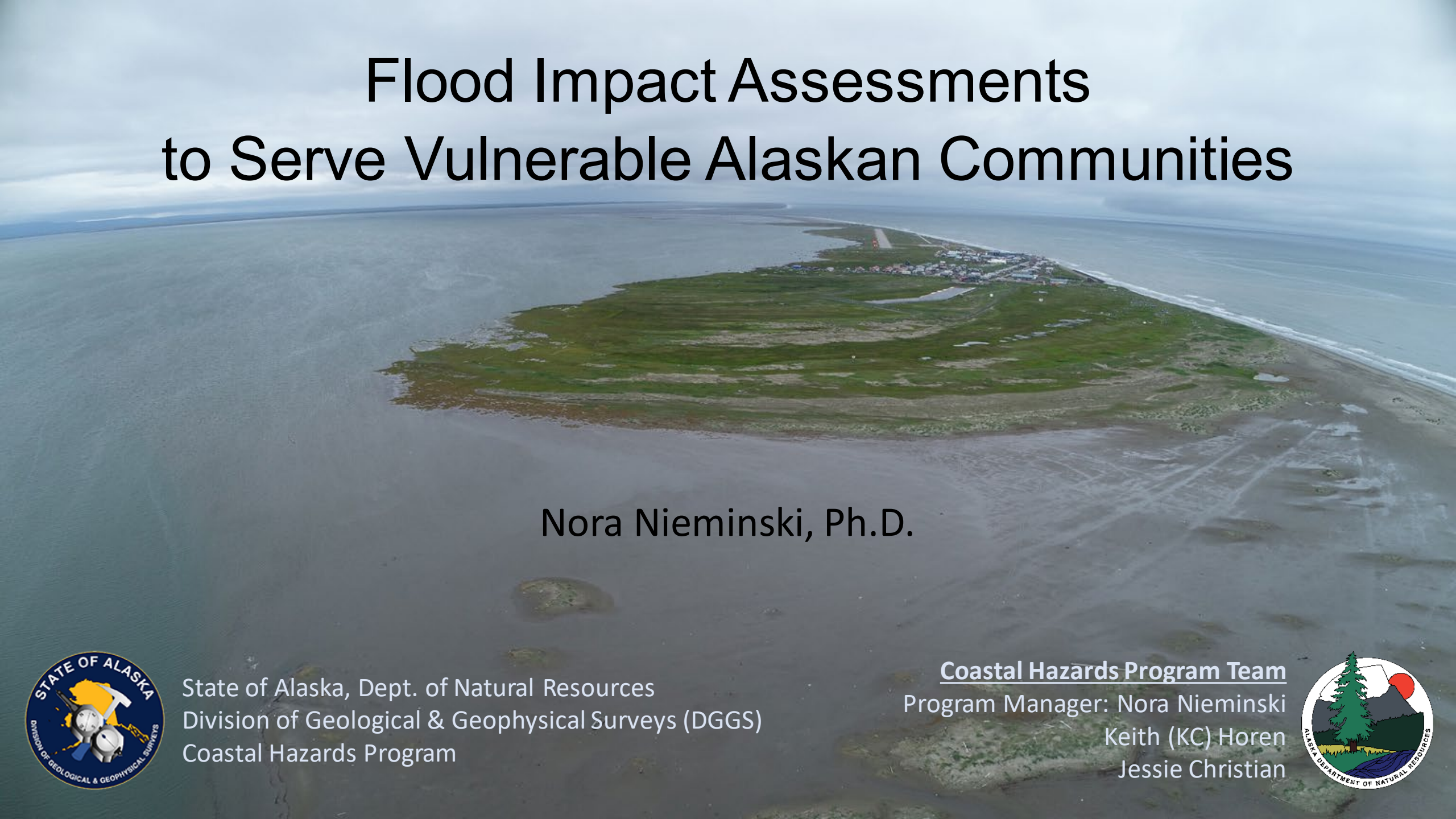
Flood Impact Assessments to Serve Vulnerable Alaskan Communities



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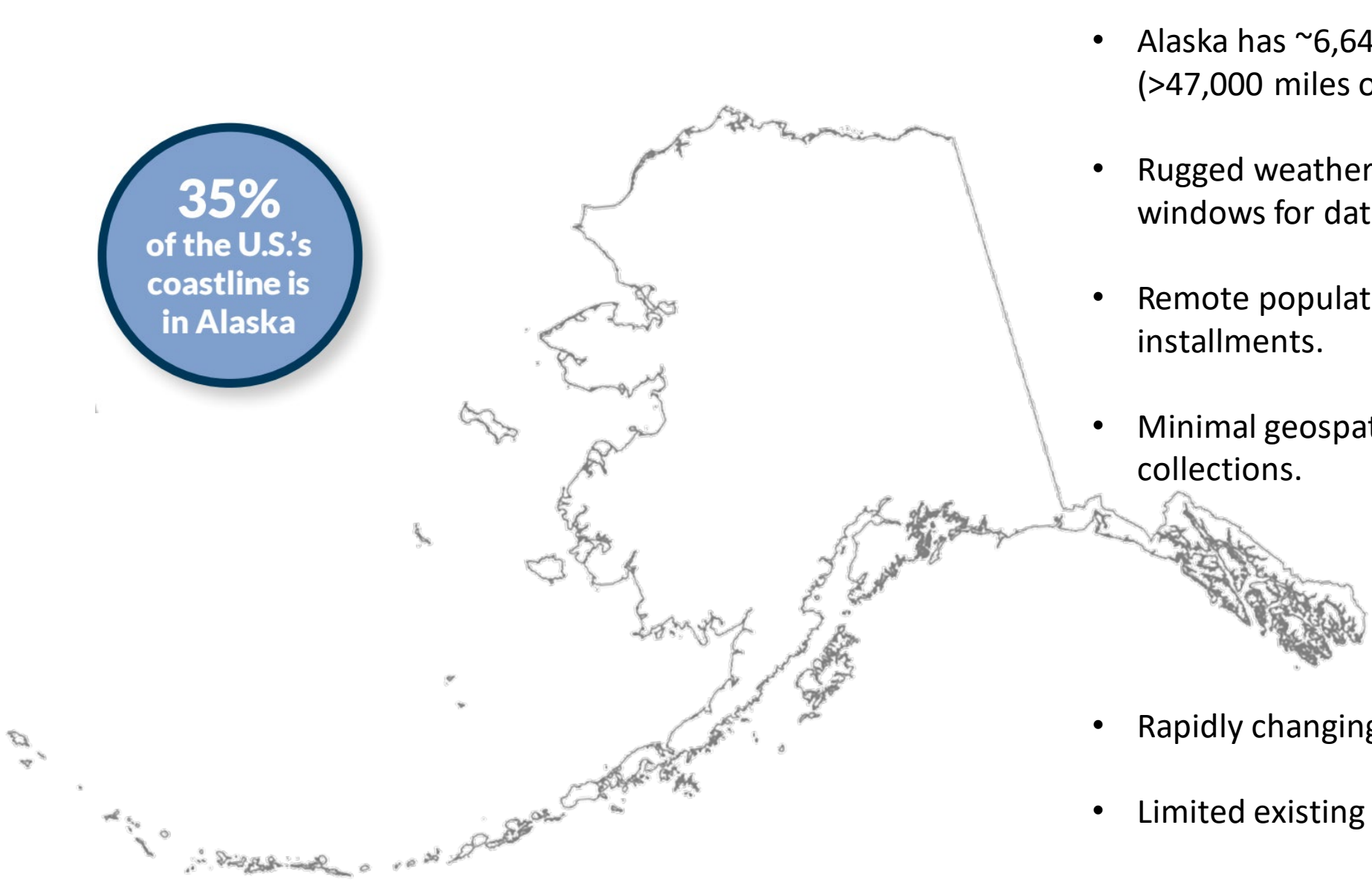
State of Alaska, Dept. of Natural Resources
Division of Geological & Geophysical Surveys (DGGS)
Coastal Hazards Program

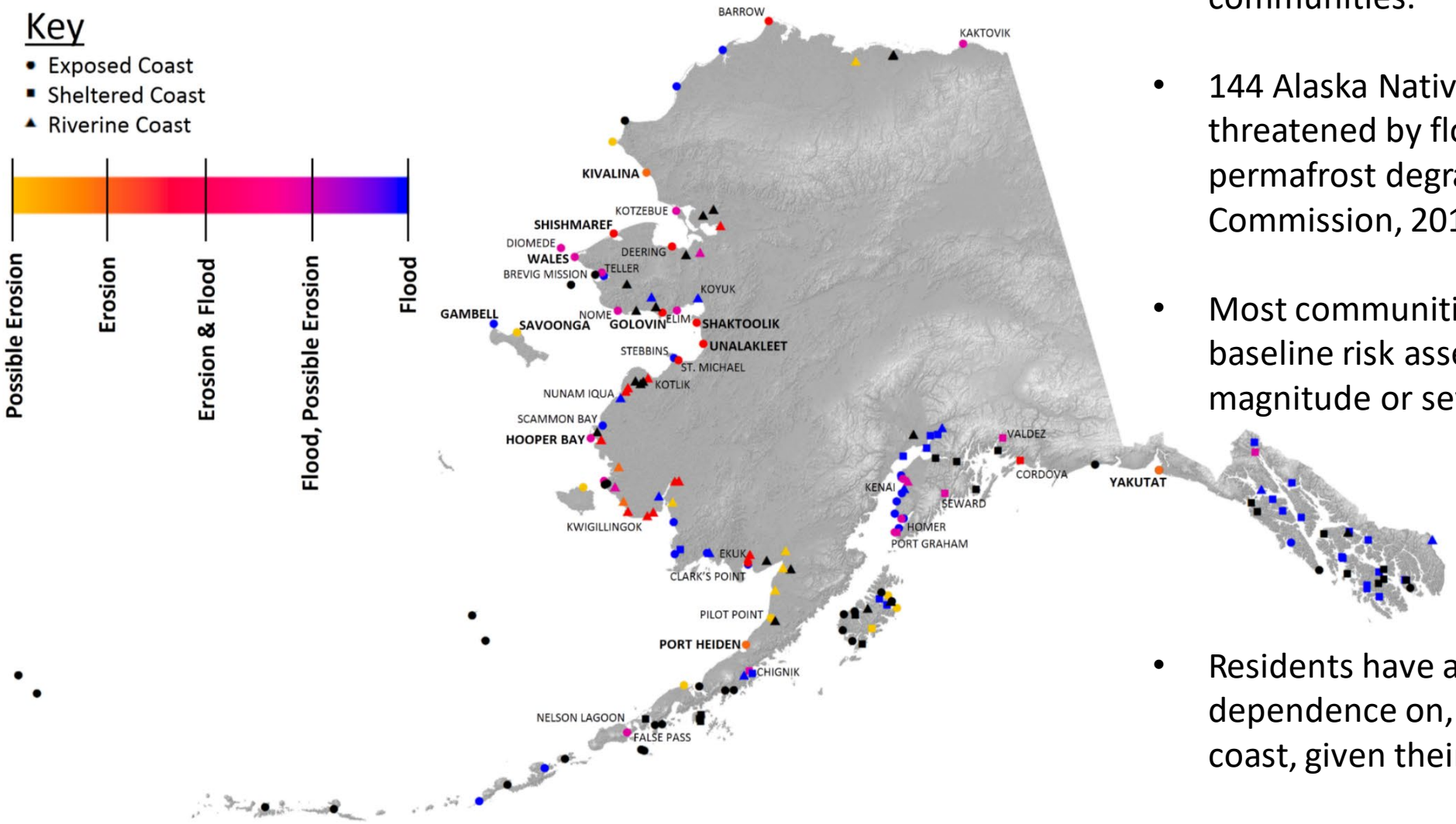
Coastal Hazards Program Team
Program Manager: Nora Nieminski
Keith (KC) Horen
Jessie Christian

FLOOD RISK IN ALASKA: CHALLENGES



- Alaska has ~6,640 miles of coastline (>47,000 miles of tidal shoreline).
- Rugged weather conditions & short seasonal windows for data collection.
- Remote population centers & infrastructure installments.
- Minimal geospatial infrastructure to assist in collections.
- Rapidly changing environmental conditions.
- Limited existing data.

FLOOD RISK IN ALASKA: MOTIVATION



- 64% of Alaska residents live in coastal communities.
- 144 Alaska Native Communities are threatened by flooding, erosion, and/or permafrost degradation (Denali Commission, 2019).
- Most communities do not have access to baseline risk assessments to quantify the magnitude or severity of threats.
- Residents have a special relationship with, dependence on, and understanding of the coast, given their subsistence lifestyles.

Coastal communities of Western & Northern Alaska are regularly impacted by storms and experience frequent flooding and erosion, which threaten critical infrastructure and traditional ways of life.

AOOS Alaska Ocean Observing System

National Fish and Wildlife Foundation

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

STATE OF ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

NATIONAL WEATHER SERVICE

USGS science for a changing world

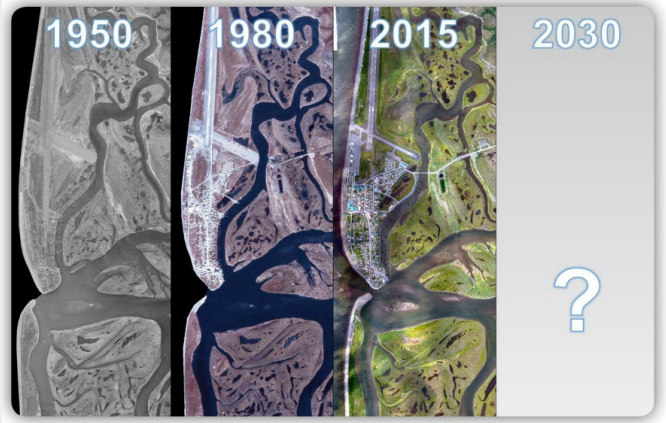
STATE OF ALASKA COASTAL HAZARDS PROGRAM

The goal of the Coastal Hazards Program is to enhance decision making support for coastal geohazard response and resource management by providing Native Alaska communities with ***sound scientific investigations of coastal processes that are informed by local knowledge****.*

Event Response

Extratropical Typhoon Merbok 2022 flooding in Tuntutuliak, AK

Baseline Data Collection

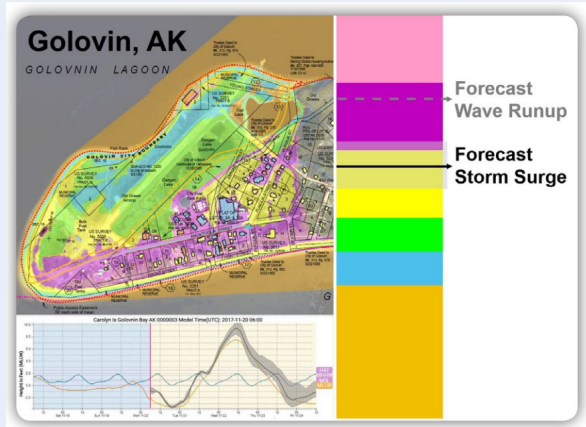


Historical aerial imagery of Unalakleet, AK

Data Processing

Digital Elevation Model of Kipnuk, AK

Analysis & Assessment



Flood forecast map of Golovin, AK

We want to collect more data in Alaska, connect Alaskans to these data, and provide them with the methods and tools they need to make well informed decisions, helping make them less vulnerable and increasing their climate resiliency.

The DGGS Coastal Hazards Program regularly collects:

- Aerial imagery (tied to ground control points)
- Elevation data (DSM)
- High water mark elevations
- Historical flood points
- Coastal elevation profiles
- Single-beam bathymetry
- Time-lapse monitoring data
- Water level monitoring (sensors, flood staffs, etc.)
- Community-based monitoring updates

Water level – Kongiganak, AK

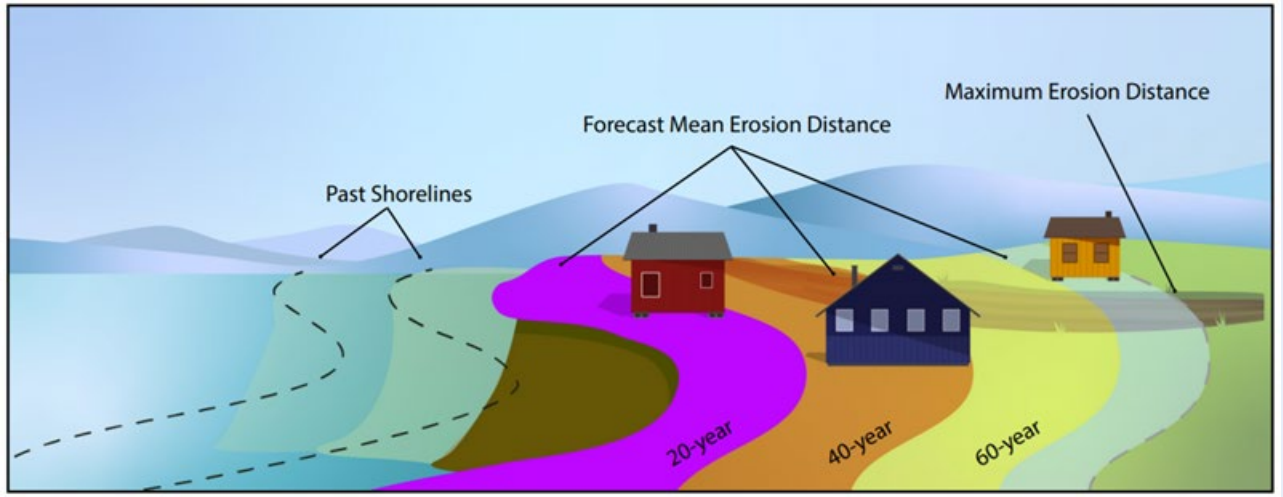
Orthoimagery (2022) of Kivalina, AK

Surveying HWM debris line in Shaktoolik, AK

COMMUNITY-BASED MONITORING & INVOVLEMENT

Geologic Hazard Risk Assessments in Alaska's Environmentally Threatened Communities

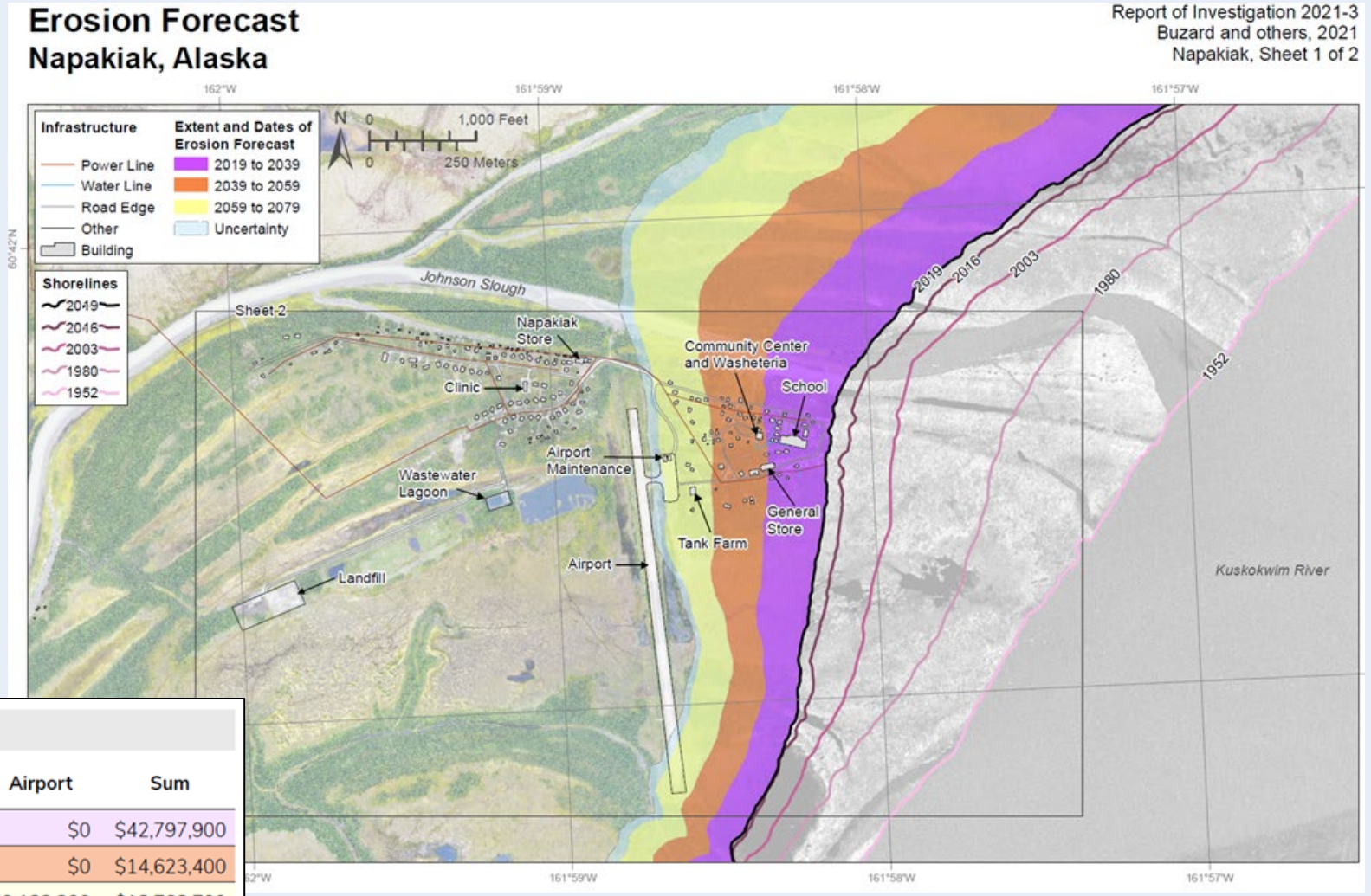
Erosion Exposure Assessments:
https://dggs.alaska.gov/pubs/id/30672



Flood Assessments:
https://dggs.alaska.gov/pubs/id/30573

Erosion Exposure Assessments

- Delineate historical shorelines
- Forecast erosion at the historical rate
- Determine cost of infrastructure in erosion zone
- Estimate replacement cost of lost infrastructure



Cost to Replace Exposed Infrastructure

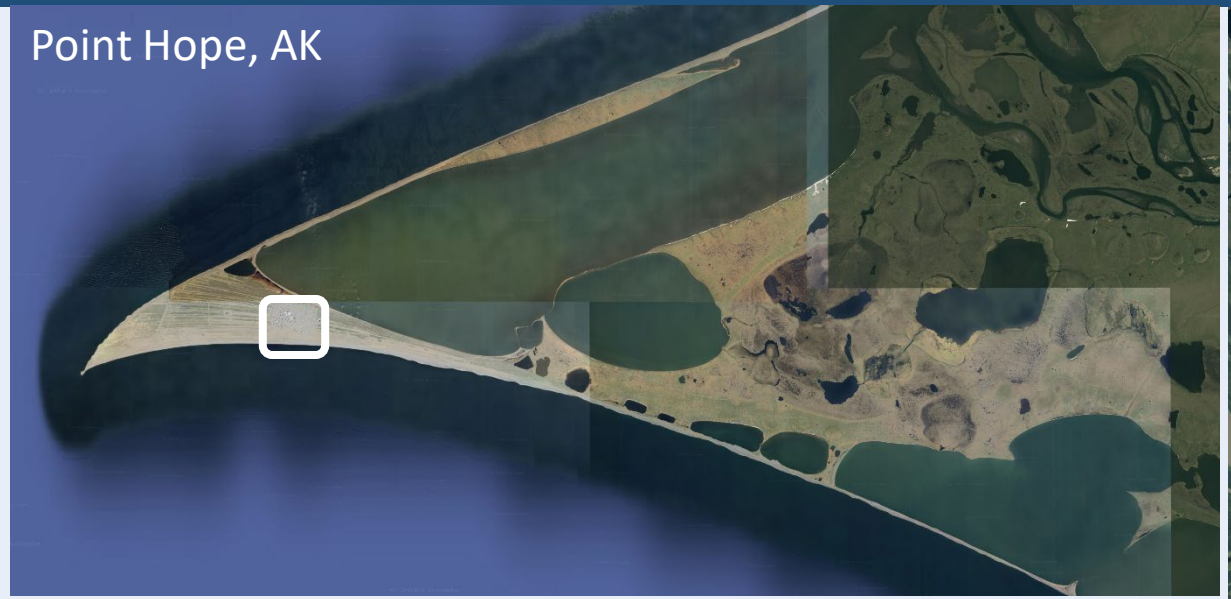
Erosion Forecast Date Range	Buildings & Tank Facilities	Power Lines	Water Lines	Roads	Airport	Sum
2019 to 2039	$41,525,900	$196,500	$239,100	$836,400	$0	$42,797,900
2039 to 2059	$13,050,000	$223,400	$115,000	$1,235,000	$0	$14,623,400
2059 to 2079	$8,450,000	$244,400	$0	$951,000	$9,123,300	$18,768,700
Combined Total	$63,025,900	$664,300	$354,100	$3,022,400	$9,123,300	$76,190,000

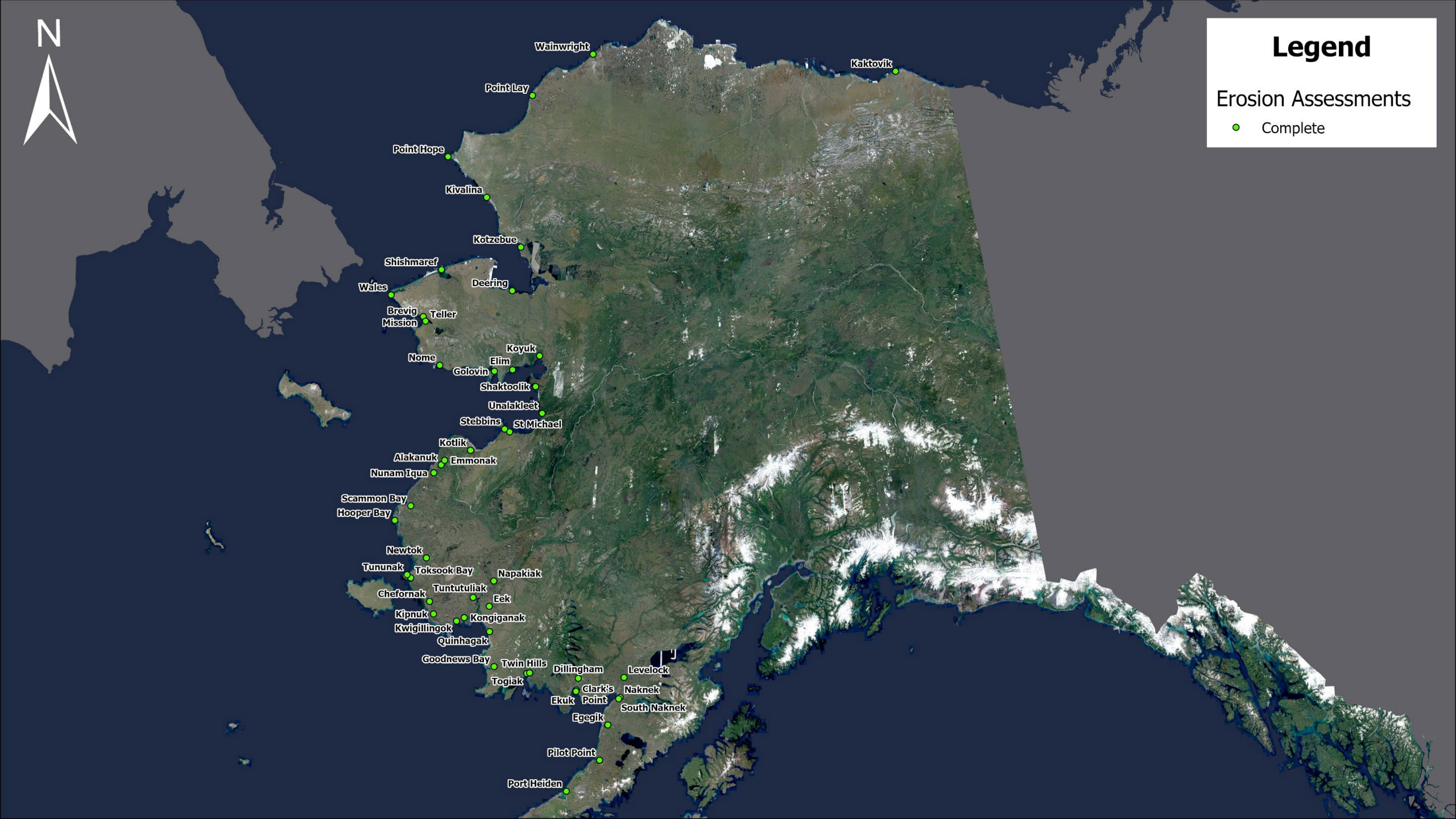
Flood Risk Assessments

- Compile baseline elevation data
- Perform historical flood research
- Quantify historical storm impacts to current infrastructure based on minor, moderate, and major flood guidelines
  (NWS Guidance: https://www.weather.gov/aprfc/terminology)

	Elevation Feature	Elevation (ft MHHW)	Vertical Uncertainty (ft)
Other	Evacuation center (school)	9.4	0.1
	Fuel tank farm platform	9.3	0.1
	Water treatment plant	8.3	0.1
Major	Highest recorded flood	7.7	0.4
	Several buildings (flooded 1 or more ft)	6.0	0.1
	Wastewater lagoon	5.6	1.3
	Lowest residences (flooded 0 to 1 ft)	5.5	0.5
	Airstrip covered	5.4	1.1
	Major	**5.4**	**1.1**
Moderate	Access way to lager parts of town	4.2	0.5
	Lowest building	4.1	0.1
	Airstrip use or access	3.5	0.5
	Moderate	**3.5**	**0.5**
Minor	Access road threatened	3.0	0.5
	Low-lying property	2.2	0.6
	Minor	**2.2**	**0.6**

GEOLOGIC CONTEXT




N
Legend
Erosion Assessments
Complete
Wainwright
Kaktovik
Point Lay
Point Hope
Kivalina
Kotzebue
Shishmaref
Deering
Wales
Brevig Mission
Teller
Koyuk
Nome
Elim
Golovin
Shaktoolik
Unalakleet
Stebbins
St Michael
Kotlik
Alakanuk
Emmonak
Nunam Iqua
Scammon Bay
Hooper Bay
Newtok
Tununak
Toksook Bay
Napakiak
Tuntutuliak
Chefornak
Eek
Kipnuk
Kongiganak
Kwigillingok
Quinhagak
Goodnews Bay
Twin Hills
Dillingham
Levelock
Togiak
Clark's Point
Naknek
Ekuk
South Naknek
Egegik
Pilot Point
Port Heiden

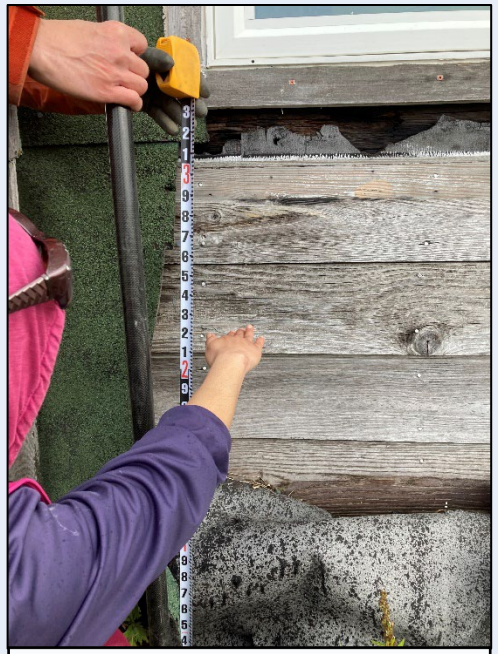

N
Utqiagvik
Wainwright
Point Hope
Kivalina
Kotzebue
Shishmaref
Deering
Teller
Golovin
Shaktoolik
Stebbins
St Michael
Kotlik
Alakanuk
Emmonak
Nunam Iqua
Hooper Bay
Napakiak
Napaskiak
Tuntutuliak
Chefornak
Kongiganak
Kipnuk
Kwigillingok
Legend
Flood Assessments
Complete
In Progress
Data Collected
Data Not Collected

Estimating historical flood heights

- Flood staff heights
- Verbal accounts, pointing to water level
- Flood photographs

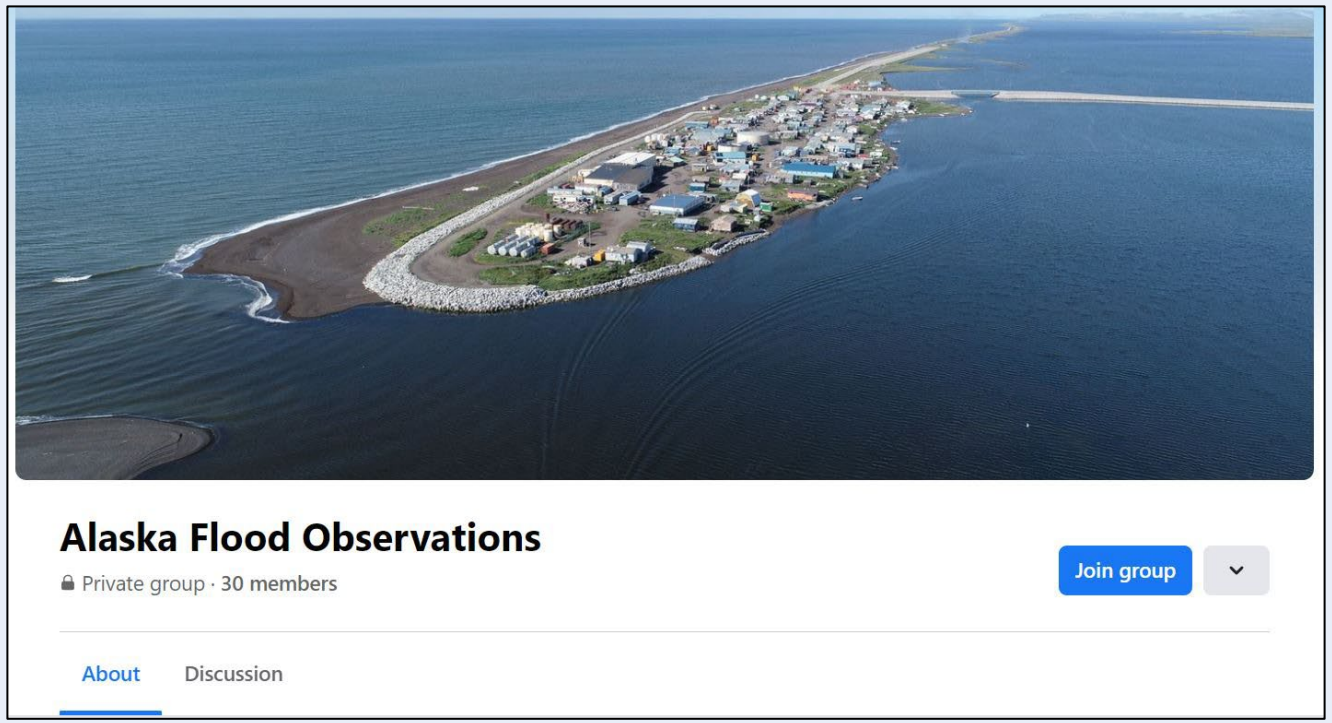
Flood staff flood water levels (2017) Kwigillingok, AK

Resident pointing out high water level in Kipnuk, AK



Post-storm verbal HWM collection in Teller, AK

Post-storm HWM from photo collection in Teller, AK



A private Facebook group for citizen scientists to connect and contribute local knowledge and **help improve modeled and forecasted inundation with on-the-ground observations**.

https://akdggs.com/floodphotos

DGGS Coastal Hazard Photo Database

https://maps.dggs.alaska.gov/photodb/#search=flood
https://maps.dggs.alaska.gov/photodb/#search=storm

Title
Kipnuk Storm 2016 October 28 p01

Credit
Facebook

Description
Flood waters at Kipnuk clinic looking northeast

Taken
10/28/2016

Tagged
storm, flood, October, Kipnuk, 2016

Kipnuk Storm 2018 October 4 p01
Facebook

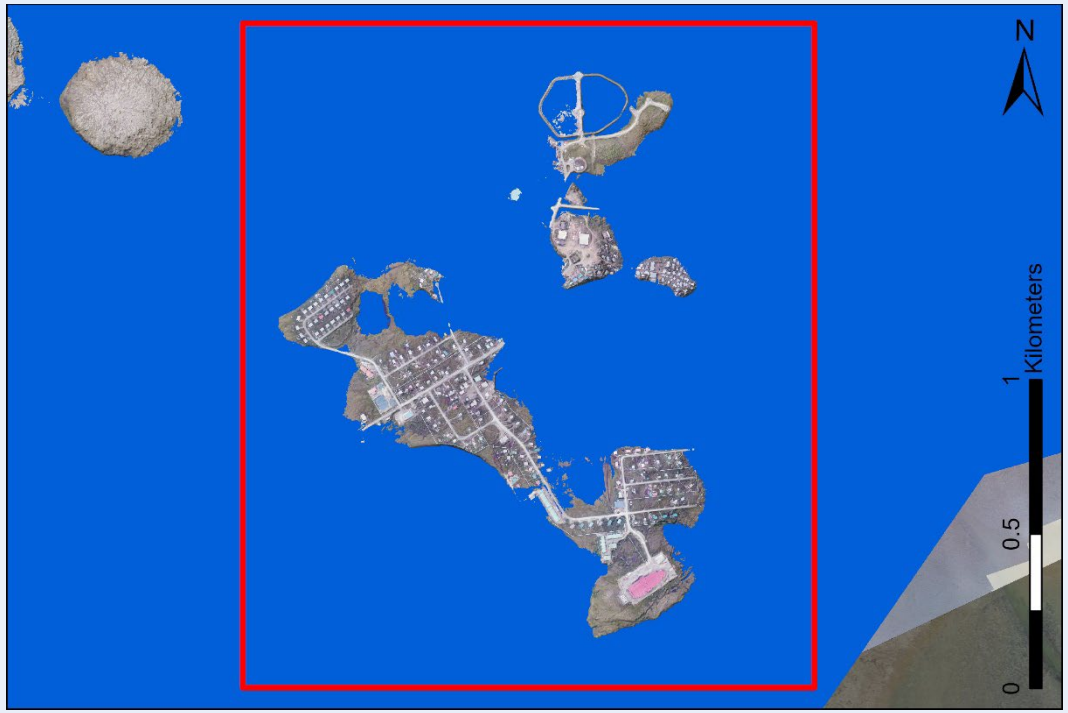
Kipnuk Storm 2016 October 28 p01
Facebook

Kipnuk Storm Oct 28 2016 p06
Kipnuk EPA IGAP

Kipnuk Storm Oct 28 2016 p03
Kipnuk EPA IGAP

Contributions to the Alaska Flood Observations group will be added to the DGGS Photo Database, **connecting Alaskans to a visual historical record of flood events throughout the State.**

Traditional "Bathtub" Model



Still Water Inundation Model

Modeled flood inundation from Extratropical Typhoon Merbok, 2022, in Hooper Bay, AK

The still water inundation model (SWIM) method leverages hydrological connectivity data to more accurately model inundation extents.

Still **W**ater **I**nundation **M**odeling (SWIM)

- Efficient, user-friendly method for accurate still water inundation extent modeling
  - This method does not rely on expert knowledge of hydrodynamics, nor does it require access to complex modeling software
  - Users do not need to edit DEMs or visually select hydrologically connected areas

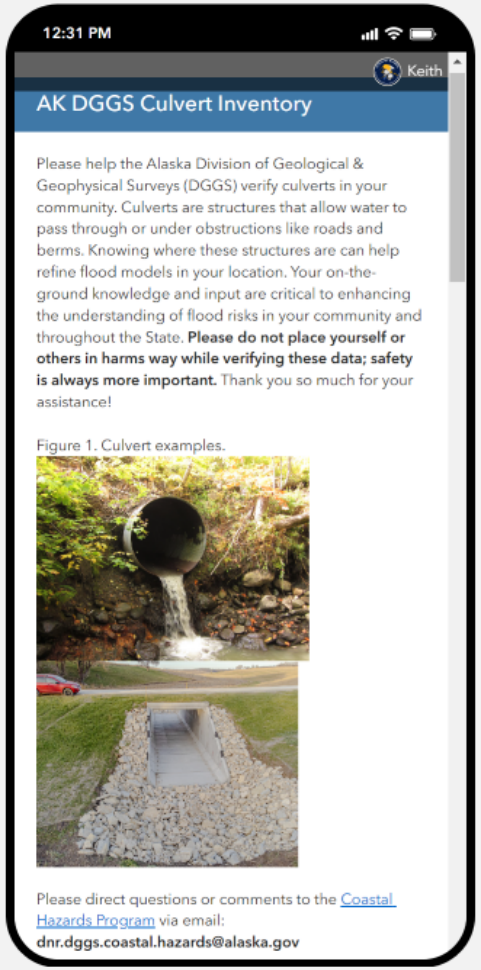
- Limited to estimating still water inundation extents
  - Tidally influenced zones are subject to dynamic flooding that includes wave set-up, run-up, and overtopping
  - Dynamic flooding can reach greater extents than what can be estimated with an eBTM

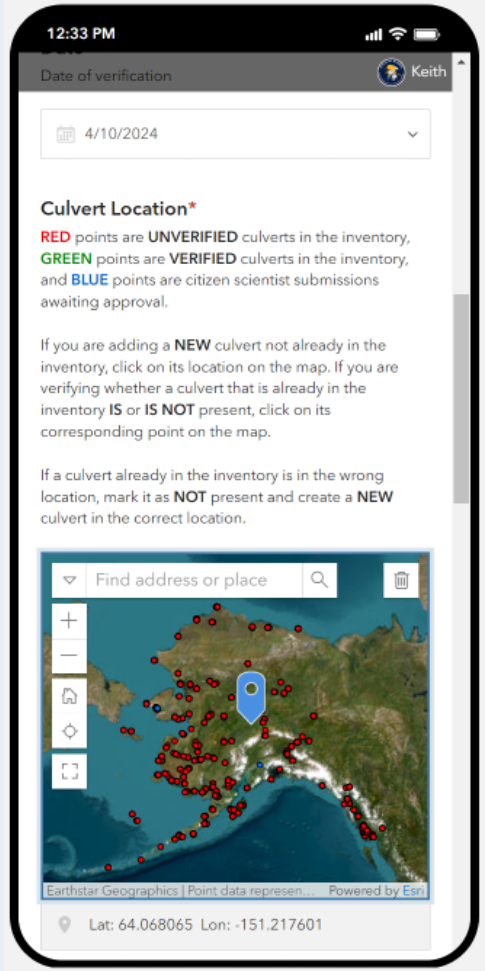
eBTM showing flooding over road.

Photographic evidence of debris flooding road.

CULVERT INVENTORY SURVEY

https://akdggs.com/culverts





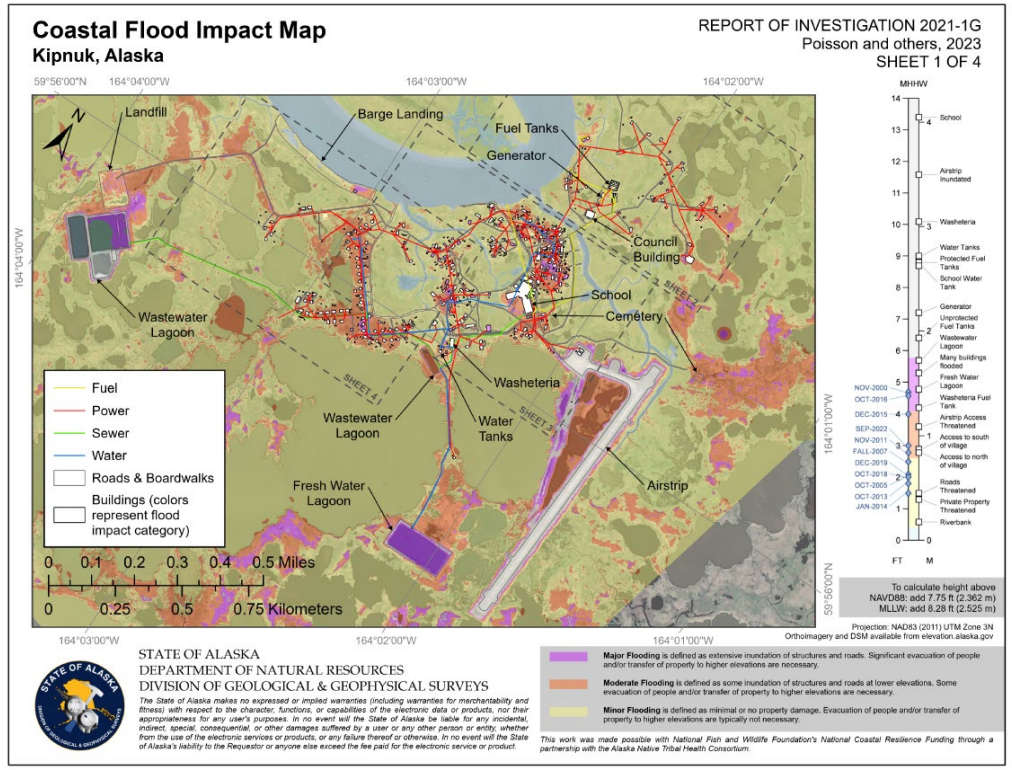
A publicly available web application for citizen scientists to **verify hydrological connections in their communities**.

In conjunction with the SWIM method, DGGS is working to establish a repeatable flood categorization schema based on quantifiable criteria that will be available for **local governments to use for community planning and risk assessment**.

Table 1. Summary of infrastructure elevations and flood categories. Gray = Extreme, purple = Major, red = Moderate, and yellow = Minor. The Extreme category represents infrastructure situated at elevations above the highest estimated flood height with uncertainty included. Categories are based on current infrastructure conditions.

Elevation Feature	Elevation (ft MHHW)	Vertical Uncertainty (ft)	Elevation (m MHHW)	Vertical Uncertainty (m)
School	13.4	0.1	4.07	0.04
Airstrip inundated	11.6	0.2	3.53	0.06
Washeteria	10.1	0.1	3.08	0.04
Water tanks	9.0	0.1	2.73	0.04
Fuel tank containment wall	8.8	0.1	2.68	0.04
School water tank	8.7	0.1	2.64	0.04
Generator	7.2	0.1	2.20	0.04
Fuel tanks	6.4	0.1	1.96	0.04
Many buildings flooded	6.2	0.1	1.90	0.04
Extreme	**5.8**		**1.78**	
Several buildings flooded	5.7	0.1	1.74	0.04
Wastewater lagoon	5.7	0.2	1.72	0.06
Freshwater lagoon	4.8	0.2	1.48	0.06
Lowest residences flooded	4.6	0.1	1.40	0.04
Washeteria fuel tank	4.2	0.1	1.27	0.04
Major	**4.1**		**1.25**	
Airstrip access	3.6	0.2	1.09	0.06
Access to large portions of village	2.8	0.2	0.84	0.06
Moderate	**2.6**		**0.79**	
Low-lying roads threatened	1.5	0.2	0.46	0.06
Private property threatened	1.3	0.2	0.38	0.06
Riverbank	0.6	0.2	0.17	0.06
Minor	**0.4**		0.11	

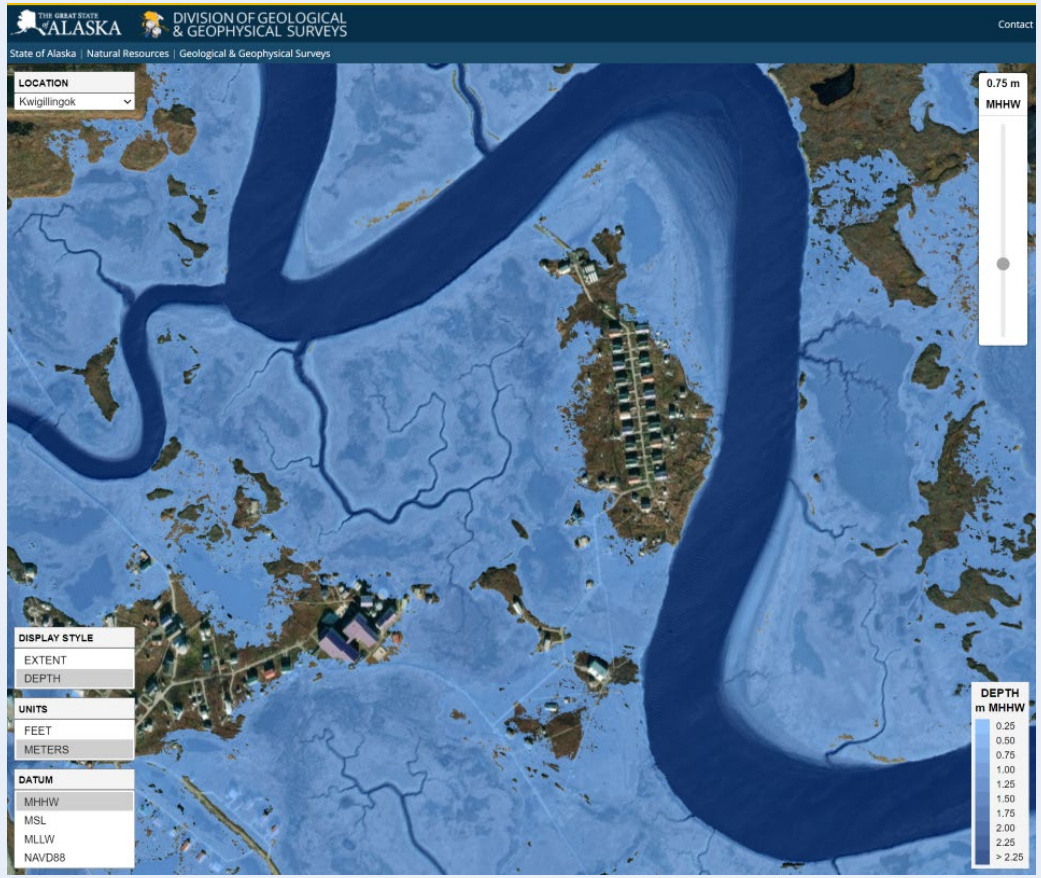
Example Flood Impact Categorization for Kipnuk, AK



Flood Impact Map of Kipnuk, AK

Hot off the press!

Alaska Flood Inundation Tool (AK-FIT)



AK-FIT is a web-based flood modeling application *that will bring together the connections we hope to make through outreach and* **connect Alaskans with their data in a user-friendly and impactful way**.

https://akdggs.com/akfit-demo

COMMUNITY CONNECTION

Historic accounts from village elders (Kongiganak, AK)

Children in Stebbins supervising deployment of a bathymetry survey

Children in Kwigillingok helping w/ permafrost probe

Science outreach with children

https://dggs.alaska.gov/pubs/

Check out our recent DGGS Publications:

Horen, K.C., 2024, **Still water inundation modeling with hydrological connectivity***: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 176, 35p.*

Horen, K.C., Poisson, A.C., Christian, J.E., Nieminski, N.M., 2024, **Methods for evaluating coastal flood impacts in Alaska communities***: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 177, 13p.*

Horen, K.C., Poisson, A.C., Seimsen, Z., Christian, J.E., Nieminski, N.M., 2024, **Coastal flood impact assessment for Kipnuk, Alaska**: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2024-5, 45p.

THANK YOU!

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Coastal Hazards Program Website:
https://dggs.alaska.gov/hazards/coastal/