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## Kwigillingok: Community Profile

Prepared on behalf of the  
Native Village of Kwigillingok

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# Kwigillingok, Alaska



Map showing location of Kwigillingok (Kuigilnguq) (map generated using Alaska Department of Natural Resources Alaska Mapper, <http://dnr.alaska.gov/mapper/>).

## I. Introduction and Report Objectives

Kwigillingok (Kuigilnguq), Alaska, is imminently threatened by flooding and erosion. Flooding occurs annually in Kwigillingok as a result of storm surge, ice jams, ice override (called *venuq*), and other factors. Estimates of average erosion rates range from two to fifteen feet per year. The community also experiences ground failure from thawing permafrost and a variety of other severe weather hazards. The combined effects of erosion, flooding, permafrost thaw, and severe weather have resulted in significant damage to homes and infrastructure in Kwigillingok and created significant health risks to the community.

Kwigillingok seeks dialogue with federal and state agencies regarding the availability of funding and technical assistance to accomplish the following urgent actions:

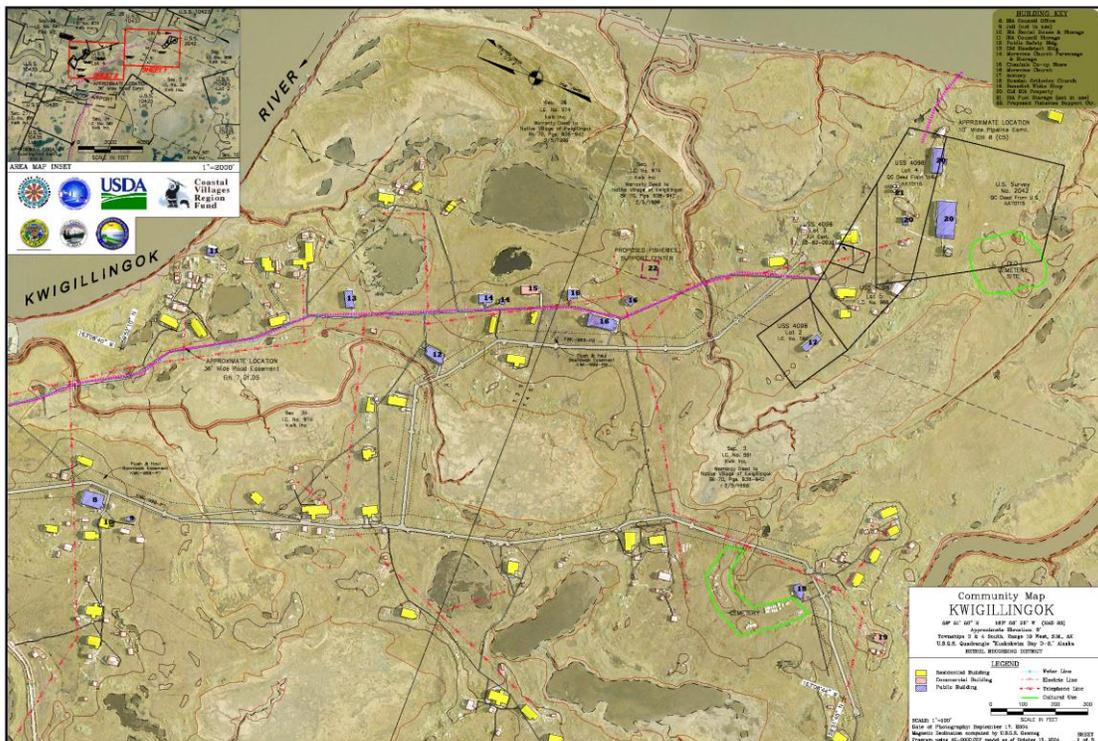
- replacement of heavy equipment to be used for relocating homes;
- relocation of homes that are vulnerable to natural hazards,
- construction of flood mitigation infrastructure to protect homes and infrastructure, including the airport; and
- funding for ongoing monitoring and resilience planning activities.

The community has been working for decades to protect people, homes, and infrastructure from the threats of flooding, erosion, permafrost thaw, and other natural hazards and has succeeded in relocating several homes using local labor and equipment. Many studies and reports have analyzed these threats and made recommendations for mitigation measures to protect the community, but little funding or technical assistance has been provided to the community to implement those recommendations.

This report documents the severe natural hazards that affect the community of Kwigillingok and the actions the community is taking to respond to those hazards. The report includes the following information:

- A summary of previous studies regarding the rate and severity of erosion, flooding, permafrost thaw, and other natural hazards in Kwigillingok;
- Federal and state agency recommendations for mitigation measures to protect the community from these threats;
- Documentation of the effects of erosion, flooding, permafrost thaw, and other natural hazards on the community, including the results of ongoing community-based monitoring and weather documentation;
- Documentation of the efforts the community has made to protect homes and infrastructure, including the relocation of homes that are at risk; and
- The need for federal and state assistance to protect the community.

## II. Community Profile



Community profile map of Kwigillingok (Kuigilnguq) showing community infrastructure and cultural use areas (Map prepared by Coastal Villages Region Fund, Inc. in cooperation with Alaska Department of Commerce, Community and Economic Development (2004). Retrieved from Division of Community and Regional Affairs Community Profile Maps, <http://dced.maps.arcgis.com/apps/webappviewer/index.html?id=18fdb060875740fdad22099ca779d637>).

*Location*—In Yup'ik, *Kuigilnguq* (Kwigillingok) means “no river.” The village of Kwigillingok is located on the western shore of Kuskokwim Bay, about 77 miles southwest of Bethel and 388 miles west of Anchorage, entirely within the boundaries of the Yukon Delta National Wildlife Refuge (HMP, 2015, p.2-1). Kwigillingok is not accessible by road. Residents travel to nearby villages by boat in the summer and by snow machine or ATV in the winter and use boardwalks for travel within the village. Freight and bulk fuel are delivered by barge from Bethel. The geography of the area is mostly low lying lands subject to flooding, with areas of higher ground. The higher ground, where most of the community is located, is only about three feet higher than the low lying areas (USACE 2009b, p. 2).

*Population*—In 2017, the Alaska Department of Commerce, Community and Economic Development (DCCED) certified a population estimate of 398 people in Kwigillingok. Over 98 percent of the village identifies as Alaska Native, primarily Yup'ik Eskimo (DCCED, 2019a). According to the 2010 census, there were 82 households in Kwigillingok, with an average of four individuals per household (US Census Bureau, 2010). The Native Village of Kwigillingok's 2015 Hazard Mitigation Plan reported that, at that time, there were a total of 84 homes (HMP, 2015, p.2-2). Kwigillingok has one of the fastest growing populations in the Yukon-Kuskokwim Delta region. Between 2010 and 2017, the population grew by 24 percent (Agnew Beck, 2017, p. 17).

*Subsistence & Economy*— Residents of Kwigillingok rely on traditional subsistence activities for their livelihoods, and depend heavily on salmon, halibut, clams, herring, whitefish, and marine mammals (HMP, 2015, p. 2-3; NOAA, 2013). Local government jobs, including schools and tribal government, provide the primary source of income for the community, but other opportunities include trade, transportation, utilities, and manufacturing. According to the American Community Survey, in 2017 the workforce in Kwigillingok consisted of 217 people, of which 103 were actively employed (US Census Bureau, 2017). According to the 2013 – 2017 American Community Survey, the median household income in Kwigillingok was \$46,250 with a per capita income of \$10,590. This is about one third of the statewide per capita income (US Census Bureau, 2017; Agnew Beck, 2018, p. 29). Kwigillingok meets the Denali Commission's criteria for “distressed communities” (NOAA, 2013).

*Climate*—Kwigillingok has a maritime climate, with temperatures ranging from an average winter low of -1°F to an average summer high of 63°F. The area receives about 22 inches of precipitation annually, including almost 43 inches of snow (HMP, 2015, p.2-1). In 2016, Indian General Assistance Program (IGAP) Coordinator Darrel John observed that Kwigillingok is starting to receive snowfall toward the end of January or the beginning of February, whereas before, snowfall typically began in November or December (AIJ personal communication, January 27, 2016).

*Governance & History*—The Yukon-Kuskokwim Delta has been occupied by Yup'ik people for thousands of years. Moravian missionaries built a station in the current location of Kwigillingok in 1891 and built one of the first homes there in 1914. Between 1929 and 1950, the population grew from 104 to 215, possibly because an abundance of seals along the coast drew people to the area (HMP, 2015, p. 2-1). In the late 1960s, tidal waters reached the village and many residents relocated to higher ground in an area that is now called Kongiganak. By 1970, the population of Kwigillingok declined to 148 (HMP, 2015, p.2-2). Kwigillingok is an unincorporated community and the Native Village of Kwigillingok, a federally-recognized tribe, is the main governing body for the community. Kwik Inc., the native village corporation, operates a retail store in the village (Willie Atti, AIJ personal communication, January 7, 2016). Contact information for the tribe and the corporation follows:

**Native Village of Kwigillingok**

P.O. Box 90  
Kwigillingok, AK 99622  
[www.kwigtribe.org](http://www.kwigtribe.org)  
Ph: (907)588-8114  
Fax: (907)588-8429

**Kwik Inc.**

P.O. Box 110  
Kwigillingok, AK 99622  
Ph: (907)588-8112  
Fax: (907)588-8313

*Alaska Native Claims Settlement Act status*—There is no Alaska Native Claims Settlement Act § 14(c)(3) survey plat recorded for Kwigillingok (DCCED, 2019b).

*Infrastructure*—Kwigillingok has a health clinic, a public use sea plane base and airport with a gravel airstrip, community hall, washeteria, K-12 School and library, and other public facilities. The village council operates the community landfill. Drinking water comes from snow melt and a lake reservoir, and residents haul water to the washeteria and their homes. The school has its own water treatment system. Not all homes are plumbed. Those that are not use honey buckets. The closest hospital is in Bethel (NOAA, 2013). A complete list of the critical infrastructure in Kwigillingok is provided in Appendix A. Much of the infrastructure is vulnerable to erosion, flooding, permafrost thaw, and other natural hazards (HMP, 2015).

**III. Natural Hazards and Weather Data**

Over the past several decades, the people of Kwigillingok have worked to protect their community from the effects of erosion, flooding, permafrost thaw, and other severe weather. Using local skills and labor, Kwigillingok has elevated some homes and moved others out of the floodplain and is working to obtain resources needed to relocate other homes and construct new homes to replace homes that cannot be moved. Kwigillingok is also working to identify funding sources and technical assistance to construct mitigation measures to protect people and infrastructure from erosion and flooding (Lewis Amik III, AIJ personal communication, July 26, 2019). Over the long term, most of the homes and community infrastructure in Kwigillingok need to be relocated to higher ground. Further assistance is needed to complete these high priority community goals.

Various state and federal agencies have recognized the risks to the community, but few financial and technical resources have been provided to the community to assist with implementing recommended mitigation measures. Kwigillingok has worked with several entities, including the United States Army Corps of Engineers, the United States Environmental Protection Agency's Indian General Assistance Program (IGAP), the State of Alaska Division of Homeland Security and Emergency Management, the National Weather Service, the Alaska Division of Geological and Geophysical Surveys (DGGS), the Bureau of Indian Affairs Tribal Resilience Program, and the Alaska Institute for Justice (AIJ) to document and study hazards and weather events in the community.

The United States Government Accountability Office published reports in 2003 and 2009 identifying Alaska Native communities that experience flooding and erosion as a result, in part, of rising

temperatures. Kwigillingok was identified in these reports as one of the 31 villages imminently threatened by flooding and erosion (GAO, 2009, p. 13; GAO, 2003, p. 54). In 2009, in response to Congressional direction, the United States Army Corps of Engineers completed a *Baseline Erosion Assessment* (BEA) to analyze the severity of erosion in Alaska Native villages and coordinate, plan, and prioritize the agency response. Consistent with the GAO reports, the 2009 BEA categorizes Kwigillingok as a “priority action community,” the category most at risk to erosion (BEA, 2009, p. 4-2).

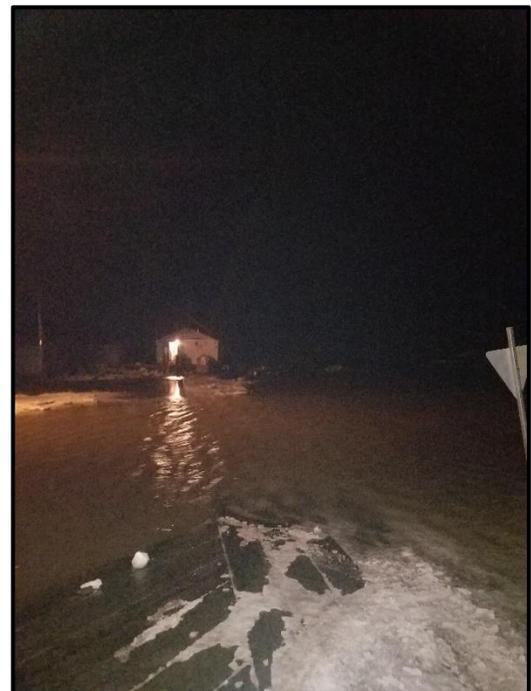
**Table 1. Projected costs related to damages from natural hazards in Kwigillingok** (based on information provided in HMP, 2015, p. 6-13).

Number of people affected	Facilities affected	Approximate value
349	84 residences	\$23,900,000
60	3 government and emergency response facilities	\$2,505,000
200	2 educational facilities	\$4,000,000
10	1 medical facility	\$2,000,000
21	10 community facilities	\$1,010,000
	10.2 miles of boardwalk	\$10,200,000
	5.3 miles road system	\$5,406,000
	4 bridges	\$150,000
	2 transportation facilities	\$5,500,000
16	13 utility facilities	\$27,635,000
<b>Total:</b>		<b>\$82,306,000</b>

Flooding, permafrost thaw, and severe weather interact and the combined effects of these hazards increase the rate and severity of erosion. Homes and infrastructure in Kwigillingok, including the airport, cemeteries, medical facility, school, and utilities are at risk to these natural hazards. The 2015 hazard mitigation plan projects that all facilities and infrastructure within the hazard zone for flooding, ground failure, and severe weather could be lost if nothing is done to mitigate the risk and calculates the cost of replacement at \$82,306,000 (HMP, 2015, p. 6-13).

In 2015, the Native Village of Kwigillingok worked with DHSEM and AECOM to complete a Tribal Hazard mitigation Plan (HMP), which was approved by FEMA and is in effect through December 7, 2020. The HMP assesses the risks of erosion, flooding, ground failure, severe weather, earthquakes, and volcanoes in the community and identifies possible mitigation actions to address those risks. Kwigillingok is currently in the process of updating the hazard mitigation plan and expects to have a new plan in place before the 2015 HMP expires.

This report will focus on the studies of and responses to erosion, flooding, ground failure, and severe weather.



*Flooding in downtown Kwigillingok, January 14, 2018 (Phillip, 2018).*

## **Flooding**

Kwigillingok experiences floods on an annual basis as a result of ice jams, ice override, storm surge, and winter and spring flooding. Floods occur primarily in winter, when high tides and high winds cause the pickup of ice and water, which breaks onto the beach and causes flooding (HMP, 2015, p.5-13). The frequency and intensity of flooding in Kwigillingok may increase dramatically as a result of climate change (HMP, 2015, p. 5-31).

At least fourteen recorded flooding events affected Kwigillingok between 1966 and 2018, including seven flooding events between October 2016 and August 2019 (HMP, 2015; AIJ Storm Narratives, 2018). These events, described in more detail in Table 2 below, resulted from high tides, strong wind, coastal storms, and *venuq*, or ice override. Ice override occurs when onshore wind causes ice sheets to slide along or override the beach or move inland up to several hundred feet.

Kwigillingok's Hazard Mitigation Plan rates the probability of a major flood event occurring as a one in three year, or 33% chance, based on previous data and analysis. The Plan categorizes the likely extent of damage as "critical," meaning that a major flood could result in the shutdown of critical facilities for at least two weeks and damage to more than 25 percent of the property in the village (HMP, 2015, p.5-20). According to the 2015 hazard mitigation plan, approximately 84 homes are located in the flood hazard area and are therefore at risk of damage in a flood. Of those, 29 homes have been elevated and 55 still need to be elevated or relocated (HMP, 2015, p. 5-21).



*December 2015 flooding in Kwigillingok (Phillip, 2015).*



*December 2015 flooding in Kwigillingok (Phillip, 2015).*

Damages from flooding: Flood events in Kwigillingok have damaged infrastructure, including boardwalks, fuel tanks, bridges, and homes (HMP, 2015, p. 5-11). During at least one event, residents vacated their homes because of safety concerns. Descriptions of recorded floods that have occurred in Kwigillingok since 1966 and the damage they caused are provided in Table 2 below.

**Table 2: Reported Flooding Events and Damage in Kwigillingok**

<b>Date</b>	<b>Resource(s)</b>	<b>Location &amp; Description</b>
<b>1966</b>	1973 USACE; 2015 HMP; Native Village of Kwigillingok	After a flood event, almost one-half of the community relocated from Kwigillingok to higher ground. The area where they relocated is now called Kongiganak.
<b>11-12/1973</b>	1971 USACE	In November and December 1973, high tide and south to southwest winds led to pilings of ice and water, which breached the beach and caused two flooding events in Kwigillingok. A resident reported that flooding occurs in Kwigillingok annually, with floods at least a ½' to 1' deep, because of south and southwest winds. The resident also noted that these floods were not considered "serious" (USACE, 1971).
<b>11/8/1979</b>	1/15/1980 Letter from Christy L. Miller (AK Div. Emergency Services) to USACE	A severe coastal storm with winds reaching 80 mph caused flooding to lift and float the village boardwalks. Storage area for fuel barrels was also flooded.
<b>1985</b>	1987 USACE trip report	Council member Roland Lewis said a flood event occurred in 1985, which involved south and southeast winds that caused high tides in Kwigillingok. This scared villagers and they vacated their homes. Villagers moved ¾ of a mile upstream above the airstrip, to an area only accessible by boat (USACE, 1987)
<b>2007</b>	HMP 2015	Photographs of shoreline flooding and <i>venuq</i> that occurred in winter 2007, which caused the boardwalk and barge landing to flood (HMP, 2015, p.5-13 to 5-14).
<b>1/2011</b>	2011 Kwigillingok River Erosion PowerPoint	Chunks of ice scattered from the mid-winter floods in January 2011. Homes located in the south end of the village were almost impacted by ice.
<b>10/2012</b>	HMP 2015	Floodwaters and high winds overturned and damaged the boardwalk. With assistance from the NRCS Emergency Watershed Protection Program (EWP), almost 500 linear feet of boardwalk were repaired. EWP funds were also used to move one home away from an eroded riverbank. The landfill across the village was flooded and caused debris to scatter. (HMP, 2015, p.5-14 to 5-15).
<b>10/24/2016 – 10/31/2016</b>	AIJ Storm Narratives	Several flooding events and high winds affected Kwigillingok. One resident had to move equipment to higher ground because of flooding under his house. Several skiffs were damaged. Erosion along riverbanks increased with flooding.
<b>10/04/2017</b>	Lewis Amik III and Gavin Phillip	Flooding lasted ~6 days, with south winds getting as high as 57MPH. On Oct. 5 <sup>th</sup> , there was a full moon so the tides were higher. No damage to infrastructure.
<b>12/15/2017</b>	Native Village of Kwigillingok, AIJ, and NWS	Flooding began at 11pm on Dec. 14 and lasted until Dec. 16 at 1:30pm. South winds 20-30 mph. Residents stayed in homes instead of evacuating to the school because wind was not strong enough. No damage to infrastructure was reported.
<b>12/19/2017</b>	Native Village of Kwigillingok, AIJ, and NWS	NWS reported on evening of Dec. 20 and 21 strong winds to be expected coming from east and southeast jamming into the water. Kwigillingok experienced a southerly wind storm during the night of Dec. 19 through Dec. 22 which resulted in a flooding event downtown and midtown. Storm impacts include flooding in southern and low-lying areas of community.

<b>01/14/2018</b>	Native Village of Kwigillingok, AIJ, and NWS	Kwigillingok experienced a flooding event with southeast winds at 35 mph occurred with a mixture of rain and snow. High water began to rise over the riverbank at 7pm and high tide occurred at 11pm. Areas of flooding include downtown and midtown. Flooding overtopped boardwalks and made these areas inaccessible. No damage of infrastructure was reported.
<b>10/3/2018</b>	Native Village of Kwigillingok, AIJ, and NWS	SE Winds 30 – 35 mps. Signs of erosion and <i>usteq</i> after flood receded. A foot of river bank was lost that undercut the boardwalk by the Kwik, Inc. store.
<b>8/2/2019-8/4/2019</b>	Native Village of Kwigillingok, AIJ, and NWS	S winds 25-30 mph with gusts to 40 mph, heavy rain for three or four days, and tide surge resulted in minor flooding. There were no planes in or out of Kwigillingok for two or three days. After the water receded, new cracks were visible near the 20 unit housing, in the direction of Kwig Inc., suggesting ground instability

*Kwigillingok flood, October 4, 2017 (Amik III, 2017).*



Community-based Flood Monitoring: In the summer of 2017, DGGs, in collaboration with AIJ and the Kwigillingok IGAP team, installed a flood staff in Kwigillingok to allow community members to document the height of flood waters. When it is possible to reach the flood staff, community members photograph the flood staff to show the height of the water during a flood. In addition, when flooding events happen, residents of Kwigillingok photograph the events and work with AIJ to document the severity of the flood and the damage it caused.

In 2019, the National Oceanic and Atmospheric Administration, in collaboration with DGGs, Alaska Ocean Observing System, and the Kwigillingok IGAP department, installed two tide sensors on a bridge in Kwigillingok to continuously measure sea water levels near the village. One of the two sensors reports information to the following website: <https://stilltek.com/akdggg/kwglngk/> (at the time of this report, the sensor was temporarily broken).

### **Erosion**

Erosion in Kwigillingok typically happens during spring break up and the fall storm season. Ice in the spring degrades the river bank while the soil is soft, resulting in erosion. Similarly, storm surges from fall storms saturate the soils, leading to erosion. (USACE, 2009b, p.2). Erosion in Kwigillingok may increase dramatically as precipitation increases with the changing climate (HMP, 2015 at 5-31).

Studies of the causes, rates, and effects of erosion in Kwigillingok have estimated erosion rates ranging from 1.4 feet per year to as much as 15 feet per year. Local residents, however, documented the loss of 20 feet of riverbank to erosion over the course of eight months between May 2011 and October 2011 (Native Village of Kwigillingok, 2011). The earliest studies, conducted primarily by the United States Army Corps of Engineers, predicted that erosion could result in a need to relocate homes or infrastructure by the late 1990's or early 2000's. The studies have recommended a variety of mitigation measures to protect the community, including measures to reduce foot traffic on the river banks and placement of riprap, but no financial resources or technical assistance have been provided to the community to facilitate the implementation of these recommendations. Table 3, below, summarizes the conclusions of each of the erosion studies.

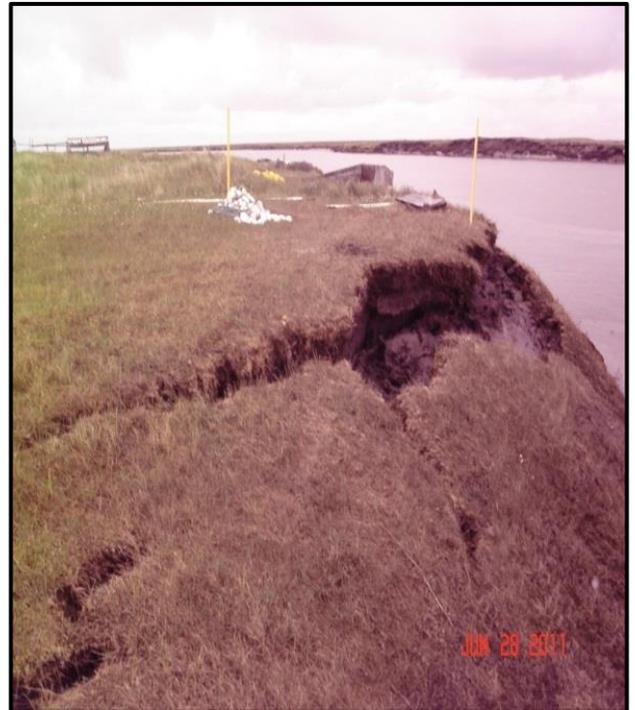


*Tide sensor installed in 2019 (Amik III, 2019).*

**Table 3. Summary of erosion studies for Kwigillingok**

Date	Source	Description of erosion problem and rate	Recommendations
1981	U.S Army Corps of Engineers trip report by Donald Ryan (USACE, 1981)	Erosion occurs in 3 areas along the right bank of the Kwigillingok River at rate of about 10 feet per year. Relocation of facilities likely not necessary for 15 years (1996).	<ul style="list-style-type: none"> <li>• Construct wooden stairway to eliminate foot traffic on banks and protect natural vegetation</li> <li>• Place filled barrels along upper banks</li> <li>• Prevent construction of new buildings in path of erosion</li> </ul>
1983	1984 Erosion Control Task Force Report (AKDOT, 1984)	Erosion rate of 1.4 feet per year along a 1,750 foot stretch of the riverbank. Some homes at risk in 5 to 10 years (1988 to 1993), but erosion not likely to substantially affect community for 25 years (2003).	<ul style="list-style-type: none"> <li>• Sacrificial gravel berm</li> <li>• Seeding operation</li> </ul>
1987	U.S. Army Corps of Engineers trip report by Don Bethel	Erosion rate of 10 – 15 feet per year along a 600 – 800 foot stretch of riverbank between the older part of town and the school site.	<ul style="list-style-type: none"> <li>• Construct wooden stairway to eliminate foot traffic on banks and protect natural vegetation</li> <li>• Place filled barrels along upper banks</li> <li>• Prevent construction of new buildings in path of erosion advancement</li> </ul>
2003 and 2009	US Army Corps of Engineers Community Erosion Assessment and Baseline Erosion Assessment (USACE, 2009a; USACE, 2009b)	<p>Divided community into four “reaches” starting from southern end of town and moving upstream. Estimated erosion rates:</p> <ul style="list-style-type: none"> <li>• Reach 1: 4 feet per year</li> <li>• Reach 2: 7.7 feet per year</li> <li>• Reach 3: 2.0 feet per year</li> <li>• Reach 4: 13 feet per year</li> <li>• Total loss of about 48,050 square feet of land per year</li> </ul> <p>Report identifies Kwigillingok as a “priority action community” and projects that 25 outbuildings and 8 residences are at risk within the next 50 years (2059).</p>	<ul style="list-style-type: none"> <li>• 6,000 foot riprap revetment to protect two bends of river.</li> <li>• Estimated cost: \$26.7 million</li> </ul>

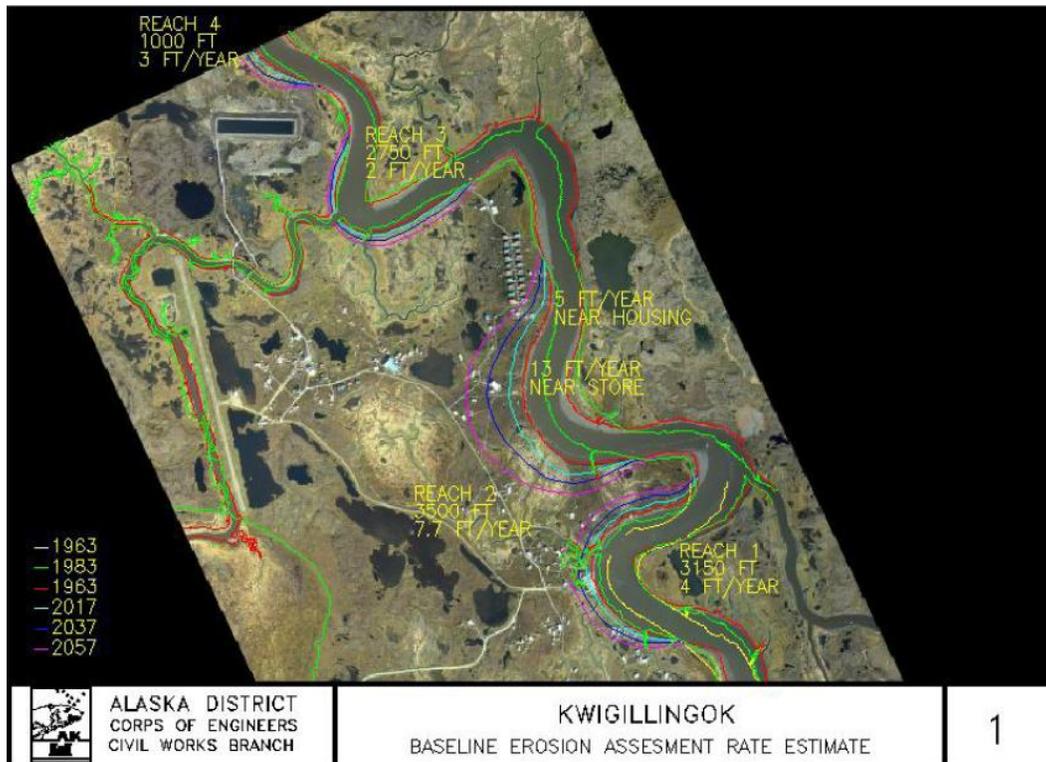
The Kwigillingok IGAP department has also monitored erosion in the community over the past decade to document the severity of the problem. Photos taken by staff of the Kwigillingok IGAP department in 2011 show the erosion of more than four feet of riverbank near a boardwalk between June and October of 2011 (Darrel John, AIJ personal communication, Jan. 8, 2016). Other photographs taken by the Kwigillingok IGAP department document the erosion of an 11 foot wide by 96 foot long section of riverbank in June 2011, and the erosion of 20 feet of riverbank near an occupied house between May 2011 and October 2011 (Native Village of Kwigillingok, 2011). The community’s documentation demonstrates that, in at least some events, erosion happens at a higher rate than previous studies have estimated.



*Photos showing the loss of an 11 foot wide by 96 foot long section of riverbank in June, 2011. The yellow stakes shown in the photos were installed by Kwigillingok to document the loss of land to erosion (John, 2011).*

**Damages from erosion:** Erosion has damaged the Kwigillingok air strip, boardwalk, and other infrastructure (HMP, 2015, p. 5-16). Erosion also threatens a number of other facilities, including the barge landing, fishery structures, fuel header, fuel tanks, the main store, power lines, homes, and the boardwalk. (HMP, 2015, p.5-16). In its 2003 Community Erosion Assessment, the US Army Corps of Engineers mapped the rate of erosion along the Kwigillingok River and projected the potential erosion damages over the next 50 years. The study projects that 25 outbuildings and 8 residences are at risk because of erosion in the next 50 years, with expected structural damages totaling \$3.1 million. In addition, it projects \$26.5 million in damages to infrastructure, including fuel storage facilities, a bridge, boardwalks, and utility infrastructure (USACE, 2009a p. 4-5).

**Airport:** The airport has been damaged by erosion, but is currently useable. The Alaska Department of Transportation and Public Facilities provided some assistance for resurfacing the runway, but the airport site continues to erode and improvements are needed. The community is working with state and federal agencies to secure funding for needed improvements and is also trying to work with the owners of native allotments near the airport to obtain suitable land for improvements (Lewis Amik III, AIJ personal communication, July 26, 2019).



*Kwigillingok Erosion Map (map reproduced from USACE, 2003, p. 3).*

Community-based erosion monitoring: Kwigillingok has actively monitored and documented erosion rates through photographs, measurements, and other reports since 2011. In 2011, the community placed yellow plastic poles 25 feet away from the edge of the riverbank in two locations to monitor the loss of land to erosion and began keeping regular erosion records. The community photographed the poles as the riverbank eroded, demonstrating the ongoing erosion problem. Within one to two months of the date the poles were installed, the poles had fallen over the riverbank because of erosion (Darrel John, AIJ personal communication, Aug. 8, 2019). The poles were used until 2017, when Kwigillingok began monitoring erosion rates in partnership with DGGs and AIJ.

In 2017, Kwigillingok partnered with DGGs and AIJ to install erosion monitoring stakes in several locations along the Kwigillingok River. Local staff take measurements of the distance between the eroding riverbank and stakes at regular intervals.

In addition, Kwigillingok has documented erosion through photographs and written documentation of community observations. In 2011, Kwigillingok collected photographs of significant erosion events in a PowerPoint presentation submitted to



*Erosion near the 20 unit housing area in October 2018 (Philip, 2018).*

the Natural Resources Conservation Service (NRCS) as part of a request for assistance with erosion mitigation (Darrel John, AIJ personal communication, Jan. 8, 2016). Kwigillingok has also recorded observations of erosion events on the Local Environmental Observer (LEO) Network, an online forum for local observers to document changing environmental conditions. For example, in July, 2015, IGAP coordinator Darrel John reported that erosion occurred along the banks of the Kwigillingok River, 100 feet east of the main store, and caused erosion and damage to the boardwalk (LEO Network, 2015).



*Erosion of Kwigillingok River bank in 2011. Photo shows the yellow poles used to monitor erosion (John, 2011).*

### **Ground Failure**

Kwigillingok is located in an area with sporadic or discontinuous permafrost and muddy soils. The area is susceptible to ground failure, which occurs in a number of locations in Kwigillingok. Land subsidence, including permafrost thaw and floodwater soil saturation, is the most common form of ground failure in the community. Although there are few written studies of ground failure in Kwigillingok, residents have documented the occurrence of ground failure and its effects on community infrastructure. According to the 2015 Hazard Mitigation Plan, ground failure is “likely” within a three year interval in Kwigillingok, with a greater than 20 percent but less than 33 percent chance of an event in any year. The likely extent of damage is considered “limited,” because ground failure typically occurs over time, with warning signs, and is therefore not likely to cause injuries or death or to shut down critical facilities and services. It could, however, cause severe damage to 10 percent or more of the property in the community (HMP 2015, p. 5-23, 5-26).

Damages from ground failure: Subsidence has caused damage to structures, roads, cultural sites, and the airport in Kwigillingok. Some facilities have sunk on their pilings as a result of subsidence. The K-12 School, constructed in 2015, has cracks in the interior walls as a result of settling from thawing permafrost (Gary Evon, AIJ personal communication, Aug. 7, 2019). Two cemeteries have also been affected by subsidence, with one of the two sites becoming ponded (HMP 2015, p. 5-23 to 5-26).

### **Severe Weather**

The entire village of Kwigillingok is vulnerable to severe weather events, including heavy snow and drifting snow, freezing rain, ice storms, extreme cold, and high winds. These severe weather events are exacerbated by climate change, which is expected to increase the amount of rain and snow and result in more unpredictable weather patterns. The most common severe weather events in the area are high winds and severe winter storms. During a high wind event in 2011, Kwigillingok experienced winds of over 80 mph. Residents reported other severe weather events in 2007-2008 and 2012. Between 1988 and 2013, 13 severe weather events occurred in the Kuskokwim Delta area, which includes Kwigillingok. Although not all of these events directly impacted Kwigillingok, the events are representative of the type of event that occurs in Kwigillingok and the frequency with which they occur. These events included high winds, winter storms, extreme cold with wind chills as low as -70° F, blizzards, winds over 100mph, storm surge, and ice storms (HMP, 2015, p.5-28 to 5-34).

The 2015 Hazard Mitigation Plan projects that the probability of a severe weather event occurring in the next year is “likely,” with up to a 100 percent chance of a severe storm event occurring each year. The likely impact of severe weather events is “limited,” meaning that injuries would not result in permanent disability or complete shutdown of critical facilities for more than one week, but severe damage to more than 10 percent of the property in the community could occur (HMP 2015, p. 5-34).

Damages from severe weather: Severe weather can result in the closure of airports and roadways, disrupt the delivery of supplies and emergency medical services, damage structures and utilities, sink boats, and cause injuries and deaths (HMP 2015, p. 5-34).

In recent years, Kwigillingok has experienced unusually warm winter temperatures and there has been less sea ice near the community than was present historically. The sea ice that exists has also been less stable. With less sea ice to block storm waves, the ocean has been rougher, which puts local hunters, who rely on boats or stable sea ice to hunt, in peril (AIJ, 2018).

Community-based weather monitoring: Kwigillingok partners with AIJ to document severe weather events that affect the community. The Kwigillingok IGAP department assists AIJ in compiling narratives and photographs describing weather events. AIJ provides the narratives to the National Weather Service, DGGs, and other agencies to document the changing weather conditions the community experiences and improve the information available to the community to plan for severe weather events.



*Ice piled up along the shore after a storm and flooding event in January of 2011 (John, 2011).*

### **III. Effects on Community health and safety**

Erosion, flooding, and other severe weather exacerbate community health hazards in Kwigillingok. For example, the Alaska Department of Environmental Conservation’s (DEC) Contaminated Sites database lists three contaminated sites in Kwigillingok that have not been decommissioned and cleaned up: the old community clinic fuel storage tanks, the former BIA school fuel tanks, and the Kwik Inc., tank farm. There is also an old landfill that has not been decommissioned. These sites are all vulnerable to erosion and flooding. Because soil in these areas is contaminated, erosion and floodwaters cause the contaminants to flow into the river, affecting the local ecosystem and fish stocks (USACE, 2009a, p. 5; ADEC, 2019). The community is heavily dependent on fish as a food source, so contamination that affects the fish stocks can have a detrimental effect on community health.

In March 2015, one of the contaminated sites listed on DEC’s database, the old BIA school site was demolished, but the site is still listed as a contaminated site (Darrel John, AIJ personal communication, January 8, 2016; Lewis Amik III, AIJ personal communication, Aug. 7, 2019). Hazardous materials were removed and community members repurposed the fuel tanks from the site, but no monitoring devices were installed to determine whether the soil is still contaminated (Lewis Amik III, AIJ personal communication, Aug. 7, 2019; Darrel John, AIJ personal communication, Aug. 9, 2019). The remaining contaminated sites have not been cleaned up and continue to pose a threat to community health.



Map showing the location of contaminated sites and landfill. Clockwise, from top: Kwik, Inc. consolidated tank farm, old landfill, Kwik, Inc. former tank farm, and former BIA school (map reproduced from Alaska Department of Environmental Conservation, Waste Erosion Assessment and Review Project (WEAR MAP). Accessed July 24, 2019 at <https://dec.alaska.gov/eh/solid-waste/wear-project/>).

In addition, warming temperatures and increasingly severe storms result in decreased sea ice extent and unstable sea and river ice conditions. This affects the ability of residents to travel over both sea and river ice for subsistence hunting and to travel to hub communities to obtain supplies, seek medical treatment, and visit family. These unpredictable ice conditions jeopardize the lives of community members, as more people are likely to fall through the ice with increasingly unstable ice near the community. These ice conditions can also prevent community members from hunting to obtain necessary food sources, straining the community's food supply.

#### **IV. Community Response to Hazards**

Kwigillingok has worked to respond to the natural hazards that affect the community by taking action to protect community members from immediate hazards, monitoring and documenting hazards and weather events, relocating homes and other facilities that are in the erosion or flood zone, collaborating with community entities and outside entities to plan for further long term responses, participating in FEMA's hazard mitigation planning process, and seeking funding and technical assistance to implement mitigation actions. In the short term, Kwigillingok is planning to relocate homes that are currently in the southern end of the community, where they are at the highest risk to flooding and erosion, and, over the long term, the community intends to relocate the majority of the homes and public infrastructure in the community to higher ground (Darrel John, AIJ personal communication, Aug. 19, 2019). The community has taken effective action with its own limited resources, but has had difficulty accessing outside funding sources to construct erosion protection measures, such as rip rap and berms. Kwigillingok hopes that the work it has done with its own resources can serve as an example for other communities.

To respond to immediate storm and flooding hazards, Kwigillingok organizes the evacuation of community residents to the local school (Gavin Phillip, AIJ personal communication, Aug. 5, 2016).

As described in section III of this report, Kwigillingok also monitors flooding, erosion, and severe weather events in the community. This information is documented in collaboration with AIJ and DGGS, and is sometimes

reported to the LEO Network as well. The documentation provides important information and feedback to the National Weather Service, DGGs, and other agencies involved in forecasting and responding to weather events and hazards that affect communities so that these agencies can better formulate the information they provide to reflect on the ground information from communities. This monitoring and documentation also helps Kwigillingok to identify the areas that are most at risk in the community and plan long-term responses.

To protect residents and homes that are in the most immediate risk, Kwigillingok has used a combination of local labor and funds and outside funding sources to elevate homes or relocate homes to higher ground outside of



*The Kwigillingok team relocating a home in March 2018 (Philip, 2018).*

the flood hazard area. According to the 2015 Hazard Mitigation Plan, 84 homes are located in the flood hazard area, and 29 of the homes have been elevated (HMP, 2015, p. 5-21). The highest priority is to relocate homes from the southern end of the community because these homes are at the greatest risk of flooding and erosion. Approximately 12 homes need to be relocated in the short term (Darrel John, AIJ personal communication, Aug. 19, 2019). Kwigillingok has relocated five homes from the southern end of the community to safer ground (Darrel John, AIJ personal communication, Aug. 18, 2019). One home was relocated in 2012 using a grant from the NRCS Emergency Watershed Protection Program. (HMP, 2015, p. 5-14 to 5-15). Other homes have been relocated using local general funds and labor (Darrel John, AIJ personal communication, Jan. 8, 2016). During the winter of 2018 to 2019, Kwigillingok attempted to relocate 10 homes using local labor, but was only able to relocate one home because of irreparable problems with heavy equipment and because the land did not freeze sufficiently during the winter to move the homes. Kwigillingok has applied for funding to purchase new heavy equipment so that the community can move the homes during the upcoming winter season. (Lewis Amik III, AIJ personal communication, July 26, 2019). Some of the remaining homes, however, have structural damage and it may not be possible to relocate them (Lewis Amik III, AIJ personal

communication, July 26, 2019). Kwigillingok is looking into programs that may be able to provide funding to construct replacement homes so that the residents of these homes can relocate to safe areas.

Kwigillingok has also moved other infrastructure to prevent damage from natural hazards. For example, in summer 2015, Kwigillingok moved a section of sidewalk 150 feet away from the river using funding provided by the Alaska Department of Transportation & Public Facilities (DOT) (Darrel John, AIJ personal communication, January 8, 2016).

Because the majority of the homes and infrastructure in Kwigillingok are at risk, the community is also planning to relocate the majority of the community further inland, to higher ground, over the long term. The community has had public meetings to discuss long term plans for relocation and has identified two possible sites: one site about 25 miles northeast of Kwigillingok and one about five miles inland from Kwigillingok. The tribe has had meetings with landowners, including village and regional corporations and native allotment owners, to discuss the viability of these sites (Darrel John, AIJ personal communication, Aug. 19, 2019).

In April of 2019, Kwigillingok hired a tribal resilience coordinator to assist the community with long term planning to adapt to the changes the community is facing. The resilience coordinator is collecting data, including photographs and GPS locations, for the homes and infrastructure that are most at risk to flooding and erosion, conducting flood damage risk assessments, taking erosion measurements, and documenting damage to foundations and house pads resulting from permafrost thaw. The tribal resilience coordinator is also collecting climate history and information about the local effects of climate change through interviews with elders and other research. Kwigillingok will use this information to create a plan for climate resilience, including a proposal for protecting or relocating the most at risk homes. The plan will be completed by early 2020 (Gary Evon, AIJ personal communication, Aug. 7, 2019).

While implementing all of these actions to respond immediately and over the long term, Kwigillingok continues to seek funding and technical assistance to repair and limit damage to homes and facilities and to protect the community.

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**Appendix A.** Critical Facilities and Infrastructure in Kwigillingok and vulnerability to natural hazards (reproduced from Native Village of Kwigillingok Hazard Mitigation Plan, 2015, Table 6-4; updated based on conversations with Lewis Amik III, Aug. 7, 2019).

Facilities	Number of Occupants	Facilities	Latitude	Longitude	Estimated Value	Building Type	Earthquake	Flood/Erosion	Ground Failure	Severe Weather	Volcano
Government	30	Kwigillingok Office and Community Hall	59.86914	-163.14729	\$1,500,000	W1	X	X	X	X	X
	3	U.S. Postal Service	59.87598	-163.16382	\$400,000	W1	X	X	X	X	X
	25	Army National Guard Bldg.	59.86408	-163.14022	\$250,000	W1	X	X	X	X	X
Emergency Response	2	Kwigillingok. Village Public Safety Police Station	59.88788	-163.10600	\$200,000	W1	X	X	X	X	X
	0	Fire Fighting Equipment	Undefined	Undefined	\$155,000	W1	X	X	X	X	X
Education	200	Kwigillingok School	59.88797	-163.10592	\$40,000,000	W2	X	X	X	X	X
Medical	10	Kwigillingok Health Clinic	59.87626	-163.16302	\$2,000,000	W1	X	X	X	X	X
Community		55 Non-Elevated Homes (\$250K ea)	N/A	N/A	\$13,750,000	W1	X	X	X	X	X
		29 Elevated Homes (pilings & beams) (\$350K ea)	N/A	N/A	\$10,150,000	W1	X	X	X	X	X
	5	General Store	59.87653	-163.16515	\$300,000	W1	X	X	X	X	X
	5	A And L Variety Shoppe	Undefined	Undefined	\$300,000	W1	X	X	X	X	X
	2	Eclectic Stitchery	Undefined	Undefined	\$30,000	W1	X	X	X	X	X
Roads	2	Harry's Transportation And Warehousing	Undefined	Undefined	\$30,000	W1	X	X	X	X	X
	2	Kwigillingok Incorporated (Inc.) Store	Undefined	Undefined	\$300,000	W1	X	X	X	X	X
	0	Kwigillingok Inc. Store's Storage	Undefined	Undefined	\$10,000	W1	X	X	X	X	X
	0	Kwigillingok Inc. Store's Outbuilding	Undefined	Undefined	\$10,000	W1	X	X	X	X	X
	0	IRA Council Storage Building	Undefined	Undefined	\$10,000	W1	X	X	X	X	X
	0	Old Cemetery	59.86265	-163.13787	\$10,000	N/A	X	X	X	X	X
	0	New Cemetery	59.86396	-163.14493	\$10,000	N/A	X	X	X	X	X
	0	10.2 Miles of Boardwalk Roads	N/A	N/A	\$10,200,000	N/A	X	X	X	X	X
	0	5.3 Miles of Road	N/A	N/A	\$5,406,000	N/A	X	X	X	X	X
	Boardwalk Bridge #1	59.87201	-163.14977	\$20,000	N/A	X	X	X	X	X	

<b>Bridges</b>	0	Boardwalk Bridge #2	59.87977	-163.16624	\$75,000	N/A	X	X	X	X	X
		Boardwalk Bridge #3	59.87182	-163.14673	\$25,000	N/A	X	X	X	X	X
		Boardwalk Bridge #4	59.87034	-163.14559	\$30,000	N/A	X	X	X	X	X
<b>Transportation</b>	0	Kwigillingok Runway (1835' by 40')	59.87645	-163.16757	\$4,000,000	AFO	X	X	X	X	X
	1	State DOT Airport Maintenance Building	Undefined	Undefined	\$500,000	SiL	X	X	X	X	X
	0	Barge Landing	59.87065	-163.14527	\$1,000,000	N/A	X	X	X	X	X
<b>Utilities</b>	3	Kwigillingok Power Company (Power Generation Facility)	59.87669	-163.16167	\$5,000,000	EPPS	X	X	X	X	X
	0	Wind Turbines w/battery storage unit	59.87314	-163.15741	\$10,000,000	N/A	X	X	X	X	X
	0	Kwigillingok, Inc. Fuel Storage (Fuel Storage Tanks)	59.83188	-163.15192	\$2,500,000	OTF	X	X	X	X	X
	0	School Fuel Storage (Fuel Storage Tanks)	59.87761	-163.15808	\$1,000,000	OTF	X	X	X	X	X
	0	Village Safewater Fuel Storage (Fuel Storage Tanks)	59.87679	-163.16637	\$1,000,000	OTF	X	X	X	X	X
	0	Village Council Fuel Storage (Fuel Storage Tanks)	59.86937	-163.14725	\$1,000,000	OTF	X	X	X	X	X
	0	Marine Fuel Header	59.08252	-163.15308	\$85,000	OIPE	X	X	X	X	X
	0	LKSD Kwigillingok (Reservoir/Water Supply)	59.88245	-163.16650	\$3,000,000	N/A	X	X	X	X	X
	3	Potable Water Production and Treatment Facility	59.87673	-163.16270	\$1,500,000	PWTS	X	X	X	X	X
	10	Kwigillingok Washeteria	59.87399	-163.15280	\$350,000	W1	X	X	X	X	X
	0	Kwigillingok Class III Muni Landfill	59.86650	-163.13658	\$700,000	N/A	X	X	X	X	X
	0	New landfill with berms (closed)	Undefined	Undefined	Undefined	N/A	X	X	X	X	X
	0	Sewage Lagoon	59.86334	-163.16937	\$1,500,000	N/A	X	X	X	X	X
<b>Total Occ</b>	349			<b>Total Damages</b>	\$117,116,000						

(John 2014, DHS&EM 2014b)