Dredging
- Power line maintenance to airport - poles need to be deeper

Comments from Interviews during August 9th-10th, 2011 community meetings/visit

Reporter Christy Miller, Tetra Tech

- New sewage lagoon has no barrier between lagoon and erosion (advancing coastal erosion from Kuskokwim Bay); coast line has advanced 10 feet towards the lagoon since it was installed.
- Along river at the old airport river has eroded 64 feet since last fall (2010). Old airport site still not cleaned up; wire and drums, other debris. - From interview with George Johnson, Quinhagak Public Works Director.
- Gravel borrow site between coast and City Dock is likely to wash out. Tide water goes into gravel pits.
- Tundra pond edges are slumping.
- Ground is sinking.
- Problems in housing is with wet rot, not dry rot. - From interview with Willard Church, Mayor of Quinhagak
- Float planes no longer can land on the Kanektok River at Quinhagak due to the siltation.
- Coastal Villages Seafood closed the Quinhagak plant, only producing ice currently, and moved their processing to Platinum.
- In the 1990s, the boat harbor was dredged with an excavator.
  Henry Mark, Native Village of Kwinhagak Tribal Administrator, hfmark.nvk@gmail.com
- USDA, Natural Resources Conservation Service (NRCS) Bethel office marked point with GPS 6-7 years ago; took weigh points and measurements. Contacts are Andy Oxford and Ryan Maroni (907) 543-7155

Comments by City Council and Mayor on draft Hazard Mitigation Plan

- Permafrost melt impacts all types of structures in community not just along the Kanektok River.
- Wind is a hazard issue; knocks houses off their foundations. West wind storms cause most of the erosion. South wind sometimes heavy rainfall.
- River rising from heavy snowpack causes early runoff problems. Old village site (houses at point) as erosion continues, Kanektok River will be directed more towards bulk fuel tanks/gas station, go into old gravel pit area.

Comments from Interviews during January 30-31, 2012 joint NVK/COQ meeting/site visit

- Underground water in addition to stream water drains through community, causes flooding at old wood bridge area between Moravian Church and housing subdivision.
- High level of e coli and fecal coliform levels along stream during spring break up.
- Footprint Lake Lagoon still being used for honey bucket bunker disposal and drains through this area.
- Add new sewage lagoon and landfill to erosion prone areas to monitor
- Concern about increased transport across Kuskokwim Bay and potential spills as a result of Donlin Creek Mine development

Agency and Company Contacts

- Sally Russell Cox, sally.cox@alaska.gov 269-4588
- Anthony Caole anthonycaole@gmail.com
- Mark Roberts, Alaska Division of Homeland Security and Emergency Management (DHSEM)
- Erv Petty, DHSEM (428-7015)
- Matt Walker, Department of Environmental Conservation, Village Safe Water (269-7563)
- Bruce Sexauer, Alaska District, U.S. Army Corps of Engineers
- Melanie (Harrop) Peterson, Alaska District, U.S. Army Corps of
- Will Kemp, CRW Engineering, Project Engineer (562-6776)
- Andrea Meeks, CRW Engineering
- Steve Munn, CRW, Superintendent Quinhagak water/sewer project (556-8278)
- Jim Galanes, The Boutet Company, Project Administrator/Planner (522-6776)
- Donna E. Gryer-Boutet, Project Manager, Boutet Company dboute@theboutetcompany.com
- Nathan Wardwell, JOA Surveys, erik@joasurveys.com
- Scott Simmons, URS Corporation (261-9706)
- J.W. Graves, Director of Construction, Division of Environmental Health and Engineering (DE), Alaska Native Tribal Health Consortium (729-3792)
- Rick Buckaloo, ANTHC Head of Equipment (278-4033)
- Ruth Carter, Department of Transportation and Public Facilities, rutha.carter@alaska.gov
- Craig T. Boeckman, DOT/PR craig.boeckman@alaska.gov
- Aaron C. Hughes, DOT/PF aaron.hughes@alaska.gov
- Ryan Maroney, USDA, Natural Resources Conservation Service, Fairbanks ryan.maroney@ak.uska.gov

Appendix B: Community Photos

Photos taken August 9th and 10th, 2011 in Quinhagak by Christy Miller, Tetra Tech, Inc. unless otherwise identified.

Figure 1. Super sacks foreground, and in the distance, along Kanektok River shoreline adjacent to the old airport runway placed in an attempt to curb erosion.

Figure 2. Along the Kanektok Riverbank in the distance white super sacks are placed to curb erosion along an outside meander bend of the river adjacent to the old airport runway.

Figure 3. View is to the north at two 24” culverts under Old Quinhagak Airport Road (Qunirtuuq Drive) near intersection with Agalik Avenue. Road has been over topped and washed out.

Figure 4. Downstream side of two 24” culverts under Old Quinhagak Airport Road (Qunirtuuq Drive). Note the large sediment deposits carried into the wetlands below the road.

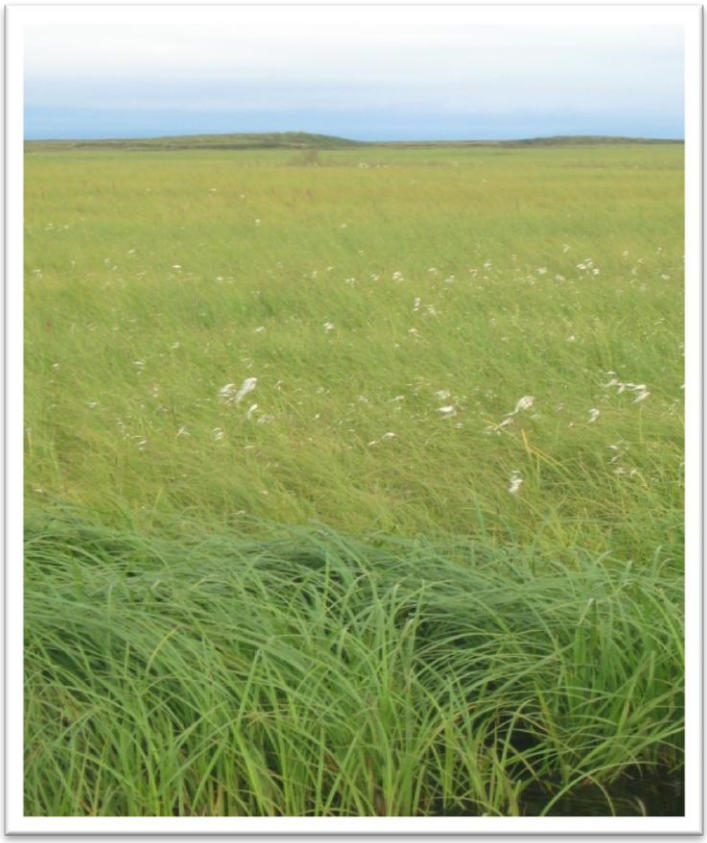

Figure 5. Mounds in distance are sewage disposal site and old dump site near John O. Mark Road to new airport, locally known as Qemirrayagaak Nanvaak.

Figure 6. New building pad being placed and utility line near washeteria/clinic building.

Figure 7. View looking upstream of Kanektok River at end of the Old Village point, Adolf Pleasant home is on right.

Figure 8. Adolf Pleasant's home was approximately 50' from the top of the eroding river bank on August 9th, 2011. Home is at end of Old Village, also called Nuuk area.

Figure 9. Otto Hunter's home, next to Adolf Pleasant's home in Nuuk area.

Figure 10. John River's home in Old Village point – Nuuk area.

Figure 11. Wilbur Small's home in Nuuk area. Note the home is settling to the left.

Figure 12. Peter Foster's home in Old Village point area.

Figure 13. View of City Dock from Old Village (Nuuk) area.

Figure 14.River view of west end of City Dock.

Figure 15. Shoals and sand bars in front of City Dock.

Figure 16. Quinhagak wind turbines installed by Alaska Village Electric Cooperative.

Figure 17. North docking area, an oxbow of the Kanektok River.

Figure 18. AVEC tank farm. Note: the tilt of the tanks.

Figure 19. Fenced Clinic/Washeteria sewage lagoon in center extending to right of photo; AVEC tank farm on left.

Figure 20. Moravian Church

Figure 21. New Quinhagak cemetery; Old Village Cemetery was lost to erosion many years ago.

Figure 22. Seven new homes built starting in 2007 along the Carter Road Housing Subdivision to alleviate overcrowding and deteriorating housing conditions.

Figure 23. Cold Regions Housing Research home built as a demonstration model.

Figure 24. Jeff Hoffman inspecting Triodetic foundation system on new Community Service Center being built for Coastal Villages Seafoods (CVS).

Figure 25. Close-up of new Triodetic foundation system under Community Service Center building.

Figure 26. Completed Community Service Center (January 31, 2012)

Figure 27. NVK clinic, city office, and washeteria building.

Figure 28. NVK Clinic and washeteria building.

Figure 29. Katie Cleveland's home was 43' 7" from top of river bank on August 10th, 2011. Home is approximately 40 years old and is poorly insulated.

Figure 30. View of road into Katie Cleveland's home. Kanetok River is to right and in back of home. This low area reportedly floods annually.

Figure 31. Katie Cleveland home foundation corner. The understructure of the home likely could withstand a move but heat loss is an overriding concern. Elevated structure is sitting on wood blocking foundation system with sturdy cross members.

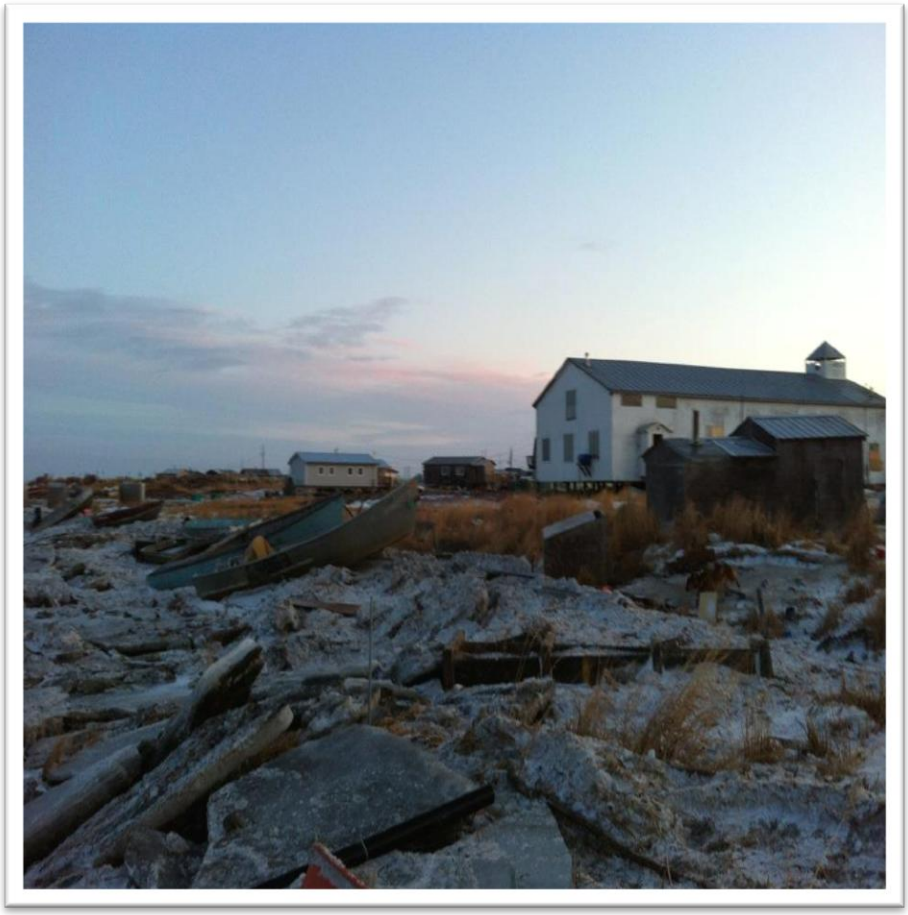

Figure 32-35

Photos of flooding and ice provided by Rebecca (Church) Wilbur on October 12, 2011.

Figure 32.

Figure 33.

Figure 34.

Figure 35.

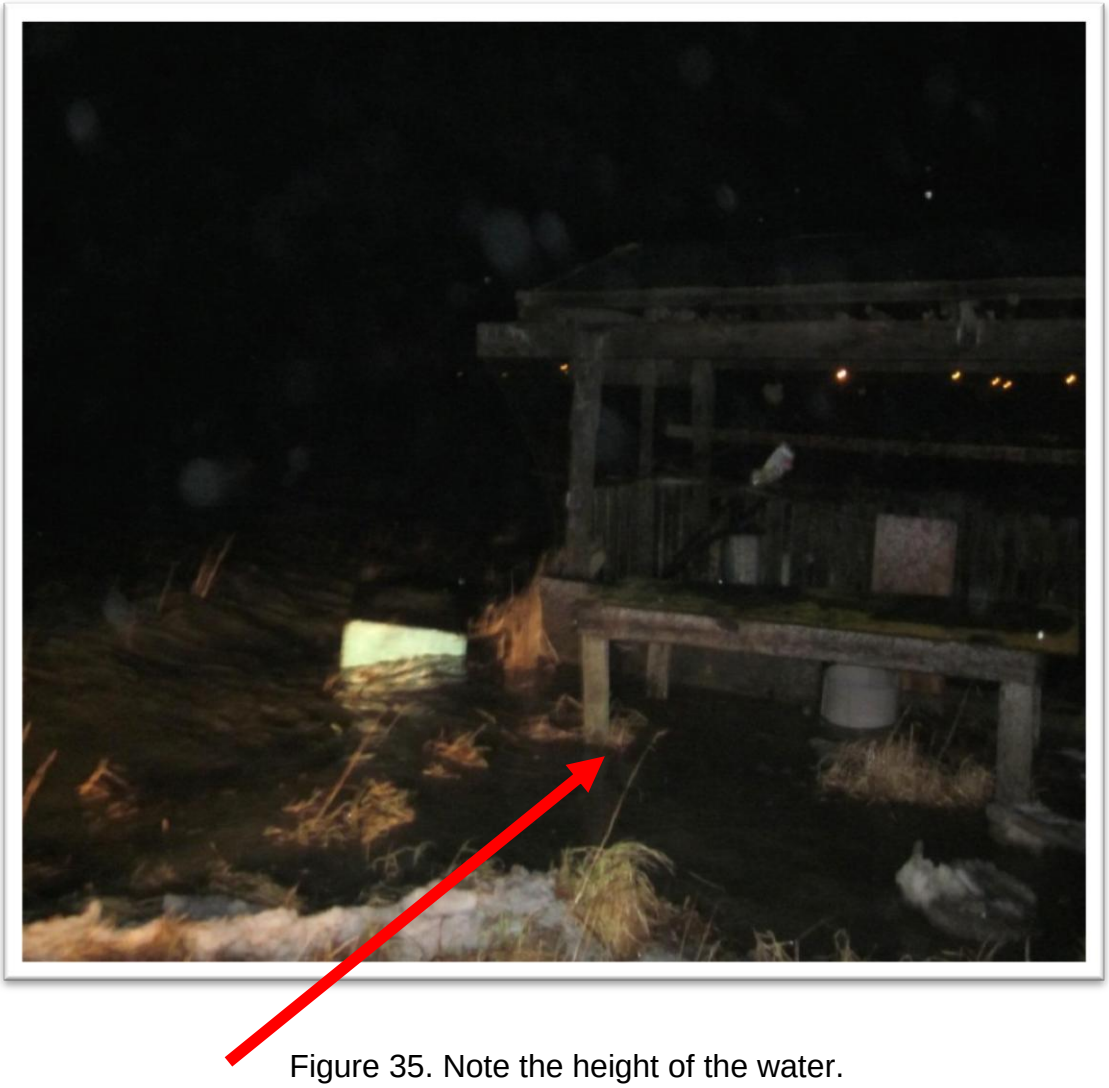

Figure 35. Note the height of the water.

Figure 36. Quinhagak Overview Map