

## EROSION EXPOSURE ASSESSMENT—KIPNUK

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Aerial orthoimagery of Kipnuk, Alaska, in 2015 (Overbeck and others, 2016).



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Report of Investigation 2021-3 Kipnuk

State of Alaska  
Department of Natural Resources  
Division of Geological & Geophysical Surveys

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# EROSION EXPOSURE ASSESSMENT—KIPNUK

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## KIPNUK EROSION EXPOSURE ASSESSMENT

This is a summary of results from an erosion forecast near infrastructure at Kipnuk, Alaska. We conduct a shoreline change analysis, forecast 60 years of erosion, and estimate the replacement cost of infrastructure in the forecast area. Buzard and others (2021) describe the method and guidance for interpreting tables and maps.

Source data for this summary include the following:

- Delineated vegetation lines and change assessment by Buzard and others (2021) following the methods of Overbeck and others (2020).
- Infrastructure AutoCAD outlines and metadata from Division of Community & Regional Affairs (2004) Community Profile Map series.
- Added infrastructure such as roads, power distribution lines, and outbuildings, delineated if visible in the most up-to-date high resolution ( $\leq 0.66$  ft [20 cm] ground sample distance) aerial orthoimagery (Overbeck and others, 2016).
- Computed infrastructure cost of replacement based on square or linear footage from Buzard and others (2021).

Kipnuk is located four miles inland from the Bering Sea on the outer bank of an actively eroding bend of the Kugukaktlik River. Erosion ranges between 3 and 9.8 feet per year along the bend of the river (Overbeck and others, 2020). Most of the erosion at Kipnuk is reported to occur in the



fall during coastal storm surge events (U.S. Army Corps of Engineers [USACE], 2009). A rock revetment was installed at Kipnuk to mitigate erosion but much of the rock was lost and the structure failed to provide long-term protection (USACE, 2009). However, the shoreline protection appeared to have slowed the riverbank erosion for many years (AECOM, 2016).

We forecast erosion 60 years from the most recent shoreline (2015) at 20-year intervals to identify the exposure of infrastructure to erosion. The cost to replace exposed infrastructure is greatest between 2015 and 2035 when several public and commercial buildings, the barge landing site, and fuel infrastructure are in the erosion forecast area (table 1 and table 3). The barge landing site is forecast to be mostly undermined by erosion by 2035 and fully undermined by 2055 (table 2). Fuel infrastructure and power distribution lines are in the erosion forecast area throughout the 60-year forecast (table 1). Residential buildings are within the 2035 and 2055 forecast, with several more added by 2075 (table 3). The total estimated replacement cost of infrastructure exposed to erosion is \$15.7 million ( $\pm$  \$4.7 million) through 2075 (table 2; fig. 1).

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**Table 1.** Quantity of infrastructure with estimated erosion exposure by linear footage (LF), square footage (SF), or count (n).

Quantity of Exposed Infrastructure						
Erosion Forecast Date Range	Buildings & Tank Facilities (n)	Power Lines (LF)	Fuel Lines (LF)	Water Lines (LF)	Roads & Boardwalks (LF)	Barge Landing (SF)
2015 to 2035	6	333	537	0	741	38,850
2035 to 2055	10	768	340	0	1,781	3,480
2055 to 2075	17	837	210	79	1,928	0
Combined Total	33	1,938	1,087	79	4,450	42,330

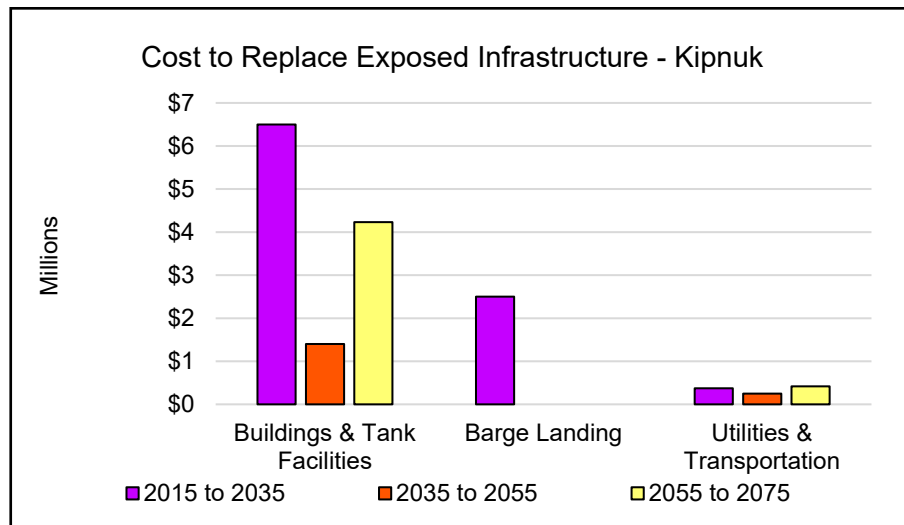
**Table 2.** Replacement cost of infrastructure exposed to erosion per 20-year interval.

Cost to Replace Exposed Infrastructure							
Erosion Forecast Date Range	Buildings & Tank Facilities	Power Lines	Fuel Lines	Water Lines	Roads & Boardwalks	Barge Landing	Sum
2015 to 2035	\$6,500,000	\$66,600	\$32,200	\$0	\$275,000	\$2,500,000	\$9,373,800
2035 to 2055	\$1,400,000	\$153,600	\$20,400	\$0	\$76,900	\$0	\$1,650,900
2055 to 2075	\$4,230,200	\$167,500	\$12,600	\$50,000	\$186,200	\$0	\$4,646,500
Combined Total	\$12,130,200	\$387,700	\$65,200	\$50,000	\$538,100	\$2,500,000	\$15,671,200

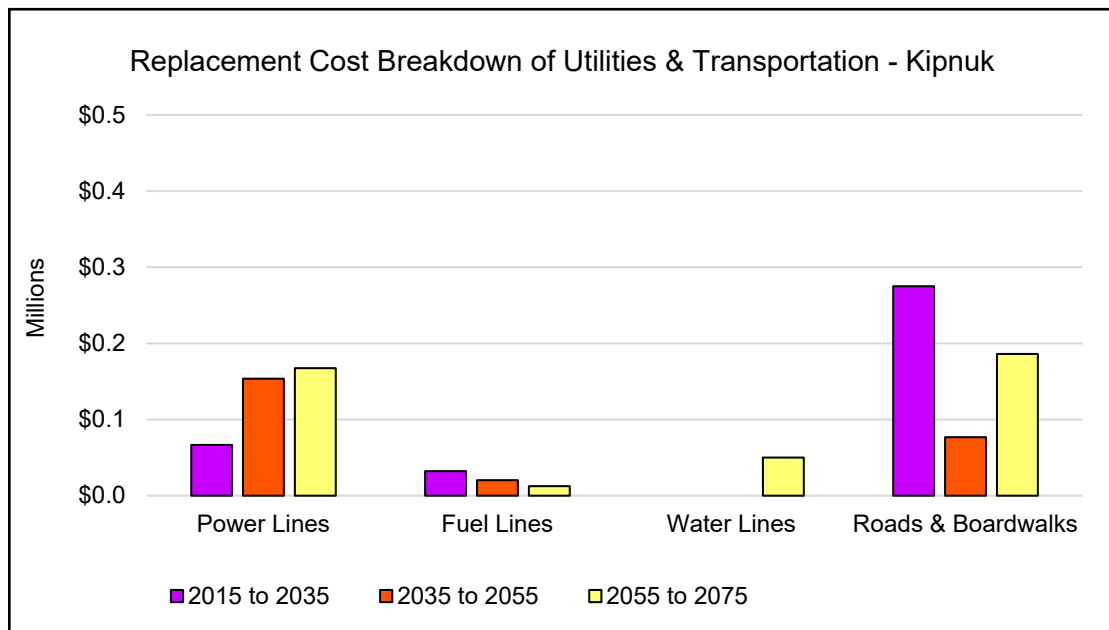
**Table 3.** Cost estimate of erosion exposure to buildings and tank facilities by 20-year interval. The count of exposed residential or unspecified buildings is denoted in parentheses. NCA designates buildings with no cost assigned.

Cost to Replace Exposed Buildings and Tank Facilities		
Erosion Forecast Date Range	Building Type	Cost of Replacement
2015 to 2035	KTC Lodge	\$1,000,000
	Kugkaktlik Ltd. Fuel Tanks	\$4,500,000
	Hardware Store	\$500,000
	ANTHC Office	\$500,000
	Unspecified (1)	NCA
2035 to 2055	Residential (3)	\$900,000
	KTC Garage	\$500,000
	Abandoned Tank Farm	NCA
	Unspecified (5)	NCA
2055 to 2075	Residential (8)	\$4,230,200
	Unspecified (9)	NCA





**Figure 1.** This figure summarizes the replacement cost of all infrastructure that are in the erosion forecast area per 20-year intervals. 20-year intervals are symbolized by color: purple represents the time interval 2015 to 2035, red represents 2035 to 2055, and yellow represents 2055 to 2075. Buildings and tank facilities have a total cost of \$12.1 million over 60 years. Utilities and transportation have a total cost of \$1.0 million over 60 years.



**Figure 2.** This figure breaks down the replacement cost of all utilities and transportation in the erosion forecast area by 20-year intervals. Roads and boardwalks contain the largest cost at a total of \$0.5 million over 60 years.

## ACKNOWLEDGMENTS

This work was funded by the Denali Commission Village Infrastructure Protection Program through the project “Systematic Approach to Assessing the Vulnerability of Alaska’s Coastal Infrastructure to Erosion.” The community of Kipnuk was not consulted for this report.

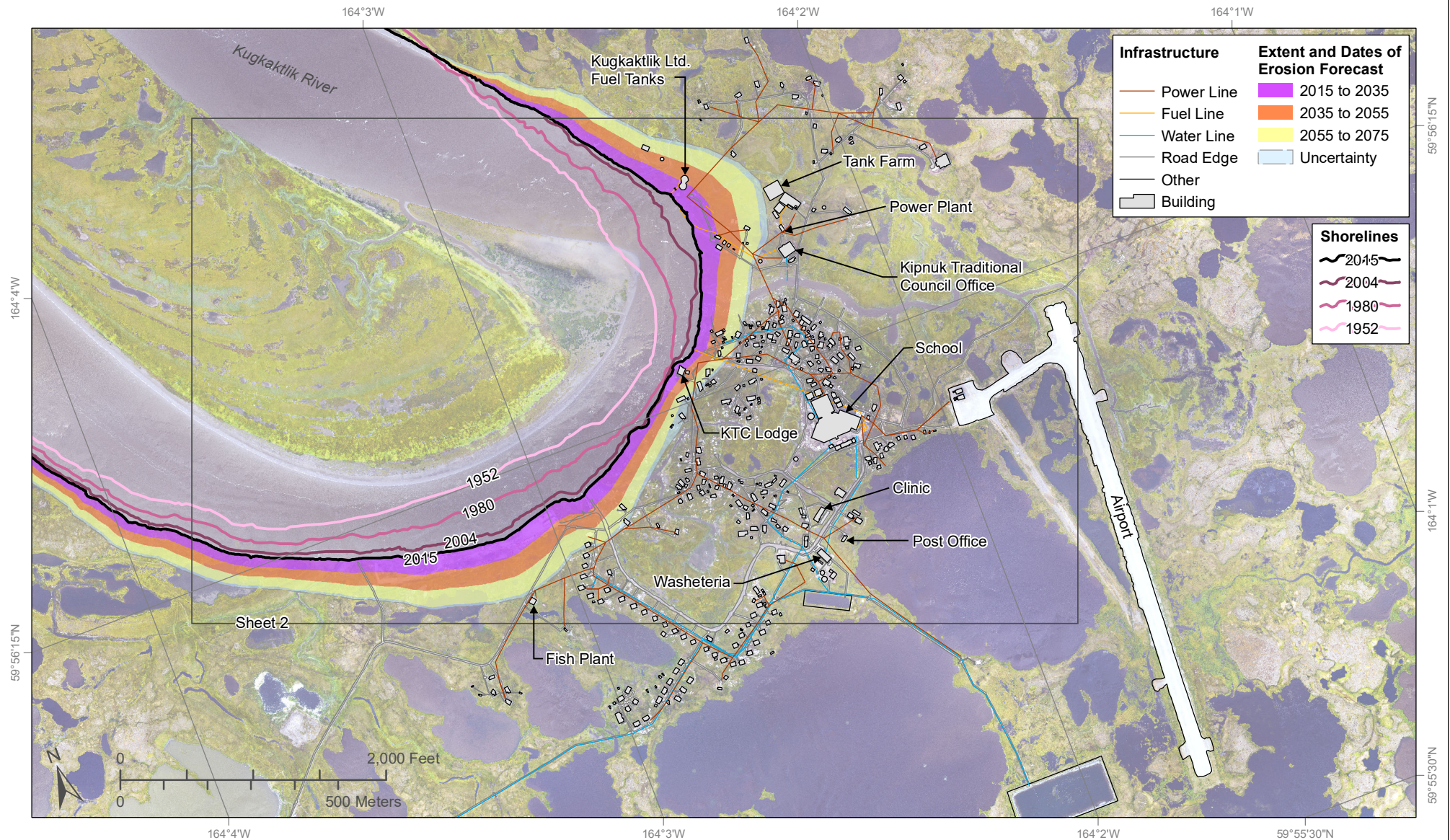
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# Erosion Forecast Kipnuk, Alaska

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Kipnuk, Sheet 1 of 2



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Erosion and accretion of coasts and rivers result in shoreline change. These rates of shoreline change at Alaska communities are calculated from historical and modern shorelines (shorelines shown as lines in pink scale and labeled by year). The long-term (1952 to 2015) shoreline change rate is used to forecast where erosion could impact community infrastructure. Erosion is forecast to reach the colored areas by specified time intervals: 2015 to 2035 (purple), 2035 to 2055 (orange), and 2055 to 2075 (yellow). The area of uncertainty of the 2075 shoreline at a 90 percent confidence interval is light blue. Areas that are not colored by time interval are not forecast to erode by 2075 based on the historical shoreline change rate. For more detailed information about the impacts to infrastructure from erosion at Kipnuk, refer to the Kipnuk erosion exposure assessment report.

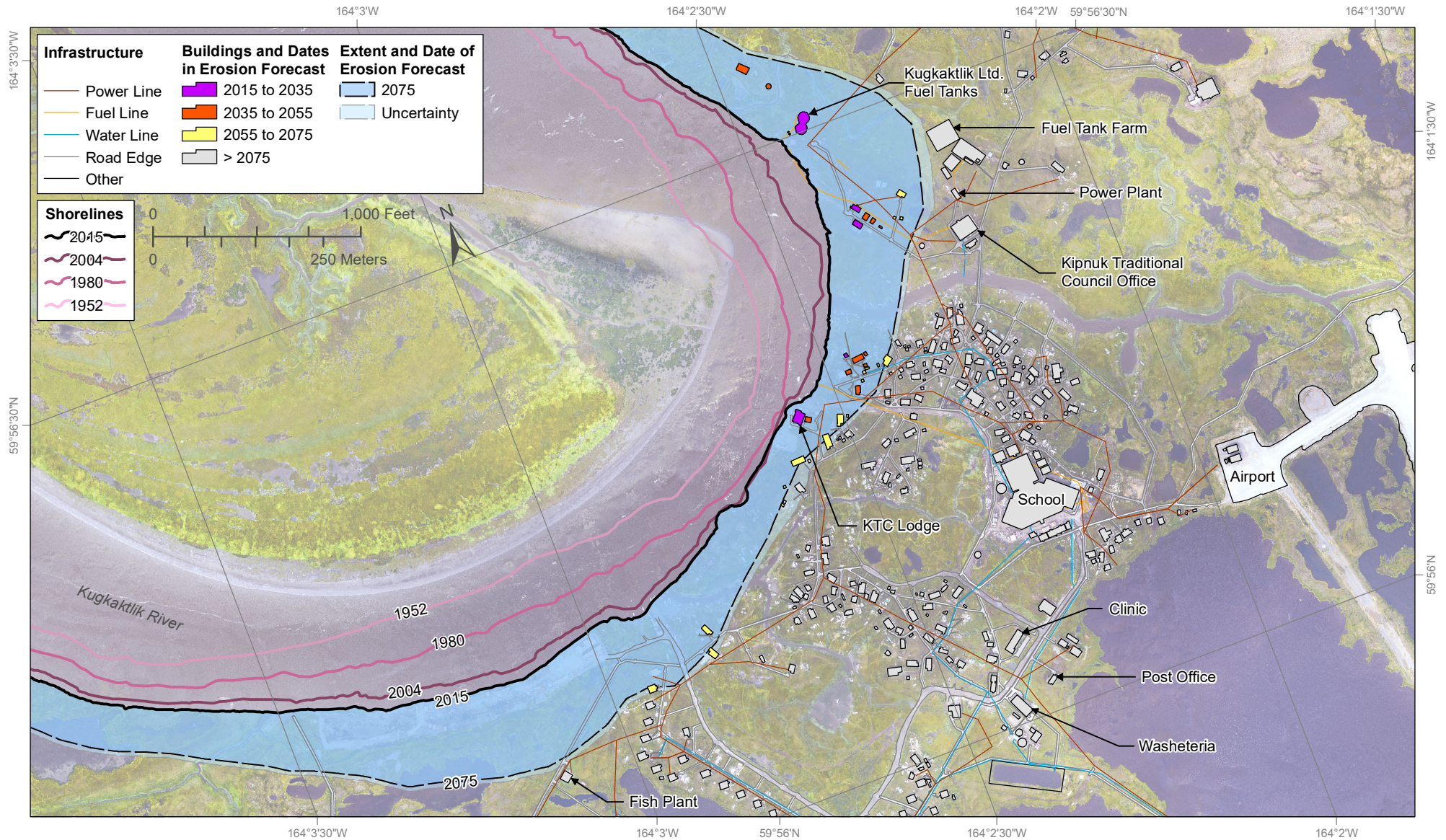
This work is part of the Coastal Infrastructure Erosion Vulnerability Assessment project funded by the Denali Commission Environmentally Threatened Communities Grant Program. Components of this map were prepared by the Alaska Department of Commerce, Community, and Economic Development (DCCED) using funding from multiple municipal, state, federal, and tribal partners. The original AutoCAD drawing of the infrastructure data layers was converted to ArcGIS.





# Erosion Exposure Kipnuk, Alaska

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Buzard and others, 2021  
Kipnuk, Sheet 2 of 2



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Erosion and accretion of coasts and rivers result in shoreline change. These rates of shoreline change at Alaska communities are calculated from historical and modern shorelines (shorelines shown as lines in pinkscale and labeled by year). The long-term (1952 to 2015) shoreline change rate is used to forecast where erosion could impact community infrastructure. Erosion is forecast to year 2075 (dark blue) with a 90 percent confidence interval area of uncertainty (light blue). Buildings forecast to be impacted by erosion are colored by the range of years when the impact is forecast to occur: 2015 to 2035 (purple), 2035 to 2055 (orange), 2055 to 2075 (yellow), and no impacts expected by 2075 (gray). For more detailed information about the impacts to infrastructure from erosion at Kipnuk, refer to the Kipnuk erosion exposure assessment report.

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