Report of Investigation 2021-3 Quinhagak

EROSION EXPOSURE ASSESSMENT—QUINHAGAK

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Quinhagak, Alaska, in 2018. Photo: Alaska Division of Geological & Geophysical Survey.

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EROSION EXPOSURE ASSESSMENT—QUINHAGAK

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QUINHAGAK EROSION EXPOSURE ASSESSMENT

This is a summary of erosion forecast results near infrastructure at Quinhagak, 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, water and sanitation facilities, and out-buildings, delineated if visible in the most up-to-date high resolution (≤ 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) and City of Quinhagak (2012).

Quinhagak is located on the southern Yukon-Kuskokwim Delta where the Kanektok River empties into Kuskokwim Bay. Erosion on the coast is caused by storm surge. Erosion on the river can occur during high stage caused by storm surge, spring break up, and ice jams. Flooding can thaw permafrost, leading to an erosion process called

usteq (Bronen and others, 2019). The community has lost considerable infrastructure, cultural resources, and significant sites to erosion (City of Quinhagak, 2012).

We forecast erosion 60 years from the most recent shoreline (2015) at 20-year intervals to identify the exposure of infrastructure to erosion. In Quinhagak, this erosion forecast method is only appropriate for the coastal section of the community where erosion occurs at a linear rate. Most of the infrastructure in Quinhagak is adjacent to the Kanektok River, which has a history of significant non-linear channel migration and avulsion (rerouting through a new channel). From 1952 to 1982, one section of the river migrated over 600 ft north, away from town. By 2005, the channel diverted and migrated 3000 ft south. The new channel undermined the airstrip in two areas and had to be abandoned.

We cannot forecast erosion for the Kanektok River because it is non-linear (Hooke, 2007). To provide some context of erosion exposure, we map the visible extent of past river migration and the topographic floodplain (methods below). River delineations shown in the Quinhagak River Channel Change Map illustrate the general change in shape of the river, but the exact extent contin-

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uously changes over decades, years, and seasons (Hooke, 2007). For meandering and braided rivers like the Kanektok, a terrace wall indicates the edge of the topographic floodplain (also called the channel belt or stream corridor [David and others, 2016]). This line represents the boundary of past river extent wherein abandoned channels still exist and can be reoccupied in a relatively short amount of time, which is what happened between 1982 and 2005. The topographic floodplain represents areas exposed to rapid river change. Flooding can exceed the boundary (such as overbank flooding). The river can also erode the boundary, but this process is typically slower than channel migration (Hooke, 2007). We designate anything in the topographic floodplain at risk of channel migration but cannot estimate likelihood. Structures near the floodplain boundary will be exposed to erosion if the river migrates to the boundary. We find the City Dock, located at the riverbank boundary, exposed to erosion due to documented erosion events (City of Quinhagak, 2012).

The wastewater lagoon is exposed to coastal erosion between 2056 and 2076 (table 1). No other types of infrastructure are within the 60-year coastal erosion forecast area. In the topographic floodplain there are power lines, water lines, roads, and buildings (including many small sheds and fish drying racks; table 1). The greatest costs of exposed infrastructure are roads ($3.2 million) and buildings ($2.4 million), especially around the old airport (tables 2–3; fig. 1). The total replacement cost is estimated to be $15.3 million (± $4.6 million).

Method to map topographic floodplain and historical riverbanks

We map the topographic floodplain using elevation and color-infrared imagery. First, we create a slope map from the interferometric synthetic aperture radar elevation model (available at elevation.alaska.gov). Next, we map vegetation health using the normalized difference vegetation index of the 1982 color-infrared image. Stark changes in vegetation health can represent change in elevation, ground saturation, and freshwater or saline inundation, all of which are floodplain boundary indicators (Marchetti and others, 2020). The topographic floodplain terrace wall is identified where vegetation health change and steep slopes overlap.

We delineate historical and modern river extents using automated techniques followed by manual corrections on imagery. For multi-band imagery, we use the principal component analysis technique to reassign raster values based on features that are correlated across bands (Rodarmel and Shan, 2002). The reclassified raster output emphasizes rivers (and other features like lakes, roads, infrastructure, and vegetation), making for an easy river extraction using a band threshold value. For the single-band 1952 image, we apply band thresholding in image subsets to avoid broad changes in the brightness gradient. All automated results are manually corrected to represent the visible extent of major waterways and active channels of the Kanektok River for the respective image date.

Table 1. Quantity of infrastructure with estimated erosion impacts 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 (LF)**	**Wastewater Lagoon (SF)**	**City Dock (n)**
2016 to 2036	0	0	0	0	0	0	0
2036 to 2056	0	0	0	0	0	0	0
2056 to 2076	0	0	0	0	0	69,319	0
Floodplain	32	3,398	0	1,123	8,071	0	1
Combined Total	32	3,398	0	1,123	8,071	69,319	1

Table 2. Replacement cost of infrastructure exposed to erosion per 20-year interval and within the topographic floodplain.

Cost to Replace Exposed Infrastructure							
Erosion Forecast Date Range	**Buildings & Tank Facilities**	**Power Lines**	**Fuel Lines**	**Water Lines**	**Roads**	**Wastewater Lagoon & City Dock**	**Sum**
2016 to 2036	$0	$0	$0	$0	$0	$0	$0
2036 to 2056	$0	$0	$0	$0	$0	$0	$0
2056 to 2076	$0	$0	$0	$0	$0	$6,000,000	$6,000,000
Floodplain	$2,404,900	$679,600	$0	$449,200	$3,228,500	$2,500,000	$9,262,200
Combined Total	$2,404,900	$679,600	$0	$449,200	$3,228,500	$8,500,000	$15,262,200

Table 3. Cost estimate of exposed buildings and tank facilities in the topographic floodplain. 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	
Building Type	**Cost of Replacement**
Residential (3)	$1,204,900
Unspecified (24)	$400,000
Fish camp	$300,000
Vacant warehouse	NCA
Water Intake / Infiltration Gallery	$500,000

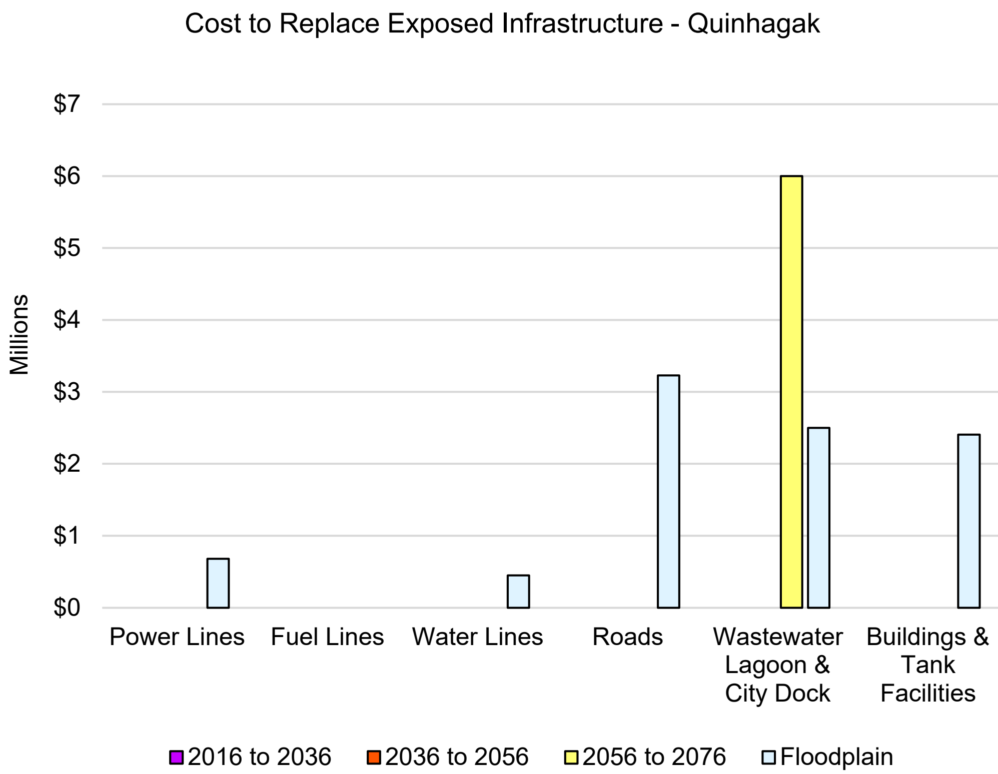

Figure 1. This figure shows the replacement cost of infrastructure in the erosion forecast area and within the topographic floodplain (blue). The only infrastructure exposed to coastal erosion is the wastewater lagoon in the 2056 to 2076 period (yellow). Infrastructure within the topographic floodplain are exposed to erosion but the timing is not known.

ACKNOWLEDGMENTS

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Erosion Forecast
Quinhagak, Alaska

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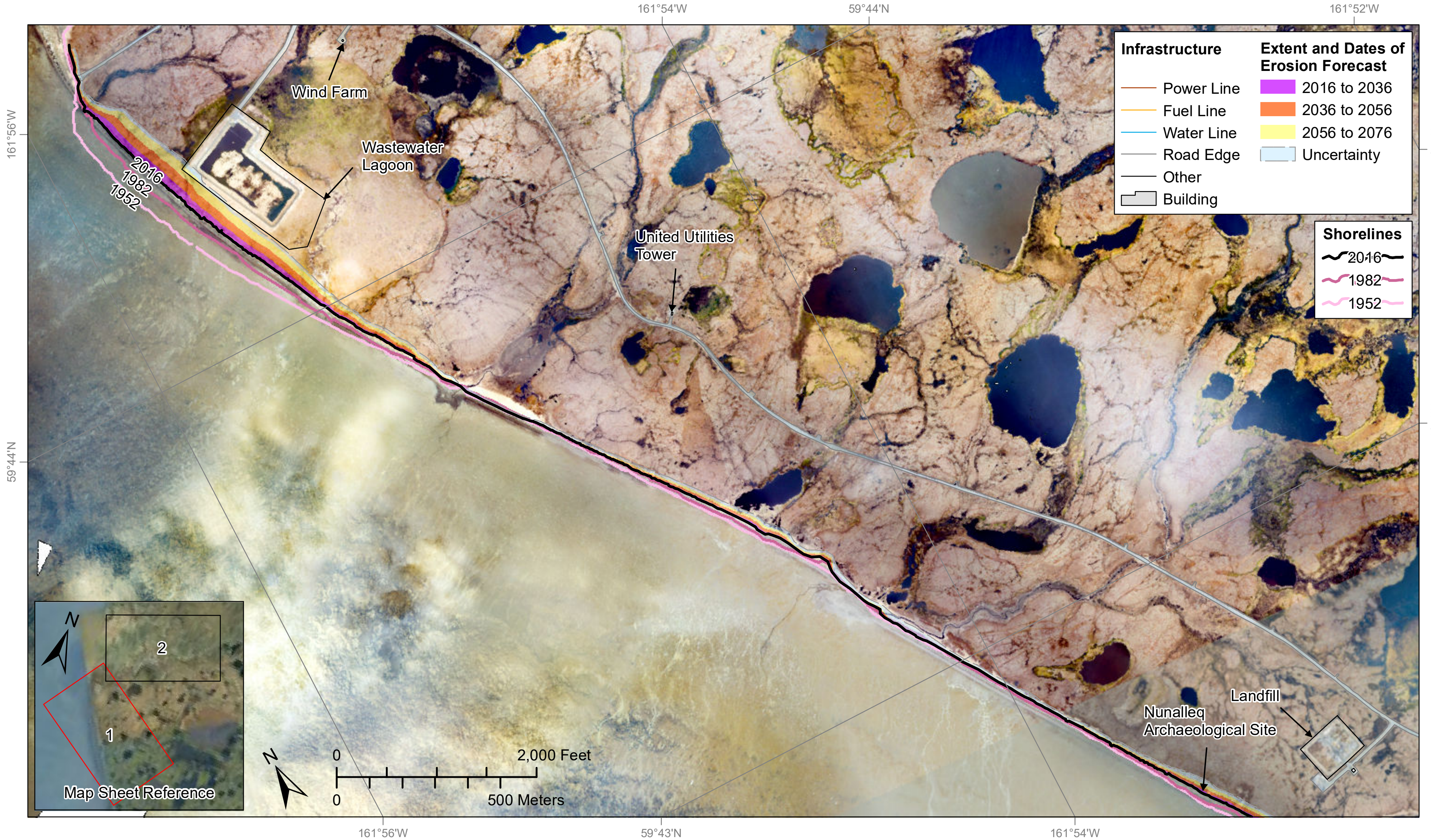
Quinhagak, Sheet 1 of 2



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website: dggs.alaska.gov

Projection: NAD83 UTM Zone 4N. Orthoimagery year: 2016. Orthoimagery available from elevation.alaska.gov

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 2016) 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: 2016 to 2036 (purple), 2036 to 2056 (orange), and 2056 to 2076 (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 2076 based on the historical shoreline change rate. For more detailed information about the impacts to infrastructure from erosion at Quinhagak, refer to the Quinhagak 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 were converted to ArcGIS.

River Channel Change
Quinhagak, Alaska

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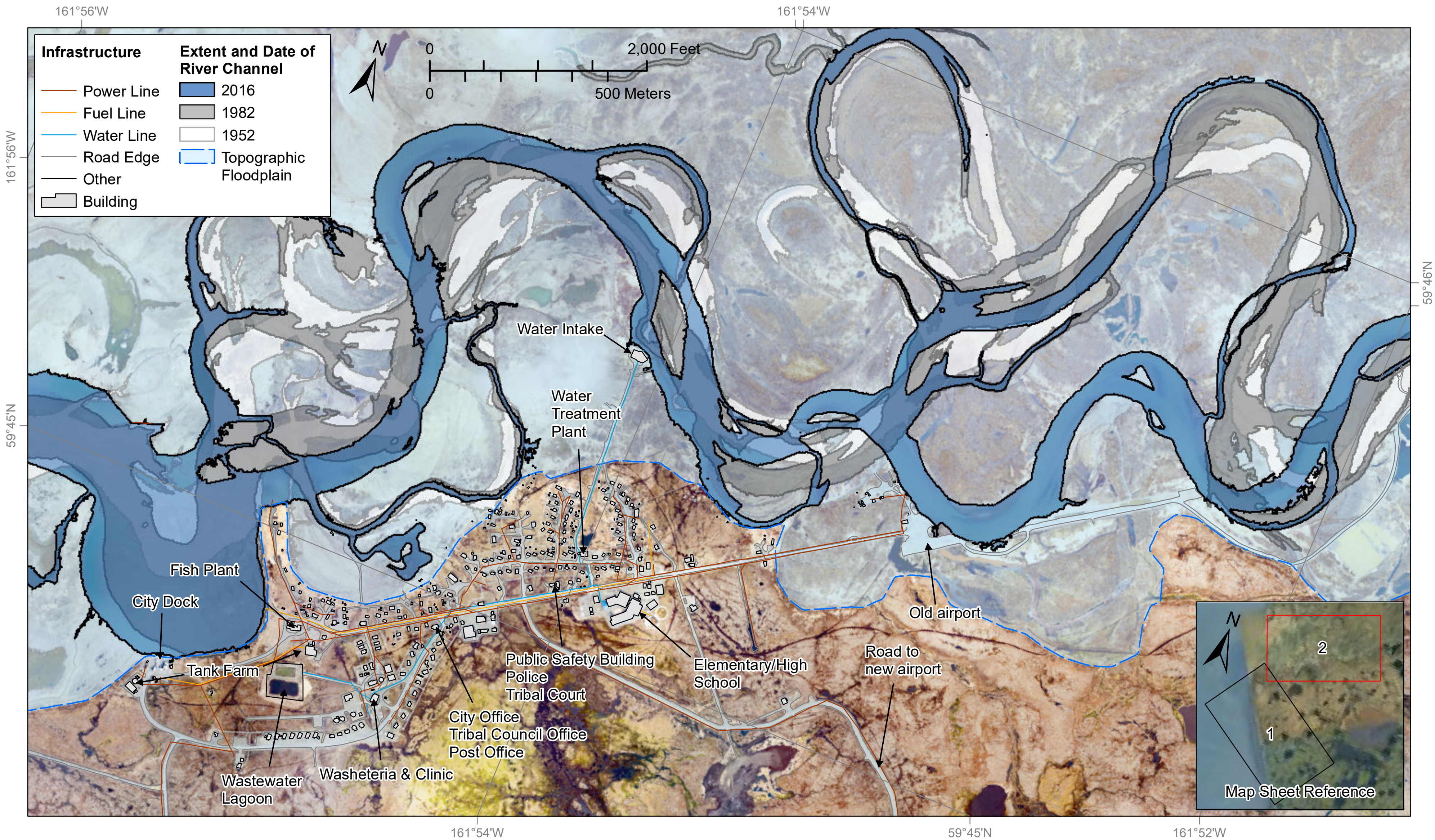
Buzard and others, 2021
Quinhagak, Sheet 2 of 2



Projection: NAD83 UTM Zone 4N. Orthoimagery year: 2016. Orthoimagery available from elevation.alaska.gov

Erosion and accretion of coasts and rivers result in shoreline change. The past and current footprints of the Kanektok River are shown here in white (1952), gray (1982), and dark blue (2016). The light blue region represents the topographic floodplain. This is the lowland area where the river may have reached at some point before 1952. For more detailed information about the impacts to infrastructure from erosion at Quinhagak, refer to the Quinhagak erosion exposure assessment report.

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