

Engaging Local Knowledge to Inform Measures Protecting Alaskan Coastal Communities from Erosion and Permafrost Thaw

PART 1 – FACTFINDING

Findings Related to Permafrost Thaw and Erosion in The Native Village of Kaktovik and The Native Village of Point Lay

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Distribution Statement A: Public release, distribution unlimited



List of Acronyms and Abbreviations

ASTAC – Arctic Slope Telephone Association Cooperative

ATV – All Terrain Vehicle

CEQ – Council on Environmental Quality

CRREL – Cold Regions Research and Engineering Laboratory

DoD – Department of Defense

DEW Line – Distance Early Warning Line System

ERDC – Engineering Research and Development Center

Evidence Act – Foundations for Evidence-Based Policymaking Act of 2018

FOIA – Freedom of Information Act

FPIC – Free Prior and Informed Consent

IQA – Information Quality Act

HISA – Highly Influential Scientific Assessments

NSB – North Slope Borough

OSTP – Office of Science and Technology Policy

TK – Traditional Knowledge

USACE – United States Army Corps of Engineers

USFWS – United States Fish and Wildlife Service

VHF – Very High Frequency Radio

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Table of Contents

PART 1 – FACTFINDING

List of Acronyms and Abbreviations	1
Acknowledgements.....	2
Table of Contents	3
1 Introduction	6
2 Methodology	7
2.1 Literature review.....	7
2.2 Semi-structured interviews	8
Data collection.....	8
Data analysis.....	8
Validation	9
3 Kaktovik.....	10
3.1 Community overview	10
Public services and communication.....	10
Transportation.....	11
DoD presence	11
3.2 Progression of erosion and permafrost thaw	12
Erosion.....	12
Permafrost.....	12
3.3 Infrastructure impacts	13
3.4 Impacts on travel and subsistence.....	14
3.5 Local knowledge specific to current or former DoD sites.....	15
3.6 Local priorities, information needs, and other questions.....	16
Highlighted Priorities and Concerns.....	17
Information Needs	17
Other Questions	18
3.7 Key sites of interest	19
4 Point Lay	22
4.1 Community overview	22
Public services and communication.....	22
Transportation.....	23

	DoD presence	23
4.2	Progression of erosion and permafrost thaw	23
	Erosion.....	23
	Permafrost.....	24
4.3	Infrastructure impacts	25
4.4	Impacts on travel and subsistence.....	26
4.5	Local knowledge specific to current or former DoD sites.....	28
4.6	Local priorities, information needs, and other questions.....	30
	Highlighted Priorities and Concerns.....	30
	Information Needs	31
	Other Questions	32
4.7	Key sites of interest	33
	Bibliography	37

PART 2 - FRAMEWORK

Considerations for CRREL Arctic Research and Engagement Activities

	List of Acronyms and Abbreviations	40
	Acknowledgements.....	41
1	Introduction and Objectives	42
2	Background – DoD in Arctic Alaska	42
2.1	Arctic context	42
2.2	Regulatory Environment.....	43
2.3	Traditional Knowledge in research, policies, and decision-making:.....	44
3	Methods.....	45
3.1	Limitations.....	46
3.2	Theoretical basis	46
	Good governance.....	46
	Guidance for Federal Departments and Agencies on Indigenous Knowledge	47
	Multiple evidence base approach.....	49
4	Results and Discussion.....	50
4.1	Current performance in relation to good governance principles	50
4.2	Considerations for growing and maintaining relationships in Arctic research.....	53
	Acknowledge historical context and past injustice.....	53
	Practice early and sustained engagement	53

	Earn and maintain trust.....	54
	Respect different processes and worldviews	54
	Recognize challenges	54
	Pursue co-production of knowledge	55
4.3	Best practices for applying Traditional Knowledge	55
	Plan ahead and consider developing a Traditional Knowledge plan	56
	Conduct initial meetings.....	56
	Include TK in Federal decision-making and research	57
	Regularly coordinate with other agencies and researchers to facilitate information-sharing	58
5	Conclusion	58
	Bibliography	59

Attachments

Attachment A – Annotated Bibliography

Attachment B – Environmentally Threatened Communities Data and Risk Assessment Status Kaktovik
and Point Lay

Attachment C – Kaktovik and Point Lay Logistics

Attachment D – Traditional Iñupiaq Values

1 Introduction

The U.S. Army Corps of Engineers (USACE) is prioritizing coastal protection efforts and overseeing infrastructure development that includes proposed expansion of DoD training activities and radar infrastructure in the Alaskan Arctic. These initiatives are taking place in the context of climate change where Alaskan Arctic coasts are eroding at rates of up to 10 meters per year, among the highest coastal retreat rates on earth (Lantuit *et al.*, 2012). DoD's capacity to implement its Arctic strategy and respond to environmental contingencies in the region is impacted by the challenge of obtaining timely, dependable, and comprehensive information for decision-making. Specifically, there is a need for high resolution baseline information necessary for monitoring efforts and long-term Arctic infrastructure and adaptation planning (Vargas-Moreno *et al.*, 2016). Toward this end a research effort involving semi-structured interviews is being piloted by Cold Regions Research and Engineering Lab (CRREL) to enrich DoD Multiple Evidence Base (MEB) assessment capabilities encompassing the collection and use of reliable information from both Western science and Indigenous knowledge sources (Tengö *et al.*, 2014). While erosion presents a major challenge for the long-term sustainability of coastal infrastructure at many locations (Denali Commission, 2019), this pilot will focus on two Iñupiat villages in North Slope Alaska; the Native Villages of Kaktovik and Point Lay (Figure 1). Northern Social-Environmental Research (NSER) is collaborating in this research effort towards 2 key objectives:

1. Factfinding – Engage village leadership to learn about and share existing data, local observations, and traditional knowledge related to the risk of erosion and permafrost thaw, and infrastructure investment.
2. Framework – With guidance from village leadership, develop guidelines for the creation and sharing of useful information to support research, decision-making, and Department of Defense engagement with local communities threatened by erosion and permafrost thaw.

The purpose of this Part 1 report is to detail results of the project's fact-finding activities (see Section 2: Methodology) toward Objective 1. Validated results informed Objective 2 activities, including development of the final reported framework and recommendations to grow DoD capacity to engage multiple knowledge sources in Arctic research.

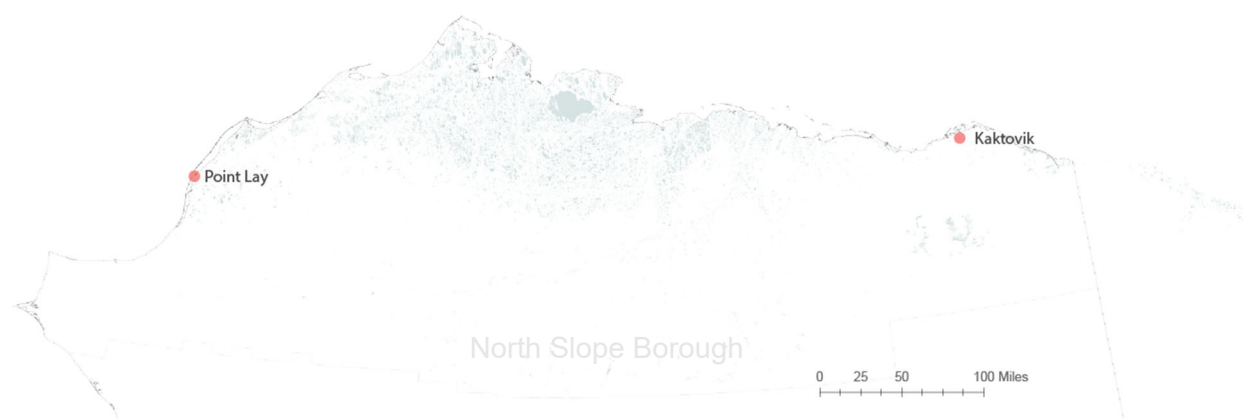


Figure 1: Point Lay and Kaktovik within the North Slope Borough

2 Methodology

This study and its proposed methodology were presented to the Native Village of Point Lay and the Native Village of Kaktovik Tribal Councils during their monthly scheduled meetings in April 2022 and September 2022 respectively. NSER collected feedback and fielded questions from Council members as part of each presentation. Neither Council expressed opposition to the study. Additionally, approval from the Kaktovik City Council was required to conduct in-person interviews in Kaktovik. This was necessary due to local COVID travel restrictions including a ban on non-essential travel that was lifted in September 2022. The City Council granted permission to visit during their September meeting.

Additional feedback on the study and its design was provided by Tribal Liaisons representing the U.S. Army Corps of Engineers Alaska District, the Pacific Air Force Regional Support Center, and the U.S. Coast Guard District 17.

Methods employed for Objective 1 (fact-finding) and Objective 2 (Framework) included a literature review, semi-structured interviews, and qualitative content analysis.

2.1 Literature review

The purpose of the literature review was to characterize the state of existing information, knowledge gaps, and data needs related to erosion, permafrost thaw, and their respective impacts on infrastructure in Kaktovik and Point Lay. Inclusion criteria for the review included journal articles, reports, or planning documents addressing landscape change and/or infrastructure in areas near or pertaining to Point Lay and Kaktovik. The review was limited primarily to materials publicly available in online repositories. For this reason, internal documents and independently commissioned studies are likely underrepresented in the literature collected.

Forty-two relevant materials were sorted into three categories: 1) General, including items of relevance to both Kaktovik and Point Lay; 2) Kaktovik, for items specifically related to Kaktovik; and 3) Point Lay for items specifically related to Point Lay (see Attachment A: Annotated Bibliography). The majority of studies (70%) can be characterized as applied research intended to collect data, identify questions, develop methods, or find practical solutions for existing local challenges. Sixty percent of the reviewed studies were performed or commissioned by Borough, State, or Federal agencies.

Statewide erosion data is generally available from publicly accessible data sources (Denali Commission, 2019). Recent shoreline change studies and erosion forecasts for Kaktovik and Point Lay are available from the Alaska Department of Natural Resources Division of Geological and Geophysical Surveys (Buzard *et al.*, 2021a, 2021b). In contrast to the availability of erosion data, local scale data on permafrost thaw is scarce and not centrally located. Data can be found in scientific publications, maps, satellite imagery, geotechnical reports, community plans and reports, and from local observations. Kanevskiy, *et al.* (2019) compiled available information for 187 Alaska villages (including Kaktovik and Point Lay) and assigned levels of risk for each based on five factors: permafrost occurrence, permafrost temperature, thaw susceptibility of frozen soils, massive ice occurrence, and existing permafrost related problems. Their ratings were the basis for the thawing permafrost risk levels reported by the Denali Commission's 2019 Statewide Threat Assessment. The compiled data is also available online through the Scenarios Network for Alaska + Arctic Planning Community Permafrost Data tool (<https://www.snap.uaf.edu/tools/permafrost>).

Data available for erosion and thawing permafrost are helpful as a starting point to plan further investigations, but not sufficient on their own for risk assessments or infrastructure design and development. Extensive, community-scale data collection and analysis are needed for village risk assessment and long-term planning (Stark *et al.*, 2021). Knowledge gaps and data needs for Kaktovik and Point Lay are described in Section 4.6: Local priorities, information needs, and other questions, and also in Attachment B, adapted from the Alaska Department of Natural Resources Data and Risk Assessment Dashboard (AK DNR, 2021).

2.2 Semi-structured interviews

Semi-structured interviews with knowledgeable community members in Point Lay and Kaktovik were conducted in July 2022 and October 2022 respectively. The interview protocol had two parts. Part 1 questions focused on documenting local observations, and Traditional knowledge related to the risk of erosion, permafrost thaw, and infrastructure. Part 2 interview questions explored topics related to best practices for research, local engagement, and information sharing between Indigenous communities and federal agencies like DoD.

Data collection

Interviews were conducted with 5 long-term residents from Kaktovik and 8 from Point Lay. Selection criteria included community members who self-reported as (1) residing in Kaktovik or Point Lay for the majority of their lives, (2) having significant experience and knowledge of the local outdoors, and (3) having served in local public office, advisory boards, or other similar capacity that involved engagement with DoD or other federal entities. Additional participants were identified based on recommendations from the initial participants, a process called snowball sampling (Denzin and Lincoln, 2011). Part 1 interview questions focused on 4 main areas; (1) observations of landscape change over time, (2) the physical and cultural impacts of erosion and permafrost thaw, (3) local knowledge specific to sites occupied by DoD assets, and (4) recommendations for research topics and sites of interests aligned with the promotion of tribal economic capacity building and self-reliance. The duration of interviews ranged between 30 minutes and 2 hours. Participants were compensated for their time, \$50 per hour up to a maximum of \$100. All participants provided their verbal consent to participate in the study and to have their respective interviews audio recorded. The quotes and interview findings reported herein are attributed to an assigned code (Kaktovik [K] 1-5 and Point Lay [PL] 1-8) for confidentiality. By study design, findings and quotations shall not be attributed to individual participants without their express permission.

Data analysis

Recorded interviews were transcribed in their entirety using Descript automated transcription (version 47.1.0) in combination with manual editing. The transcribed interviews were then coded and analyzed using Atlas.ti qualitative analysis software (version 22.1.5.0). The coding process involved assigning segments of interview text into categories describing major themes being represented (Bazeley, 2013). The exercise employed a directed content analysis approach (Hsieh and Shannon, 2005), where initial codes were developed in advance of the analysis based in this case on the project focus areas and literature review. Codes were refined using emergent themes identified during a test coding round with a subset of the collected data (1 interview). Once working codes were developed, the full data set was coded and analyzed. Excerpts and key concepts from the interviews are provided for evidence and context

throughout this report. Common themes across interviews and items participants regarded as “high priority” are organized in Section 4.6: Local priorities, information needs, and other questions.

Validation

Credibility describes the extent to which research findings are consistent with reality (Shenton, 2004). To enhance the credibility of this research, the Native Village of Kaktovik, the Native Village of Point Lay, and other local leaders that participated in interviews were provided an opportunity to review the Part 1 report. Copies of the report were emailed to the respective Tribal offices and to individual participants. The comment period was 3 weeks for Kaktovik and 4 weeks for Point Lay. Comments and minor edits were provided by one Point Lay advisor.

3 Kaktovik

3.1 Community overview

The Native Village of Kaktovik (also called Qaaktuḡvik) is located along the Beaufort Sea coast on Barter Island, which sits on the northern edge of the 20-million-acre Arctic National Wildlife Refuge (ANWR). Kaktovik is the eastern most village of the North Slope Borough, approximately 300 air miles southeast of Utqiagvik and 70 miles west of the Canadian border. The people of the Barter Island area are known as the Qaaktuḡvimiut. As the name suggests, Barter Island was historically an important destination for trade and visiting between the Canadian Inuit and the Iñupiat of the Utqiagvik region (North Slope Borough, 2021). Fur trapping was an important part of the local economy, and a trading post was established on the Island in 1923. People gathered at the trading post on holidays and for other occasions but, for the most part, maintained semi-nomadic subsistence lifestyles (Jacobsen and Wentworth, 1982).

Kaktovik grew into a permanent settlement with an influx of activity in the 1940s including coastal surveying (1945) and the construction of an Airforce runway and hangar (1947), which followed the selection of Barter Island as a radar site for the Distant Early Warning (DEW) Line system. These activities brought jobs and attracted more people to the settlement. Harold Kaveolook opened a BIA school at Kaktovik in 1951, which drew even larger numbers to the area (Jacobsen and Wentworth, 1982). DEW Line construction activities supported the local economy, but also resulted in considerable hardship as it led to the relocation of Kaktovik residents on 3 separate occasions between 1947 and 1964 (see DoD presence). The official name of ‘Kaktovik’ was adopted by the village in 1964 (North Slope Borough, 2021).

In 2022, the estimated population of Kaktovik was 265 (Alaska Department of Labor and Workforce Development, 2023), 90 percent of which were Alaska Native (2020 Census). Approximately 74 percent of Kaktovik’s labor force is employed full time with the largest employer being the North Slope Borough (‘NSB’ or ‘Borough’) (NSB, 2019). Subsistence hunting, fishing, and whaling are also important components of the local economy, and central to food security and cultural identity. Kaktovik’s primary subsistence resources are caribou, Dall sheep, bowhead whale, fish, and waterfowl.

The local economy is also supported by polar bear viewing tourism. Barter Island is considered a prime location to view the bears in their natural habitat as climate change forces them to spend more time on land waiting for sea ice to form. While residents want to offer high quality viewing experiences and conditions that are safe for both bears and people, there have been reported issues including conflicts with subsistence activities, reduced flight availability for locals, and change in bear habits leading to more human-bear conflict. The U.S. Fish and Wildlife Service placed a temporary freeze on issuing new guide permits in 2017 (North Slope Borough, 2021).

Public services and communication

The modern infrastructure of Kaktovik includes a power generation plant, water and sewage treatment facilities, a public health clinic, fire station, volunteer search and rescue, police station, community teleconference center, and post office. The Kaveolook School elementary and high school complex was destroyed during a 2020 fire and is currently being operated from a temporary building.

The Kaktovik Iñupiat Corporation runs the local general store which stocks groceries, clothing, first-aid supplies, hardware, sporting goods, and more. There are two hotels in Kaktovik, the Kaktovik Inn

(operated by Kaktovik Iñupiat Corporation) and Waldo Arms Hotel. Room and board per night is \$300 and \$365 respectively (2022, before bed tax).

Telecommunications facilities serving Kaktovik include a fully digital exchange telephone service, satellite internet, wireless service, and ethernet transport services. The Arctic Slope Telephone Association Cooperative (ASTAC) is the only telecommunications provider in Kaktovik. Connection to the regional and global telecommunications network is via satellite, which presents a significant limitation. Satellite bandwidth is prohibitively expensive, with limited capacity, and high latency (North Slope Borough, 2021).

Transportation

Scheduled and chartered aircraft are the primary mode of year-round transportation into and out of Kaktovik. Wright Air and Everts Air offer regularly scheduled flights between Kaktovik and Fairbanks. Other modes of transportation include vehicles, all-terrain vehicles (ATVs), and snowmachines on local roads and trails, as well as boats on rivers and oceans during open water. Barter Island is a quarter mile from the mainland across a shallow lagoon. Construction of a bridge connecting the island to the mainland has been proposed to increase year round access to subsistence resources for residents (North Slope Borough, 2021).

DoD presence

The Barter Island Long-Range Radar Site (LRRS) was constructed in 1952 as the prototype DEW Line station. The site was also part of the White Alice Communication System (deactivated in 1979). Its construction brought economic opportunities, but also led to significant social upheaval for local villagers due to three separate relocation events that occurred as a result. The first relocation occurred in 1947 when several houses had to be moved from the prehistoric village site to make way for an airport runway and hangar. Villagers were given little explanation or time to gather their possessions. In addition to losing cultural artifacts, village ice cellars and the food stored in them, were lost as a result of the move (Nielson, 1977; Mikow, 2010). The second relocation occurred in 1951 when the area surrounding Kaktovik (4,500 acres) was designated a military reserve. A final move was ordered in 1962 and implemented in 1964 to allow the Air Force to expand the facility (Mikow, 2010).

Despite having a tumultuous history, one interviewee described the community's relationship with the Air Force as "generally good" (K1).

"People in the community, in the past when the military came to create the DEW Line, worked for the Air Force. They helped build the area and also build the new community. In the past, some of the [Air Force] workers got lost in a storm and the community came together and did a search and rescue effort and saved some people. That was before my time, in my grandfather's days. I would say there's been a long history but, for the most part, our relationship with the Air Force has been fairly good" (K1).

The LRRS is currently operated by contract employees as a Minimally Attended Radar. Community members don't typically interact with the station or its crew unless they have a work relationship with the site.

3.2 Progression of erosion and permafrost thaw

The Alaska Statewide Threat Assessment ranked 187 communities in 3 groups based on the threat of flooding, erosion, and thawing permafrost, with communities in Group 1 being at high risk of near-term damage and communities in Group 3 having low near-term risk to critical infrastructure and community viability (Denali Commission, 2019) Table 1

Table 1: Kaktovik threat groupings from the Statewide Threat Assessment (Denali Commission, 2019). Communities in Group 1 are those with the highest risk of near-term damage

Threat	Kaktovik Threat Grouping (out of 3)
Flood Group:	Group 3
Erosion Group:	Group 2
Permafrost Group:	Group 1
Combined Group:	Group 1

Erosion

Kaktovik ranked 24 overall (Group 2) for the threat of erosion (ibid.). Erosion rates range between 1 and 27.9 feet per year along the northern shore, and between 1 and 3.3 feet per year along the eastern shore (Buzard *et al.*, 2021b). Based on their forecast of erosion rates near infrastructure in Kaktovik, Buzard *et al.* predict erosion will undercut the road on the northern side of the island (the ‘North Road’) and expose a significant portion of sewer outfall pipe by 2079. However, 2022 site visit photos show the North Road is already being undercut in some areas (Figure 2).

Interviewees identified the locations where they observe shoreline erosion to be most severe, including near Arey Island, the barrier islands, and generally along the north and northwest coast of Barter Island (K2). In most locations, like at Griffin Point, the beach has eroded and gotten shorter while in other areas interviewees have observed the beach growing (accreting). This is the case for the mainland beach near Arey Island (K3).

One participant observed that the speed of erosion seems to have increased the past 5 years due to sea ice conditions (K2). Sea ice is forming later (by 2-3 weeks) and is not as thick as it used to be, so it doesn’t stick around as long to protect the shoreline (ibid.).

Permafrost

For the threat of thawing permafrost, Kaktovik is ranked 4 overall (Group 1) indicating the community is significantly at risk (Denali Commission, 2019). Barter Island permafrost temperatures have been continuously monitored since 1984 near the village of Kaktovik. Similar to the central and western Arctic, permafrost temperatures are rising on Barter Island and in northern ANWR. Near Kaktovik, the permafrost warmed 2-3 °C from 1985 to 2004 (Osterkamp and Jorgenson, 2006). Subsidence resulting from permafrost thaw has caused infrastructure damage in town as well as public safety issues. Additionally, two interviewees noted that the greatest amount of permafrost thaw is being observed toward the west side of Barter Island (K1, K5).

3.3 Infrastructure impacts

Roads: There are about 10 miles of developed gravel roadways in Kaktovik. All interviewees made reference to the North Road, which is being undercut by erosion, particularly in two areas (highlighted in Figure 5 – Features 1 and 2). Though it is located outside of town, the road is crucial village infrastructure given it is an important means of accessing the western side of Barter Island, particularly for spring and summer subsistence activities such as fishing and duck hunting (K4).



Figure 2: Erosion undercutting North Road (70° 7'57.05"N, 143°40'11.27"W). (a) Facing West. (b) Facing East.

Fresh Water Lake is the main water source for Barter Island. Water is pumped to the water treatment plant in the summer and stored for winter use. The long-term resilience of Fresh Water Lake is a high priority given it is the only large fresh water source on the island (North Slope Borough, 2021). Residents have reported that Fresh Water Lake is shrinking. However, the lake is not currently being monitored (ibid.). Two interviewees expressed concern that permafrost thaw or the progression of erosion might drain the lake (K4, K5).

“There’s a lot more erosion sinking in, which is getting more and more scary because it’s getting closer to our fresh water lake, which we don’t want our fresh water lake to drain out. So we are always having to patch up those roads to make sure it doesn’t get too far into where the water lake is.” (K5)

Kaktovik’s underground water utility system is a regular maintenance issue. The pipes freeze in certain places every couple years and, when this happens, they have to be dug up for repair (K4). Impacted households may not have access to running water for days while repairs are being made.

“We had a break last year, right in December, from heat from summer to winter. The water pipe broke and we were losing a lot of water. It took them a few days to find where the break was and we were in the middle of a blizzard.” (K4)

Houses and other structures in Kaktovik are also being impacted by differential ground settling. Interviewees have observed pilings cracking and houses shifting to the extent that nails are being pulled from the walls (K4, K5).

“Some of the houses are [in danger of] falling. Like my parents’ house is one of our older buildings. There’s big cracks between their walls now where the air drafts in. It’ll even, in the winter, bring snow and frost inside the house.” (K5)

3.4 Impacts on travel and subsistence

Public safety issues noted by interviewees included hazardous conditions for land and water travel, including challenges with foot travel on the tundra. Two interviewees discussed underground streams reportedly caused by permafrost thaw (K1, K4) and issues with safety walking across the tundra in some areas. In reference to problematic areas adjacent to the North Road (Figure 5 – Features 1 and 2), one interviewee noted:

“There’s no permafrost underneath, certain places where it’s melting underground. There was a place where I noticed topsoil had fallen down. Underneath you could see a large puddle... a lake underneath the soil. So it’s unsafe in certain areas.” (K1)

Additionally, erosion has caused local sandbars to become more shallow and, in some cases, they have connected to other sandbars, which closes former access points. These obstructions are especially hazardous when they are covered with water during high west winds, which makes them difficult to see.

“The sandbars are getting closer to [Barter] Island. It’s more dangerous getting out when we’re going out hunting in the ocean. It’s harder and a lot more dangerous to get to certain camp sites.” (K3)

Water currents are also changing because of erosion. As a result, shoreline ice degrades faster in the spring, creating challenges for late season snow machine travel.

“In the springtime, there are more places where there’s current going in and out of the sand bars and the ice is a lot thinner and dangerous. And some young guys that are going out, they don’t know too much about that. Sometimes you see them get stuck and we have to go help them.” (K3)

Ability to travel and access subsistence resources has been significantly impacted by landscape change in Kaktovik. Loss of access to traditional food sources is of great concern given it is a threat to cultural practices and to local food security. Two interviewees reported the increasing difficulty of accessing hunting sites, particularly for caribou and sheep.

“You gotta go out through the ocean because inside the lagoons is pretty shallow and there’s some places you can’t get to anymore because the entryways are too shallow for boats. You just gotta adapt and find new places to go hunting... We’re starting to go out further for caribou”. (K3)

Additionally, hunters are reporting less snow in the mountains, which makes it difficult to access sheep (K3, K4).

“Growing up they used dog teams to go up into the mountains and they’d leave right when we first freeze up. They’d be up there right up until a couple days before Thanksgiving, and they’d come home with a sled load of sheep. Listening to the

hunters, they say there's not enough snow up inside the mountains and... and the rivers are still flowing." (K4).

Whaling: With increasingly shallow water in the lagoon, it is becoming more difficult to bring whales to shore (K3, K4) particularly in the last two years (K5). To reach the landing site, hunters are now having to travel further west and hug the shoreline where the water is deepest (K5). The community may need to change its butchering site in the near future, but there is currently no clear alternative location given the condition of the northern road.

"People have been talking, 'maybe we're going to have to move our butchering site', maybe to the other end of the island. But there's also a road that's eroding away. So we don't know what's going to happen in the next year or so." (K5)

Loss of key sites: The shrinking shoreline has resulted in the loss of fishing camps, coastal summer campsites, and other infrastructure such as ice cellars, sod houses, and cabins (K4, K5). Many of these sites contain cultural artifacts, which are being washed away (K5).

"Maybe 10, 15 years ago we went as a family and were excavating those sod houses just to see if we could find anything... I found a bunch of reindeer herding bells from when they used to reindeer herding. Found some old trading beads and stuff like that. Now they're gone those sites. Everything is washed away." (K5)

Interviewees also noted that graves in an old cemetery on the western side of the island are becoming exposed to the extent that caskets are now visible (K1, K5). Though this is of great concern to the community, it cannot be addressed with local labor because specialists are required for the safe handling of historic remains (K5).

In addition to threatening specific cultural and subsistence sites, landscape change is also creating general challenges for practicing subsistence throughout the area. For example, the presence of more debris in the water as a result of erosion creates a maintenance challenge for fishing nets, which need more frequent cleaning. (K4).

Ice cellars are a traditional means of underground food storage using natural refrigeration from the surrounding permafrost. Three ice cellars in the community have been lost to flooding. One personal cellar remains and a shared community ice cellar was recently constructed. The site of the new cellar was chosen based on its relatively high elevation to optimize drainage and minimize the potential for flooding (Figure 5 – Feature 8) (K1).

3.5 Local knowledge specific to current or former DoD sites

Interviewees made several observations related to landscape change impacting sites of current or former DoD activity.

Old runway site: Erosion mitigation measures installed to protect the old runway are having unintended impacts on the environment. Plastic material was installed as part of a project to protect the south

shoreline of the old airport but has begun to degrade and is now being washed into the ocean, causing pollution (Figure 3) (K2).



Figure 3: (a). Degraded shoreline protection on the southern edge of the spit. (b). Close-up of degraded plastic material

On the northern shoreline, another interviewee reported that previous shoreline protection measures may be contributing to the increasing shallowness of the lagoon, which is impacting boating and whaling (K4).

“They put it there to try to stabilize the beach, but now it’s making a new sandbar. If they dredge it, that would help the whalers.” (K4)

Contaminated sites: Two interviewees noted their awareness of remediation efforts that were taken to address contaminated sites from past DoD activity and reported skepticism regarding the clean-up standard achieved (K1, K2).

“In our past meetings they related to us that there’s too much contaminated [soil] to completely remove. They would have to remove the soil all the way to the permafrost to remove it all. All that gravel near the beach is getting eroded into the ocean. It’s been ongoing.” (K1)

One interviewee reported that community members have alerted DoD about the continued presence of metal waste and other debris in multiple locations near the old runway that have yet to be addressed.

“They did a clean-up of that old runway and picked up the metal that they could see on the gravel. But we notified them there’s also metal in the water. A few inches from the beach and quite a ways into the waters. They did a survey one time during the summer, but we never did get a report or follow-up of how they’re going to get all that metal out of the water. Now they’re saying it’s all been cleaned up already. It sounds like they don’t want to revisit doing another clean-up, but it needs to be done.” (K2)

3.6 Local priorities, information needs, and other questions

When asked about their greatest priorities and concerns relating to erosion and permafrost thaw, interviewees highlighted the following:

Highlighted Priorities and Concerns

Freshwater Lake	Community members are concerned that Freshwater Lake (Kaktovik's only water source) is vulnerable to erosion and permafrost thaw. The lake is not currently being monitored for changes. (K4, K5)
Site for future relocation	It's important for the community to be proactive about identifying a future village site in case relocation becomes necessary. (K4)
Bridge to the mainland	With decreasing access to hunting and fishing locations along the coast, having a bridge to the mainland would significantly increase subsistence opportunities during open water months. (K2)
Coffins exposed in old gravesite	Landscape change has compromised a historic graveyard on the west side of the island. Coffins are becoming exposed and community members are concerned about protecting the remains from wildlife and the elements. Specialists are needed to address the problem. (K1, K5)
Shallowness of the lagoon impacting whalers	The lagoon is becoming increasingly shallow which makes it challenging to bring whales into the community's butchering site. There are currently no good alternative butchering locations. Dredging of the lagoon may help. (K3, K4, K5)
Clean-up of degraded plastic shoreline stabilization	Shoreline stabilization installed south of the old runway has degraded over time and is currently causing pollution as it progressively detaches from the shoreline. (K2)
Clean-up of metal debris near the old runway	Despite DoD's previous clean-up efforts, large metal debris are still present in the water and onshore near the old runway. (K2)
Repair needed for houses damaged by ground subsidence	Some of the older houses in town have been significantly damaged by ground subsidence caused by thawing permafrost. Some are reportedly damaged so badly that weather is coming in through the cracks and they may eventually collapse. (K4, K5)

Interviewees also provided insight on types of research and technical information that would be most helpful for Kaktovik's planning and decision-making. In general, there is a need for baseline data collection and monitoring related to erosion and permafrost thaw.

Information Needs

Information/Research Needs	Description
Baseline data and monitoring of the depth and extent of Fresh Water Lake	Fresh Water Lake is Kaktovik's only fresh water source and residents are concerned that it may be shrinking. The lake is not currently being monitored, but there is a need for it. (K4)
Monitoring of sea level rise, permafrost thaw, and coastal erosion	Interviewees expressed interest in keeping track of year-to-year sea level rise, permafrost thaw, and erosion. (K2, K5)

Information Needs

Information/Research Needs	Description
Feasibility study for how to responsibly operate polar bear tourism in Kaktovik	Community members have noticed behavioral changes in polar bears since the growth of polar bear tourism in Kaktovik (e.g. increase in bears coming to town and deterrents not being effective). They would like to figure out how to operate tourism in a way that people are safe and enjoy themselves and the bears are safe too. (K1)

Additionally, interviewees shared general questions they have for researchers about topics related to erosion and permafrost thaw:

Other Questions

1	How high is sea level now compared to the past? How do researchers track that?
2	What is the rate of permafrost loss and erosion from year to year?
3	How much time do we have if we eventually need to move?

3.7 Key sites of interest

Participants notated the approximate locations of key Kaktovik area- and village-scale sites of interest on hard copy maps during their respective interviews. The locations shown in *Figure 4: Map 1 - Barter Island, Kaktovik, and Surrounding Area* and *Figure 5: Map 2 - Barter Island and Kaktovik* are summarized in the tables below.

Table 2: Barter Island, Kaktovik, and Surrounding Area noted landscape changes

MAP 1 – BARTER ISLAND AND SURROUNDING AREA		
Feature	Site	Description
1	Barrier island	Beach is getting longer and the surrounding water is getting shallower (K3)
2	Arey Island	Observed rapid erosion. Has gotten shallower between the island and the mainland shore. Arey island is an important location for subsistence. There are fish camps there. (K2, K3)
3	Bernard Spit Sandbar	Used to be further east. (K3)
4	Jago Lagoon Inlet	Inlet between Jago Spit and Bernard Spit has closed up. (K3)
5	Tapkaurak Lagoon Entrance	Inlet is closing and getting shallow (K3)
6	Tapkaurak Pt.	Cabin and ice cellar have gone into the lagoon (K4)
7	Griffin Pt.	Beach has gotten smaller and campsite has gone into the lagoon (K3, K5)

Table 3: Barter Island and Kaktovik noted landscape features and structures

MAP 2 – BARTER ISLAND AND CITY OF KAKTOVIK		
Feature	Site	Description
1-2	Severe erosion adjacent to road	Erosion is threatening the North Road in two main areas. (K1, K5)
3	Culvert	Culvert constructed to divert water away from the North Road is expected to need continuous maintenance. (K4)
4	Degraded shore stabilization	Material used in shore stabilization effort is degraded and breaking off into the ocean. (K2)
5	Old dump sites	Metal debris along the beach on both sides of the runway (K2)
6	Fresh Water Lake	Residents report that Kaktovik's only fresh water source is shrinking. (NSB, 2021)
7	Snow fences	The snow fences are effective at preventing snow drifts in town, but are also degrading the tundra due to ponding from snow melt. (K2)
8	Community ice cellar	New community ice cellar site chosen based on its relatively high elevation and drainage. (K2)
9	Historic cemetery	The cemetery site is reported to be heavily impacted by permafrost thaw. Graves and caskets are becoming exposed. (K2, K5)

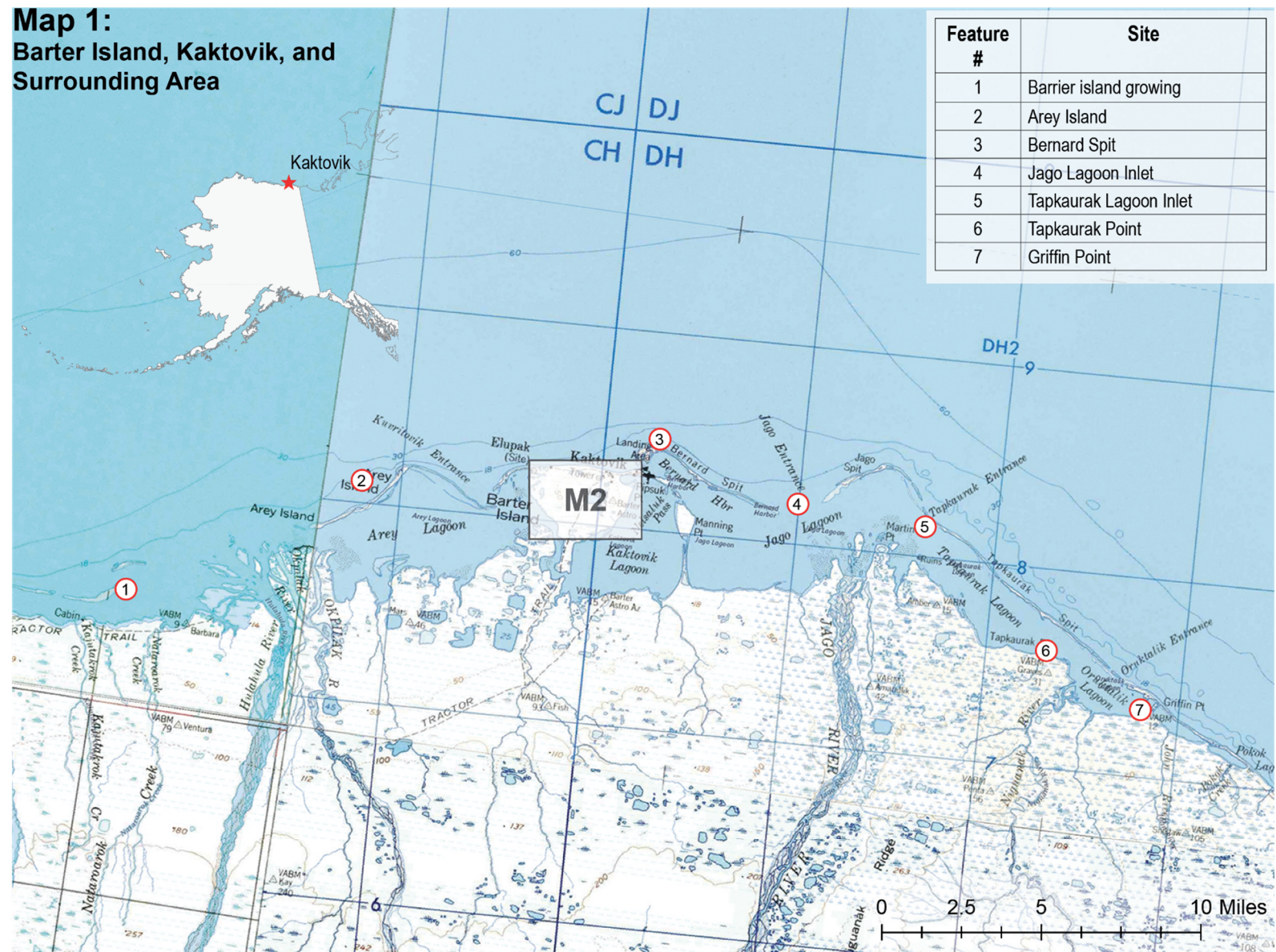


Figure 4: Map 1 - Barter Island, Kaktovik, and Surrounding Area

Map 2: Barter Island and Kaktovik



Figure 5: Map 2 - Barter Island and Kaktovik

4 Point Lay

4.1 Community overview

Kali (Point Lay) is located on the Chukchi Sea, about 180 air miles southwest from Utqiagvik. The people of Point Lay are descended from three Iñupiat groups that occupied the area between Icy Cape and Cape Lisburne; the Tikiargmiut (people from Point Hope), the Utaqqagmiut (people of the Utokok River area), and the Siainagmiut who occupied the Kasegaluk Lagoon and Icy Cape coastal areas. These territorial groups ‘nations’ were nomadic; hunting and gathering seasonal resources throughout the year, and also engaging in trade (Burch Jr, 1998).

Point Lay became a permanent settlement in 1931 when a school was established at the location causing many families from surrounding areas to move there (Native Village of Point Lay, 2017). The original village site “the old site” was on a barrier island adjacent to the mouth of the Kokolik River. The present, permanent location of Point Lay is on the mainland bluff overlooking the lagoon. Relocation to the current site became necessary due to persistent flooding at an interim settlement site on the Kokolik River delta, known as “the river site” (ibid.).

In 2022, the estimated Point Lay population was 303 residents (Alaska Department of Labor and Workforce Development, 2023), 92 percent of which were Alaska Native (2020 Census). Approximately 40 percent of Point Lay’s labor force is employed full time with the largest employers being the North Slope Borough (‘NSB’ or ‘Borough’) and the School District (NSB, 2019). Subsistence hunting, fishing, and whaling activities are a significant component of the local economy. Residents harvest marine mammals, inland and coastal fish, birds, and caribou among other staples. Point Lay is a whaling community yet, while other North Slope villages primarily rely on bowhead whale, the people of Point Lay traditionally hunt beluga whales which migrate in large numbers through shallow near-shore waters (NSB, no date). The configuration of the barrier islands, lagoons, and deeply indented shoreline in the vicinity of Point Lay have prevented effective bowhead whaling (Point Lay landed a bowhead in 2009, the first in 75 years).

Public services and communication

The modern infrastructure of Point Lay includes a power generation plant, water and sewage treatment facilities, a public health clinic, fire station/search and rescue base, police station, community teleconference center, post office, general store, and the Kali School elementary and high school complex. The village lost its fresh water source, a tundra pond called Fresh Water Lake, in summer 2016 due to bank erosion which caused the lake to drain into the adjacent Kokolik River (Native Village of Point Lay, 2017). An alternative permanent water source has not yet been identified.

Telecommunications services in Point Lay include a fully digital exchange telephone service, local dial-up internet, widely-used very high frequency (VHF) radio, satellite dish television, and the community access public teleconferencing center. The Arctic Slope Telephone Association Cooperative (ASTAC) provides internet and local and long distance telephone service. Interconnection with the regional and global telecommunications network is via satellite, which presents a bandwidth limitation for internet services (Native Village of Point Lay, 2017).

Hotel accommodations are not currently available in Point Lay. Teacher housing or classroom space may be arranged through the Kali School and NSB School District during summer months when school is not in session. Additionally, the Borough maintains itinerant lodging used by employees and contractors on

assignment in Point Lay. It is possible to arrange for use of this lodging through the Borough when it is vacant (Figure 13) (PL6).

Transportation

Scheduled and chartered aircraft flights are the primary mode of year-round transportation into and out of Point Lay. Wright Air Service operates regularly scheduled flights between Point Lay and Utqiagvik. Other modes of transportation include vehicles, all-terrain vehicles (ATVs), and snowmachines on local roads and trails, as well as boats on rivers and oceans during open water. Additionally, Point Lay recently became part of the North Slope Borough Community Winter Access Trail (CWAT) system, which provides safe, overland access between North Slope villages during the winter. The CWAT can be travelled by both 4-wheeled vehicles and track vehicles (e.g. snow machines).

DoD presence

The Point Lay DEW Line installation (69°43'N, 163°00'W) was established by the United States Air Force (USAF) in 1954 and operated as an “advance warning radar” system to guard against potential attack by enemy aircraft. It was converted to a minimally attended radar operation in 1989 and decommissioned around 1998 (exact date unknown) (USACE, Alaska, 2002; ODUSD(I&E), 2015). The Point Lay Barge Landing Site is located on the barrier island west of Point Lay (Figure 12). It was used to off-load and stage supplies, heavy equipment, and petroleum products shipped by barge for the DEW Line from 1954-1998. USAF also used area on the barrier island north of the Barge Landing Site for staging of outgoing products and demolition containers associated with remediation of the DEW Line Station. The Boat Dock Beach impact area was used as a USAF dump site prior to being turned over to the community (ODUSD(I&E), 2015).

4.2 Progression of erosion and permafrost thaw

The Alaska Statewide Threat Assessment ranked 187 communities in 3 groups based on the threat of flooding, erosion, and thawing permafrost, with communities in Group 1 being at high risk of near-term damage and communities in Group 3 having low near-term risk to critical infrastructure and community viability (Denali Commission, 2019) Table 4.

Table 4: Point Lay threat groupings from the Statewide Threat Assessment (Denali Commission, 2019). Communities in Group 1 are those with the highest risk of near-term damage.

Threat	Point Lay Threat Grouping (out of 3)
Flood Group:	Group 3
Erosion Group:	Group 3
Permafrost Group:	Group 1
Combined Group:	Group 1

Erosion

Point Lay is ranked 55 overall (Group 3) for the threat of erosion (ibid.). Erosion exposure projections over the next 60 years forecast minimal infrastructure impacts (Buzard *et al.*, 2021b). The shoreline is

retreating at a rate of 3 to 6 feet per year south of the airport, but is stable near the bulk of Point Lay's infrastructure (ibid.).

Permafrost

For the threat of thawing permafrost, Point Lay is ranked second in Group 1 indicating the community is significantly at risk (Denali Commission, 2019). Two types of permafrost soils exist at Point Lay; an ice- and organic-rich upper layer and an ice-poor lower layer (Bjella, 2015). A 2022 study by University of Alaska Fairbanks researchers from the Institute of Northern Engineering and Institute of Arctic Biology estimated the thaw subsidence potential of ice-rich permafrost in Point Lay to be nearly 40 percent its volume in the upper several meters (Jones *et al.*, 2022). The team also observed that melting of ice wedges caused more than 2 meters of differential subsidence near infrastructure (ibid.).

Point Lay residents can track the progression of permafrost thaw based on its highly visible impacts. Three interviewees (PL1, PL2, PL3) noted the increasing visibility of the lagoon from the village as an indicator of land subsidence.

"Years ago, when you were walking on the main road, you could never see the lagoon because the bluff was so high. Now, [even] when you walk on the tundra, that's all you see is the lagoon. It's dropped so much (PL2)."

Additionally, residents (including all interviewees) have watched as the foundation pilings of their homes become more exposed year after year (Figure 6).

"About 10 years ago, we had strong winds and our house waved back and forth, like it rocked us to sleep every night. When you went under our house, you had to jump to touch the bottom of the floor... it dropped so much. We filled it in... up to the point where you had to duck to get under the house. But today [10 years later], now you go under, you have to jump to touch the bottom of the floor again (PL2)."



Figure 6: Point Lay home with pilings exposed due to ground subsidence. Ben Jones, 2022.

The expansion of persistent ponds surrounding structures in town is another indicator highlighted by all interviewees (Figure 7).

“All I had was just a small pond right in the front of my house that used to be about seven feet one way and 11 feet the other way. Now this pond is right from the road and it goes all the way in back of my neighbor's house, all the way clear to the back of her house, almost clearly around her (PL4).”

These melt ponds present serious public health and safety issues. One interviewee noted they likely contain sewage runoff from spilled honey buckets and sewer line breaks (PL6). Additionally, the ponds can be surprisingly deep. Two interviewees reported an incident near the local playground where a local boy nearly drowned after falling into one such pond, which measured 15 feet deep (PL5,6).



Figure 7: Ponding surrounding homes on Point Lay 700 block.

The loss of Fresh Water Lake as the community's water source in 2016 was another highly visible, albeit abrupt impact of landscape change. Similar catastrophic lake drainage events are likely to happen more frequently in the future. A study of thermokarst lake drainage events in northwestern Alaska following the winter of 2017/2018 found that drainage events occurred at a rate 10 times the 1999 to 2014 average due to permafrost destabilization in a warm, high precipitation year (Nitze *et al.*, 2020). The study hypothesizes that permafrost destabilization and lake drainage will further intensify if loss of sea ice continues and mean annual air temperatures persist at or near 0 Celsius (*ibid.*).

4.3 Infrastructure impacts

Landscape change is impacting the structural integrity and normal operation of buildings and critical infrastructure in Point Lay.

Water and sewer: An underground sanitary sewer and water utility system (installed between 1997 and 2000) exhibits persistent performance and reliability issues (Bjella, 2015). Service interruptions occur due to settlement-related breaks, water circulation system freeze-ups, and heat trace failures (*ibid.*). The wastewater system has been abandoned in parts of the community. Those homes are now on holding tanks or on honey buckets as they await their holding tank (PL1).

Supplying the community with fresh water is another ongoing challenge. When the water lake drained it exposed old Air Force refuse that the community was previously not aware of.

“Along the water lake you can see metals popping up out of the ground... different kinds of metal, old metal barrels, cans... And that's where we [got] our water from. All that is coming out, coming just out of nowhere, and we didn't know, and we've been drinking that and now to this day... we are scared to drink our own water. We have to purchase water from the store, which is really expensive (PL3).”

Since the loss of the main water source, Point Lay has been sourcing water from the Kokolik River, which must be treated for high salt and silt content. While many residents drink the local water (PL2) two interviewees expressed significant distrust of it due to frequent boil water notices (PL3, PL6).

A permanent fresh water source for the village has yet to be identified. The potential for getting water below the lagoon was investigated but found to be infeasible because the lagoon is too saline. Other potential sources include upriver, under the dry lake, or other freshwater lakes (the closest being about 6 miles away from the village) (PL1).

Roads: Additionally, underground pipe failures directly contribute to road damage in town. Three interviewees associated worsening road damage and other thaw issues in the community with the decision to bury the water-sewer line (PL1, 2, 6). It is reported that thousands of gallons of water can be lost when pipes break due to the time it takes to identify and address the problem (PL2). Additionally, leaks in the line have caused sink holes. Caverns large enough to swallow a large vehicle have been found underneath the roads (PL1).

Public safety: Infrastructure impacted by permafrost thaw is also a public safety issue. When emergency services get called out for medical or fire emergencies, they have to adapt their protocols for one and two story houses that have become the equivalent of two and three story houses respectively due to subsidence (PL5). Subsidence has also compromised fire hydrants. The hydrant on the 700 block is especially worrying for emergency personnel (ibid.) (Figure 8).

Cumulative impacts and mitigation: Both Point Lay residents and researchers observe that the combined impacts of infrastructure and climate change in Point Lay are greater than the impacts of climate change on its own (Jones *et al.*, 2022). Permafrost thaw is happening faster in town, particularly where snow drifts accumulate and near snow berms from snow removal (PL1). The presence of gravel infill also seems to worsen permafrost thaw (PL2). Public Works tries to lessen the impact of melting snow piles in the spring by pumping water out from ponds along the bluffs (the highest point in town) towards the inland snow fence areas outside of town (PL5). The village is also exploring sod as an alternative material for backfilling subsided areas.

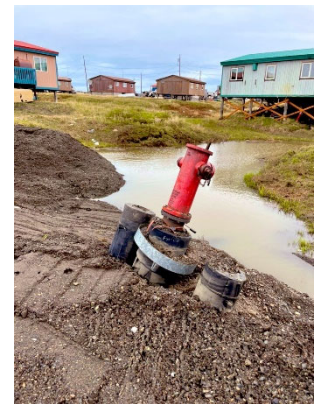


Figure 8: Fire hydrant, 700 block. Ben Jones, 2022.

4.4 Impacts on travel and subsistence

Access to subsistence resources has been significantly impacted by landscape change in Point Lay. Loss of access to traditional food sources threatens the food security and well-being of Point Lay residents (PL3).

Boating: Rivers are becoming more shallow and increasingly difficult to navigate due to land sluffing off from the banks (PL1). River channels change year-to-year which impacts the ability to access hunting spots with a boat. (ibid.). That said, people are able to boat longer into the season than they have been able to in the past. Ten years ago, Point Lay regularly had seven to eight inches of snow in September and water was frozen enough to travel over. Now, this doesn't happen until the first or second week of October (PL4). People used to have to take their boats out of the water in September but now they are

boating and hunting in October (PL1, PL4). Delayed freeze-up and snow cover also delays the ability to travel by snow machine. This creates a challenge for accessing caribou in the fall because hunters can't get very far upriver with their boats (PL1).

Trails: Residents have also lost access to popular trails formerly used to reach subsistence resources in the summer. They are having to find new trails and travel longer distances to reach familiar locations. Furthermore, the lifespan of new trails is short as they quickly become degraded (PL2, PL3, PL4).

“By the water lake we have quite a few main trails that we go out on and we can't go through those trails anymore because the permafrost split the land open so much... it's too dangerous to go through anymore... We had to reroute our hunting trails and take different routes. It takes a lot more time going out and coming back in because all these new trails are new to us and we're still trying to adapt (PL4).”

Rough trail conditions are hard on equipment and require people to travel more slowly. They can also be dangerous. Local emergency rescue services have had approximately 50 callouts in the past two years due to equipment failure or people getting lost because they are not familiar with new trails (PL5).

Ice cellars: Permafrost thaw is also impacting traditional food storage methods. Ice cellars, excavated from the upper permafrost layer, are used traditionally to store subsistence foods and are inherited by family members from generation to generation (Native Village of Point Lay, 2017). There is reportedly one remaining ice cellar in Point Lay, which takes considerable effort to maintain. The whaling crew that maintains the cellar must dig out large amounts of ice every year and is continually doing repairs to minimize flooding (PL5).

The potential loss of ice cellars threatens food security and safety. Walk-in freezers, proposed as an alternative to ice cellars, are considered inferior because they are costly to maintain and they preserve food differently (PL1). Ice cellars preserve food at warmer temperatures than freezers, which allows prized flavors to develop, and are less likely to cause freezer burn. Ice cellars also provide significantly more storage space. Some families with household freezers can't take their full share of beluga because they don't have room to store it. There are currently two walk-in freezers in town, and both are down due to the high cost of shipping freon (PL5).

Walrus: Walrus have been hauling out on land at beaches near Point Lay since 2007 primarily due to retreating sea ice. The haul-outs can be large, sometimes reaching numbers upwards of 50,000 ('As walrus haul out near Point Lay, locals ask visitors to leave them alone', 2020). The people of Point Lay are active stewards for the walrus, which are a traditional food staple. Local leaders have coordinated with the Federal Aviation Administration (FAA) to change flight patterns and keep tourists and media away from haul-out sites because the noise from planes and helicopters can trigger stampedes. Point Lay hunters have also refrained from harvesting walrus when they are in a pack (PL1, PL6). With fewer opportunities to hunt walrus, other traditional foods grow in importance for local food security.

4.5 Local knowledge specific to current or former DoD sites

When asked about their observations of landscape change impacting sites of current or former DoD activity, the **Old Air Force Hangar** and its adjacent bluffs were mentioned by multiple interviewees (Figure 12). One interviewee considered the deteriorating hangar to be a safety hazard and firmly asserted that it should be taken down (PL6). The bluffs to the south and west of the hangar were highlighted as one of the most quickly eroding locations near town (PL1, PL2, PL5, PL6). There are prominent permafrost exposures in this area (Figure 9). One interviewee noted that the progression of erosion in this area was likely accelerated by Air Force excavation of a landfill behind the Hangar (PL1).



Figure 9: Permafrost exposure along bluffs near the old Air Force hangar (see Map2-Figure 9). Billy Connor, 2022.

Icy Cape, located approximately 50 miles north of Point Lay along the coastline, was also highlighted as an area showing significant landscape change (PL2, PL3, PL4, PL5). In reference to the land surrounding what used to be a runway at the site, one interviewee commented:

“We used to go hunt here quite a bit. All this land used to be pretty straight, but now its like [Point Lay’s] bluff but even worse. There’s only a mound there and then another 10, 50 feet away there’s another big monster mound. There’s just big mounds there now and you can walk between them. That’s how bad that area fell in (PL4).”

The **exposure of old DoD artifacts** due to erosion was another commonly referenced observation. The primary site noted for containing artifacts was the boat dock beach area, which had reportedly been used by the Air Force as a landfill (PL1, PL6). Artifacts are also being revealed within the bluffs near the Air Force hangar, the bottom of the drained freshwater lake, and the Kokolik river bank.

“I’ve noticed that things that you bury try to resurface, and that’s evident with the Air Force and their shallow landfills. I’ve noticed a lot of erosion that starts showing things [along] the bluff (PL1).”

Water contamination: One interviewee reported that the water on Air Force property is assumed by Point Lay residents to be contaminated. There is a local taboo against harvesting (i.e. picking berries and other plants) near the ponds on Air Force lands (PL1).

Trenching damage: The Air Force dug a trench in the tundra to install a telephone line stretching from the old DEW line location to the edge of town in the mid-1980s. The scar from this trench is still highly prominent (Figure 10) (PL1, PL6).



Figure 10: Trenching damage looking south toward the old Air Force hangar. Tracie Curry 2022.

4.6 Local priorities, information needs, and other questions

When asked about their greatest priorities and concerns relating to erosion and permafrost thaw, interviewees highlighted the following:

Highlighted Priorities and Concerns

Drinking water	Frequent “boil water” notices go out to the community when public works cannot guarantee the safety of the drinking water. Two interviewees expressed distrust of the water to the extent that they prefer to purchase expensive bottled water rather than drink what comes out of the faucet (PL3, PL6).
Emergency services	Emergency service infrastructure including fire hydrants and the fire department/search and rescue (SAR) building need significant repair or replacement. To maintain operations, it is important for emergency services to have a secure place to store equipment and keep it warm (PL5, PL6).
Housing	The safety of homes is a major concern. Due to subsidence, the houses look like they are “on stilts” and residents can feel their houses swaying during strong winds (PL3, PL4, PL6).
Ponding	It is important to reduce the occurrence of ponding in town and address (e.g. fill) existing ponds. Ponding accelerates permafrost thaw and some are especially deep, which is a drowning hazard (PL5, PL6).
Subsistence	One interviewee expressed their largest concern was for the community’s ability to keep hunting and living off the land given all the access challenges being caused by landscape change (PL3). Iñupiat elder, Frederick Tukrook, highlighted that subsistence is the most important part of the Iñupiat way of life (Kali Community/Regional Advisory Group Meeting, 2020).
Wastewater system	The wastewater system is failing and has been abandoned in parts of the community. Some households are on honey buckets because they have been disconnected from the system but have not yet received holding tanks. In combination with other challenges, the difficulty of having to use honey buckets in sometimes crowded households has caused some young people to want to leave Point Lay (PL7).

Interviewees also provided insight on types of research and technical information that would be most helpful for Point Lay’s planning and decision-making. Not surprisingly, the recommended information/research needs are in most cases complementary to the priorities and concerns highlighted above. Some needs were also previously referenced in Point Lay’s priority list for funding by the North Slope Borough Capital Improvement Program (CIP) (Native Village of Point Lay, 2017).

Information Needs

Information/Research Needs	Description
Identification of a permanent fresh water source (CIP priority)	Point Lay lost its fresh water source in 2016 and a suitable replacement has not yet been identified. The community is temporarily sourcing water from the Kokolik River that must be treated for high salt and silt content. A potential source has been identified approximately 6 miles outside of town (PL1) (Native Village of Point Lay, 2017).
Investigate and transition to an alternative wastewater system (CIP priority)	Some parts of the wastewater system have already been abandoned and the families are on holding tanks. Some families are still awaiting their holding tank and are on honey buckets in the meantime (PL6).
Research on potential sources of gravel and dredging feasibility (CIP priority)	Point Lay’s excess gravel stockpile is nearly depleted, and no alternate source of gravel has been identified. Two interviewees (PL1 and PL 6) suggested that river dredging should be investigated. According to one interviewee (PL1), high quality gravel was dredged in the past from the Kokolik River and the proportion of fines to gravel improved the further upstream the dredge operated. However, the interviewee acknowledged that dredging would be problematic if the village began using the river as its fresh water source unless water could be retrieved upstream of dredging operations.
Research on the best locations to harvest sod for backfilling of subsided areas and gravesites	When graves are dug, most of the material excavated is ice and additional sod is needed to backfill (PL1). Backfilling subsided areas in town with gravel has led to accelerated thawing. Point Lay is experimenting with sod as an alternative, but information is needed about the best locations and methods to responsibly harvest material (PL2).
Identify sound locations to construct new ice cellars	There is one remaining ice cellar in town shared by two whaling crews. The cellar is in poor condition and requires considerable maintenance to keep it from failing (PL1, PL5).
(1) Identify feasible locations for village expansion or relocation (2) Test experimental housing designs at those locations	Identify the best places to build considering underlying permafrost and test experimental housing designs for resilience (PL1)

Information Needs

Information/Research Needs	Description
Recommended sites to monitor (Kali Community/Regional Advisory Group Meeting, 2020)	1. Proposed road to potential new fresh water source 2. Kuchiak Coal Mine (rock location with stable ground for potential future townsite) 3. Lagoon ice to see how fast its freezing and how long its staying frozen 4. Sea ice monitoring to give hunters an idea of safe ice 5. Monitor along the river for erosion and new plant/animal species

Additionally, interviewees shared general questions they have for researchers about topics related to erosion and permafrost thaw:

Other Questions

1	What has been the measured progression or speed of permafrost thaw over the past 5 years and 10 years?
2	What can we do to stop the permafrost from thawing so quickly?
3	Can we stay where we are, or will we eventually have to go? What conditions would necessitate having to move?
4	How long before the permafrost thaw situation becomes critical in a way that would necessitate having to move?
5	Thermosyphons have worked well for keeping the land under some public works buildings stable. Is it feasible to use them in residential applications?

4.7 Key sites of interest

Participants notated the approximate locations of key sites in the Point Lay area- and village-scale sites of interest on hard copy maps during their interviews. The locations shown in *Figure 12: Map 2 – Point Lay and Surrounding Area*, and *Figure 13: Map 3 – Village of Point Lay* are summarized in the tables below.

Table 5: Point Lay surrounding area noted buildings and landscape features (See Figure 12: Map 2 – Point Lay and Surrounding Area)

MAP 2 – POINT LAY AND SURROUNDING AREA		
Feature	Site	Description
1	Barrier island inlet	Inlet created by Air Force dredging closed back over time and no longer exists.
2	Barge landing site	Approximate location of Point Lay barge landing site.
3	Boat dock beach	Former landfill, DoD artifacts becoming exposed.
4	Fresh Water Lake	Drained in 2016. DoD artifacts exposed at the bottom. Trail access impacted.
5	Tundra trail access	Severely degraded due to thawing.
6	Mukpik Creek	Subsidence and erosion, unable to build summer access bridge.
7	Air force land ponds	Taboo for plant harvesting due to suspected contamination.
8	Airport hangar	Safety hazard that should be taken down.
9	Bluffs (adjacent to airport)	Significant erosion and settlement reportedly worsened by Air Force excavation of a landfill behind the hangar. Exposed ice wedges. DoD artifacts.
NA	Icy Cape (off map)	Located about 50 miles north of town. Significant erosion, subsidence, and artifacts being revealed.

Table 6: Native Village of Point Lay noted buildings and landscape features (see Figure 13: Map 3 - Village of Point Lay)

MAP 3 – NATIVE VILLAGE OF POINT LAY		
Feature	Site	Description
1	Fire hydrant	The 700-block fire hydrant is compromised by subsidence.
2	Bluffs (in town)	Significant subsidence reportedly worsened by ponding from snow dumps at the end of roads.
3	Teacher housing	Potential summer lodging availability. Organize through the NSB School District and Kali School.
4	School	Potential summer lodging availability. Organize through the NSB School District and Kali School.
5	Fire station	Building severely compromised by subsidence and annual flooding.
6	Snow fences	Effective at preventing snow drifts in town, but degrading tundra due to ponding from snow melt.
7	NSB lodging	Potential lodging availability when not occupied by NSB work crews.
8	NSB itinerant lodging	Potential lodging availability when not occupied by NSB work crews.
9	Tundra scar	Persistent tundra scar caused by trenching during installation of telephone line.
NA	Houses throughout town	Significant structural damage due to subsidence.

A map of Alaska with a red star marking the location of Point Lay on the northern coast. The text "Point Lay" is written in black above the star.

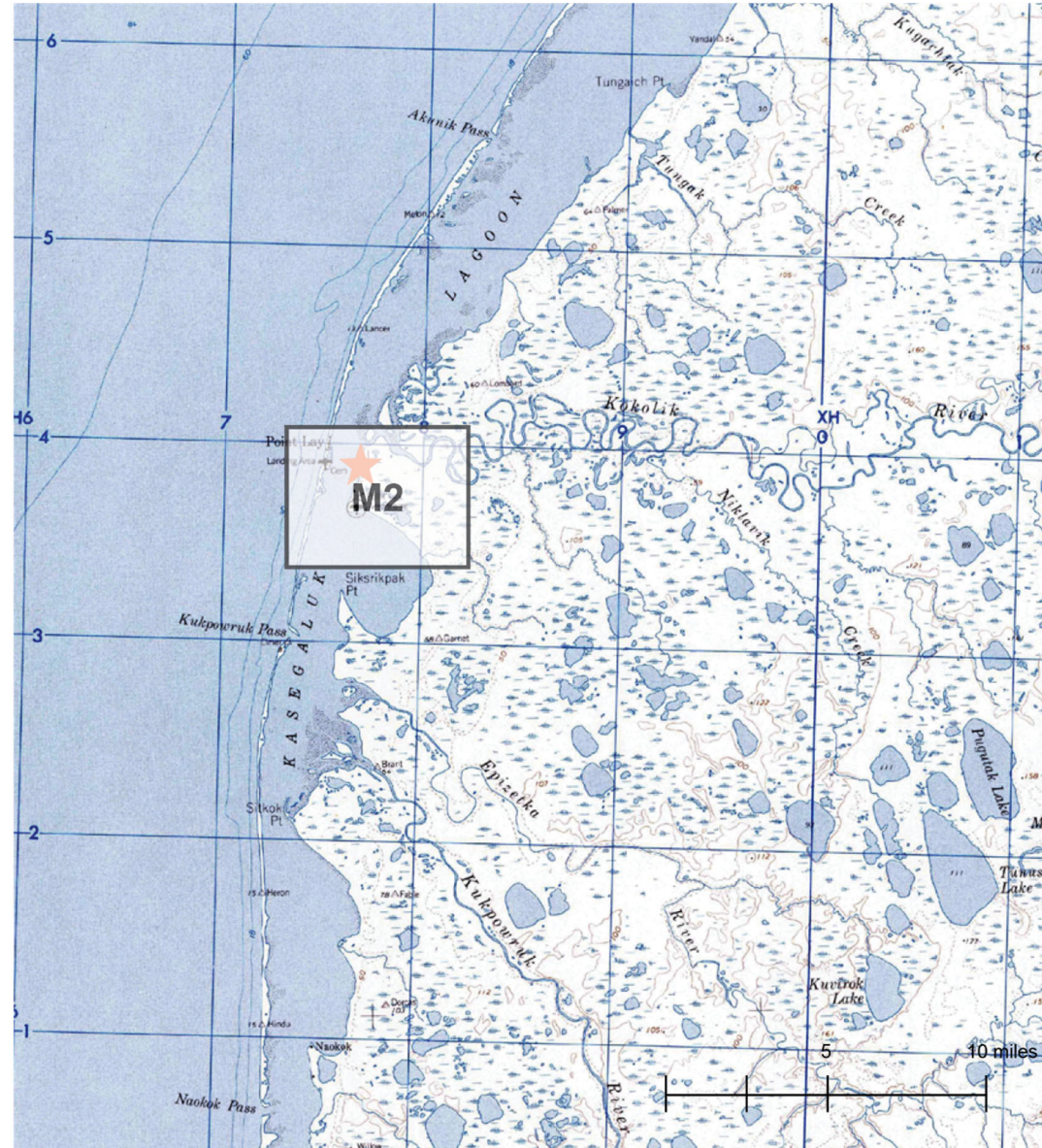


Figure 11: Map 1 – Point Lay Regional Context

Map 2:
Point Lay and Surrounding Area

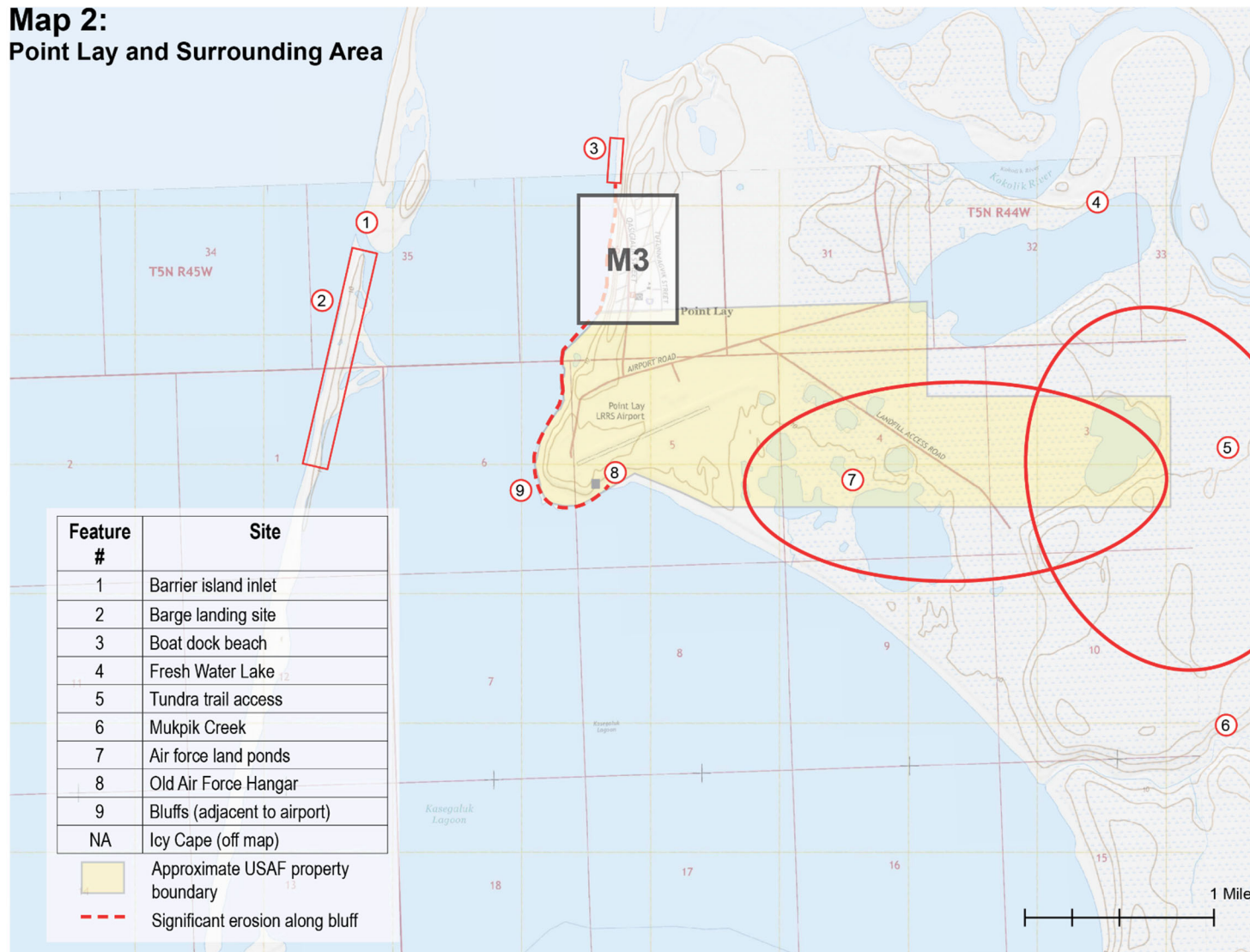


Figure 12: Map 2 – Point Lay and Surrounding Area

Map 3: Point Lay

Feature #	Site
1	Fire hydrant (700 block)
2	Bluffs (in town)
3	Teacher housing
4	School
5	Fire station
6	Snow fences
7	NSB lodging
8	NSB Itinerant lodging
9	Tundra scar from trenching
NA	Houses throughout town



Figure 13: Map 3 - Village of Point Lay

Bibliography

AK DNR (2021) *ETC Data and Risk Assessment Status - Dashboard*. AK DNR, Alaska Division of Geological and Geophysical Surveys. Available at: <https://soa-dnr.maps.arcgis.com/apps/dashboards/ba8ebf93adec4b6d9f601e2d59179fdd> (Accessed: 2 November 2022).

Alaska Department of Labor and Workforce Development (2023) *Alaska Population Estimates*. Available at: <https://live.laborstats.alaska.gov/pop/estimates/data/TotalPopulationPlace.xls> (Accessed: 12 January 2023).

‘As walrus haul out near Point Lay, locals ask visitors to leave them alone’ (2020) *Alaska’s Energy Desk*. Kotzebue: KTOO. Available at: <https://www.ktoo.org/2020/08/10/as-walrus-haul-out-near-point-lay-locals-ask-visitors-to-leave-them-alone/> (Accessed: 14 November 2022).

Bazeley, P. (2013) *Qualitative data analysis: Practical strategies*. Sage.

Bjella, K. (2015) *Point Lay Geophysical Exploration*. Cold Regions Research and Engineering Laboratory (CRREL), Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers (USACE), p. 29.

Burch Jr, E.S. (1998) ‘Boundaries and borders in early contact north-central Alaska’, *Arctic anthropology*, pp. 19–48.

Buzard, R.M. *et al.* (2021a) *Erosion exposure assessment of infrastructure in Alaska coastal communities - Kaktovik*. Kaktovik: Alaska Division of Geological & Geophysical Surveys.

Buzard, R.M. *et al.* (2021b) *Erosion exposure assessment of infrastructure in Alaska coastal communities - Point Lay*. Point Lay: Alaska Division of Geological & Geophysical Surveys.

Denali Commission (2019) *Statewide threat Assessment: Identification of threats from erosion, flooding, and thawing permafrost in remote Alaska communities*. INE 19.03.

Denzin, N.K. and Lincoln, Y.S. (2011) *The SAGE handbook of qualitative research*. Sage.

Jacobsen, M.J. and Wentworth, C. (1982) *Kaktovik Subsistence: Land Use Values Through Time in the Arctic National Wildlife Refuge*. U.S. Fish and Wildlife Service Northern Alaska Ecological Services. Available at: <https://ecos.fws.gov/ServCat/DownloadFile/132959?Reference=87607>.

Jones, B. *et al.* (2022) ‘Point Lay Permafrost’, *ARCUS Witness Community Highlights*. Arctic Research Consortium of the U.S. Available at: <https://www.arcus.org/witness-the-arctic/2022/9/highlight/2> (Accessed: 2 November 2022).

Kali Community/Regional Advisory Group Meeting (2020).

Lantuit, H. *et al.* (2012) ‘The Arctic coastal dynamics database: A new classification scheme and statistics on Arctic permafrost coastlines’, *Estuaries and Coasts*, 35(2), pp. 383–400.

- Mikow, E. (2010) 'Third time and counting: Remembering past relocations and discussing the future in Kaktovik, Alaska', *Alaska Journal of Anthropology*, 8(2), pp. 33–42.
- Native Village of Point Lay (2017) 'Point Lay Comprehensive Plan, 2017-2037'. North Slope Borough.
- Nielson, J. (1977) *Kaktovik, Alaska: An Overview of Relocations. Report to the North Slope Borough Commission on Inupiat History and Culture*.
- Nitze, I. *et al.* (2020) 'The catastrophic thermokarst lake drainage events of 2018 in northwestern Alaska: fast-forward into the future', *The Cryosphere*, 14(12), pp. 4279–4297. Available at: <https://doi.org/10.5194/tc-14-4279-2020>.
- North Slope Borough (2021) 'Kaktovik Comprehensive Plan, 2021-2041'.
- NSB (2019) *NSB 2019 Economic Profile and Census Report*. North Slope Borough.
- NSB (no date) *Point Lay, The North Slope Borough*. Available at: <https://www.north-slope.org/our-communities/point-lay/> (Accessed: 18 November 2022).
- ODUSD(I&E) (2015) *Native Village of Point Lay, Step III Site Assessment Report*. The Office of the Deputy Under Secretary of Defense: Installations & Environment.
- Osterkamp, T.E. and Jorgenson, J.C. (2006) 'Warming of permafrost in the Arctic National Wildlife Refuge, Alaska', *Permafrost and Periglacial Processes*, 17(1), pp. 65–69.
- Shenton, A.K. (2004) 'Strategies for ensuring trustworthiness in qualitative research projects', *Education for information*, 22(2), pp. 63–75.
- Stark, N. *et al.* (2021) *Summary of Results of Arctic Reverine and Coastal Interaction with Community Infrastructure (AR(CI)2) First Workshop*.
- Tengö, M. *et al.* (2014) 'Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach', *Ambio*, 43(5), pp. 579–591.
- USACE, Alaska (2002) *Inventory Project Report (INPR) for Point Lay DEW Line*. Anchorage, Alaska.
- Vargas-Moreno, J.C. *et al.* (2016) 'Prioritizing Science Needs Through Participatory Scenarios for Energy and Resource Development on the North Slope and Adjacent Seas'. GEOAdaptive, LLC.

Engaging Local Knowledge to Inform Measures Protecting Alaskan Coastal Communities from Erosion and Permafrost Thaw

PART 2 - FRAMEWORK

Considerations for CRREL Arctic Research and Engagement Activities

Prepared by:
Northern Social-Environmental Research

On Behalf of:
Cold Regions Research and Engineering Lab

February 2023



List of Acronyms and Abbreviations

ASTAC – Arctic Slope Telephone Association Cooperative

ATV – All Terrain Vehicle

CEQ – Council on Environmental Quality

CRREL – Cold Regions Research and Engineering Laboratory

DoD – Department of Defense

DEW Line – Distance Early Warning Line System

ERDC – Engineering Research and Development Center

Evidence Act – Foundations for Evidence-Based Policymaking Act of 2018

FOIA – Freedom of Information Act

FPIC – Free Prior and Informed Consent

IQA – Information Quality Act

HISA – Highly Influential Scientific Assessments

NSB – North Slope Borough

OSTP – Office of Science and Technology Policy

TK – Traditional Knowledge

USACE – United States Army Corps of Engineers

USFWS – United States Fish and Wildlife Service

VHF – Very High Frequency Radio

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1 Introduction and Objectives

Part 1 of this report detailed results of the project’s factfinding activities which engaged village leadership in Kaktovik and Point Lay to document local observations and Traditional Knowledge related to the risks of erosion and permafrost thaw and their impact on Arctic communities and infrastructure investment. Part 2 presents a framework to guide Arctic research and engagement activities aligned with Department of Defense (DoD) efforts to enhance Arctic domain awareness, meet trust obligations with Tribes, and apply multiple sources of evidence for decision-making. It also reports on recommendations from Kaktovik and Point Lay leadership regarding best practices for community engagement, and observed strengths and shortcomings related to Federal interactions with Tribal Nations and community members.

These objectives align with the 2019 Department of Defense (DoD) Arctic Strategy, which acknowledges the growing geostrategic significance of the Arctic region and the adverse effects of thawing permafrost and coastal erosion on the maintenance and development of resilient DoD infrastructure (DoD, 2019). The 2019 strategy also highlights the continuing importance of working with Alaska Natives in the Arctic and recognizes the equities of local communities as part of DoD activities in the region (ibid). Furthermore, the 2022 National Strategy for the Arctic prioritizes improving national understanding of the Arctic operating environment to enhance security capabilities in the region (Strategic Objective 1.1). This report is submitted to the Cold Regions Research and Engineering Laboratory (CRREL), a component of the U.S. Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC), as initial research intended to advance the development of formal guidance for CRREL research and engagement efforts in service of National and Tribal priorities. Throughout the report, references to DoD, USACE, and other federal agencies are included to the extent that the topics discussed are also relevant to CRREL.

2 Background – DoD in Arctic Alaska

2.1 Arctic context

The Arctic is experiencing warming air temperatures at a rate of 2 to 3 times faster than the global average (IPCC, 2018). Alaskan Arctic coasts are eroding at rates of up to 20 meters per year, among the highest coastal retreat rates on earth (USGS, 2022). Substantial DoD infrastructure is situated along the Arctic shoreline, which experiences episodic and sometimes abrupt change due to temperature-dependent phenomena such as storm activity, sea ice decline, and permafrost thaw. Major environmental incidents are happening in the region more rapidly and with increased intensity, creating challenges for infrastructure management including at the installation level, where there is a need for data to inform planning efforts (US GAO, 2014). With increasing efforts to manage climate-related risks to mission-critical infrastructure and operations in the Arctic, and a current lack of local scale data, there is a growing need for coordination and collaboration with Indigenous communities in the region.

2.2 Regulatory Environment

DoD, like all other executive departments and agencies, is mandated under Executive Order (E.O.) 13175, *Consultation and Coordination with Indian Tribal Governments* (2000), to establish regular and meaningful consultation and collaboration with Tribal officials in the development of Federal policies that have Tribal implications and strengthening the United States government-to-government relationships with Indian tribes. The Presidential Memorandum on *Tribal Consultation* of November 5, 2009, extended E.O. 13175 requiring each agency to prepare and periodically update a detailed plan of action to implement the policies and directives¹. This order was reaffirmed in 2021 with the Presidential Memorandum on *Tribal Consultation and Strengthening Nation-to-Nation Relationships* of January 26, 2021, which renewed commitment to “honoring Tribal sovereignty and including Tribal voices in policy deliberation that affects Tribal communities”.

While government-to-government consultation protocols dictate a large share of USACE interactions with Tribal entities, engagement also happens outside of the formal consultation process such as within the frequent, day-to-day interactions that occur between USACE component staff, Tribal governments, and Tribal members engaged in research (USACE Institute for Water Resources, 2020). For the purposes of this report, it is assumed that CRREL’s potential interactions with Tribes during the planning and implementation of its research activities are in the latter category. However, even when consultation is not required, research goals are secondary and USACE’s trust obligation is primary (Kendall Campbell (USACE Alaska Tribal Liaison), 2021). The USACE Tribal Policy Principles (Policy Guidance Letter Number 57, 1998) are the framework for USACE collaboration, engagement, and partnering with tribes for formal consultation and other communications.

1 Relevant DoD and Alaska policy implementation guidance include “U.S. Department of Defense Plan of Action to Implement the Policies and Directives of Executive Order 13175.” (Office of the Secretary of Defense, May 2021); “Alaska Implementation Guidance for DoD Alaska Native Related Policies and Instructions.” (US Air Force Alaska Command, April 13, 2020); “U.S. Army Corps of Engineers Tribal Consultation Policy.” (2012).



USACE Tribal Policy Principles

Tribal Sovereignty: USACE recognizes that Tribal Governments are sovereign entities, with rights to set their own priorities, develop and manage Tribal and trust resources, and be involved in Federal decisions or activities which have the potential to affect these rights. Tribes retain inherent powers of self-government.

Trust Responsibility: USACE will work to meet trust obligations, protect trust resources, and obtain tribal views of trust and treaty responsibilities or actions related to the Corps.

Government-to-Government: USACE will ensure that USACE leaders and tribal leaders meet as governments and recognize that Tribes have the right to be treated in accordance with principles of self-determination.

Pre-Decisional Consultation: USACE will involve Tribes collaboratively, before and throughout decision making, to ensure the timely exchange of information, the consideration of disparate viewpoints, and the use of fair and impartial dispute resolution processes.

Self-Reliance, Capacity Building, and Growth: USACE will search for ways to involve Tribes in programs, projects, and other activities that build economic capacity and foster abilities to manage Tribal resources while preserving cultural identities.

Natural and Cultural Resources: USACE will act to fulfill its obligations to preserve and protect trust resources and to consider the potential effects of USACE programs on natural and cultural resources.

2.3 Traditional Knowledge² in research, policies, and decision-making:

The Office of Science and Technology Policy (OSTP) and the White House Council on Environmental Quality (CEQ) jointly issued a memorandum on November 15, 2021, “recognizing Indigenous Traditional Ecological Knowledge as one of the many important bodies of knowledge that contributes to the scientific, technical, social, and economic advancements of the United States, and to our collective understanding of the natural world.” The memorandum further acknowledges that partnering with Tribal Nations and Native organizations regarding the application of Traditional Knowledge (TK) is consistent with federal commitments to the principals of scientific integrity and knowledge- and evidence-based

² Traditional Knowledge is often called by other names including Traditional Ecological Knowledge, Indigenous Knowledge, or Native Science. While in some contexts they have distinct meanings, for the purposes of this report they are equivalent. Additionally, this report recognizes local knowledge, the relatively recent place-based knowledge of a group of people, as a valuable resource.

policymaking³. In Federal contexts governed by the *Foundations for Evidence-Based Policymaking Act of 2018* (Evidence Act), Agencies are advised to include TK as a form of evidence and consider TK when “developing priority questions on agency Learning Agendas, in building evidence through inclusive methodologies, and when using evidence to improve government effectiveness”. In Federal contexts governed by the *Information Quality Act* (IQA), Agencies are advised that TK can be relevant to and may be used in Highly Influential Scientific Assessments (HISA). Government-wide guidance was released in 2022 to help agencies develop an approach to TK that is in accordance with the contexts and legal frameworks in which they operate. This guidance, in combination with the input of Kaktovik and Point Lay leaders interviewed for this study, is the basis for the recommended engagement strategies reported herein.

Understanding Indigenous Knowledge

From *Guidance for Federal Departments and Agencies on Indigenous Knowledge*, Nov 2022.

Indigenous Knowledge is a body of observations, oral and written knowledge, innovations, practices, and beliefs developed by Tribes and Indigenous Peoples through interaction and experience with the environment¹. It is applied to phenomena across biological, physical, social, cultural, and spiritual systems. Indigenous Knowledge can be developed over millennia, continues to develop, and includes understanding based on evidence acquired through direct contact with the environment and long-term experiences, as well as extensive observations, lessons, and skills passed from generation to generation². Indigenous Knowledge is developed by Indigenous Peoples including, but not limited to, Tribal Nations, Native Americans, Alaska Natives, and Native Hawaiians. Each Tribe or Indigenous community has its own place-based body of knowledge that may overlap with that of other Tribes.

¹U.S. Fish and Wildlife Service. (2011). *Traditional Ecological Knowledge for Application by Service Scientists*. <https://www.fws.gov/sites/default/files/documents/TEK-Fact-Sheet.pdf>

²Inuit Circumpolar Council (2022). *Indigenous Knowledge*, <https://www.inuitcircumpolar.com/icc-activities/environment-sustainabledevelopment/Indigenous-knowledge>

3 Methods

Semi-structured interviews with knowledgeable community members in Point Lay and Kaktovik were conducted in July 2022 and October 2022 respectively. The interview protocol had two parts. Part 1 questions focused on documenting local observations, and Traditional knowledge related to the risk of erosion, permafrost thaw, and infrastructure. Part 2 interview questions explored topics related to best practices for research, local engagement, and information sharing between Indigenous communities and federal agencies like DoD.

For a detailed description of data collection, analysis and validation, see Part 1 Sec 2 – Methodology

3 Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking (Jan. 27, 2021), <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/memorandum-on-restoring-trust-in-government-through-scientific-integrity-and-evidence-based-policymaking/>

3.1 Limitations

Two limitations of the research methodology employed for this study should be noted. First, minimal input was received from DoD staff familiar with past consultation processes or other outreach activities in which DoD has engaged Tribes in the Arctic. No DoD staff could be reached for comment, with the exception of early feedback received from Tribal Liaisons representing the U.S. Army Corps of Engineers Alaska District, the Pacific Air Force Regional Support Center, and the U.S. Coast Guard District 17.

Second, while the utmost care was taken to accurately record and represent the observations and knowledge shared by interviewees, Part 2 of this study was not reviewed by Tribal representatives and the reported results are not validated. For this reason, they are presented as initial research intended to advance the development of formal guidance. The development of formal guidance should incorporate a more robust engagement strategy than was possible within this pilot research initiative.

3.2 Theoretical basis

Good governance

Governance and government are distinct concepts. Governance concerns the network of organizations and institutions (e.g. rules, laws, regulations, policies, social and cultural norms) that form the basis of negotiating and decision-making activities undertaken by governments (or other organized groups) in the process of governing (Chaffin, Gosnell and Cosens, 2014). Broadly speaking, governance can occur wherever people organize themselves (Abrams *et al.*, 2003). The actors involved might include government agencies, Tribal governments, local communities, businesses and corporations, NGOs, international bodies, educational organizations, etc.

What constitutes **good governance** is dependent on local context and cultural perspective. However, it can generally be defined as the exercise of governing powers (means) in a fair and effective way to meet objectives (ends) (Abrams *et al.*, 2003). The United Nations Development Program developed an early good governance framework in its policy document “Governance for Sustainable Human Development” (1997). As intended, the framework has since then been adapted in various forms by scholars and practitioners to suit specific historic and socio-cultural contexts. The Inuit Circumpolar Council (ICC) promotes five key principals of good governance: **rule of law, transparency, responsiveness, equity & inclusiveness, and accountability** (ICC, 2022).

Rule of law refers to impartial legal systems that protect the human rights and civil liberties of all citizens. Rule of law must be upheld to ensure ethical, equitable engagement of TK consistent with distinct Indigenous rights, and essential to consultation and cooperation in all dimensions of and actions concerning this knowledge (ICC, 2022). Legitimacy, the validity of an organization’s authority to govern, is also a component of rule of law. Validity may be conferred by law or it may be earned. An organization may earn legitimacy by gaining approval for its responsibilities or actions directly from the people affected (Lockwood, 2010).

Transparency is the visibility of the decision-making process and is grounded in people’s right to know about matters that affect them (Lockwood, 2010). It should be easy for Tribes to see what others are doing and what actions are being performed within their communities and across their homelands, and to know about such events in advance (ICC, 2022). Authorities should also provide information to Tribes that

makes clear the reason why a particular decision was made or why a particular course of action was chosen.

Responsiveness involves reacting in a positive fashion to Inuit ways of life, values, customs, ideas, priorities, decisions, and choices in the context of monitoring, assessments, research, decision-making and other activities within their communities and in relation to Inuit lands, territories, and resources (ICC, 2022). Responsiveness also requires that governing bodies be effectively coordinated with sufficient capacity to carry out their required roles (Lockwood, 2010).

Equity includes providing the appropriate resources, policies, and structures to allow everyone to participate on equal footing. For it to be accessible, some participants may require information to be made available in particular ways (ICC, 2022). **Inclusiveness** encompasses having available and accessible opportunities to participate in and influence decision-making. The call for “nothing about us without us” is a call to respect Inuit rights and promote Inuit self-determination and self-governance (ICC, 2022).

Accountability speaks to relationships, obligations, and responsibilities held by all. It seeks to ensure that those who work with Inuit peoples or on Inuit lands through research, policy, and decision-making take their obligations toward Inuit lands, territories, and resources seriously (ICC, 2022).

Guidance for Federal Departments and Agencies on Indigenous Knowledge
Government-wide *Guidance for Federal Departments and Agencies on Indigenous Knowledge* (2022) was released Nov 30, 2022. The Guidance was developed by an Interagency Working Group with representatives from over 25 Federal departments and agencies. Input was also provided by over 1,000 individuals from Tribal Nations and other Indigenous groups during Tribal consultation and listening sessions. Suggested principles for growing and maintaining relationships with Tribes and Indigenous communities, as well as guidance for applying TK are summarized below.

Growing and maintaining relationships to support Traditional Knowledge: Growing and maintaining strong, mutually beneficial relationships between Agencies and Tribes is foundational to appropriately engaging, considering, and applying TK in planning and decision-making. The Government-wide Guidance offers the following principles and practices to build and maintain trust with Indigenous communities:

1. Acknowledge historical context and past injustice. Agencies should acknowledge the history of the department or agency they represent, and the Federal Government broadly, when working with Tribes and Indigenous peoples. Recognizing past injustice and respecting Tribal and Indigenous communities, cultures, and values will assist Agencies in developing collaborative processes that are more equitable and inclusive of Indigenous people and their knowledge systems.
2. Practice early and sustained engagement. Consultation is a cornerstone of building and maintaining trust with Tribal Nations. Agencies should also consider opportunities to engage with Indigenous peoples beyond the formal consultation process. Consultation and other interactions may provide opportunities to discuss TK with Tribal Nations and understand and understand from Tribal nations how TK could inform the agency’s decision-making process.
3. Earn and maintain trust. Agencies should proceed with patient and respectful persistence, and honest and transparent communication, to demonstrate that the desire to collaborate and listen to Tribes and Indigenous Peoples is genuine.

4. Respect different processes and worldviews. Tribes and Indigenous Peoples may use decision-making processes substantially different from Agencies, and may approach issues from a different perspective. Recognizing and respecting divergent processes and world views, and the sensitivity of Tribes about sharing information about them is important for relationship building and understanding how to engage with TK.
5. Recognize challenges. Agencies should recognize that Tribes and Indigenous Peoples face obstacles to equitable collaboration, including: (1) mistrust or skepticism; (2) lack of funding personnel, and capacity among Tribes and Indigenous Peoples to respond to Federal requests to engage; (3) lack of coordination and communication between Agencies may result in duplicate requests, causing frustration and extra work for Tribes and Indigenous Peoples; (4) changes in political administrations, budgets, and leadership priorities may affect relationship continuity and collaborative efforts; and (5) telecommunications infrastructure and lack of broadband or internet in rural areas. Agencies should consider actions to address these challenges as part of their work.
6. Consider co-management and co-stewardship structures. Where available, Agencies should consider co-management, collaborative management, and co-stewardship of lands and waters as opportunities to include Tribal Nations, Indigenous Peoples, and Indigenous Knowledge in Federal actions. These approaches bring Tribal Nations directly into Federal decision making and such collaborations may help avoid challenges around and breaches of confidentiality or data, and imbalances in power and resources. Co-management may not be possible in all scenarios, and must be consistent with relevant Federal authorities.
7. Pursue co-production of knowledge. Similarly, Federal researchers should look for opportunities to work with Indigenous Knowledge holders to co-produce scientific information and propose solutions to inform decision making. Knowledge co-production is a research framework based on equity and the inclusion of multiple knowledge systems. It requires the full partnership of Tribes and Indigenous Peoples in all aspects of a research endeavor from the outset, including ensuring that Tribal and Indigenous collaborators are compensated for the work that they do and understand up front if funding is unavailable.

Applying Traditional Knowledge: As efforts to engage TK grow, it should be acknowledged that Tribes and Indigenous People will have different preferences regarding their level of involvement in research and that preferences may change depending on the issue or project. There are also potential risks to Indigenous peoples that can result from the sharing of their knowledge in Federal and other non-Indigenous initiatives (Climate and Traditional Knowledges Workgroup, 2014). For example, agencies may not be able to protect the disclosure of sensitive information from Freedom of Information Act (FOIA) requests, or knowledge holders may have concerns regarding the protection of their intellectual property (ibid.). When considering whether and how to include TK in Federal research design and implementation, the six R's of Indigenous Research provide guidance (Ranalda L. Tsosie et al., 2022 as cited in OSTP and CEQ, 2022).

Responsibility: It is the responsibility of the research team to understand the sociopolitical landscape of a research site and research questions and to follow ethical best practices *whether or not* the research is considered human subject research. Honestly and clearly identify the purpose and motivation for the research.

Research Approach: Select appropriate research methods and parameters for the problem, the cultural context, and weaving together knowledge systems, as well as for the use of data and dissemination of results.

Relevance: When working in or with Indigenous communities, ensure research is relevant to the experiences, perspectives, priorities, and ways of knowing and living in these communities.

Representation: Indigenous communities should lead in the research process by sharing what is important to their community.

Respect: Have respect for Indigenous communities and cultures, multiple ways of knowing, and Indigenous Knowledge holders.

Relationship: Invest time and resources in engagement necessary to understand the issues, concerns, and needs from the perspective of partners. Acknowledge the nature of relationships (people-to-people and people-to-environment) as they relate to TK.

Multiple evidence base approach

Approaches to combine TK and Western knowledge systems are continually being explored. *Integrative* approaches attempt to integrate one knowledge system within another by making the former conform to the validation system of the latter (Tengö *et al.*, 2014). Integration of knowledge can be problematic given the validation measures used may not be appropriate and, by forcing one knowledge system to conform to the values of another, the ability of the former to exist as legitimate knowledge on its own terms is undermined. This is often the case when scientific methods are used to validate TK.

In contrast to integrative approaches, *parallel* approaches pursue different kinds of knowledge separately but in parallel, while identifying opportunities along the way for one to enrich the other (Berkes, 2012; Tengö *et al.*, 2014). The multiple evidence base (MEB) approach is a parallel approach that aims to enable connections across knowledge systems in a respectful and equal manner. It also stresses a focus on the process of knowledge generation, including collaboration between those involved from the onset to help mitigate power imbalances. There are three phases of the MEB approach. Phase 1 involves defining the focus of inquiry and goals in a collaborative manner that establishes mechanisms for maintaining ongoing dialogue. Phase 2 brings diverse knowledge together on an equal platform. Different knowledge systems are viewed as generating equally valid evidence for interpreting change, trajectories, and causal relationships. Phase 3 involves joint analysis and evaluation of knowledge and insights to generate cross scale synthesis and catalyze processes for generating new knowledge (Tengö *et al.*, 2014).

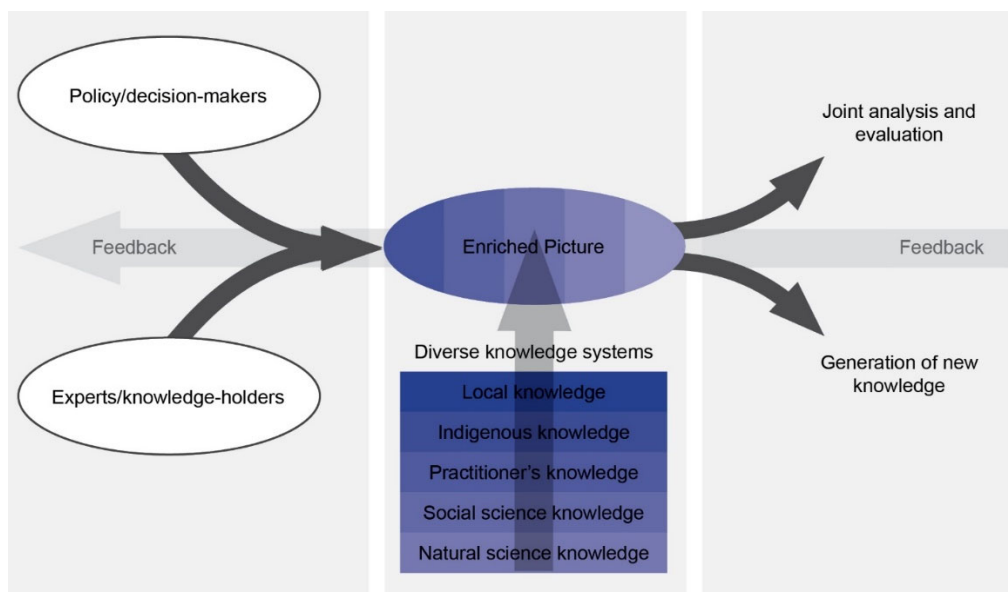


Figure 14: Three phases of the Multiple Evidence Base Approach

Among the benefits of the MEB approach is the ability to bridge temporal and spatial scales. TK systems are characterized as context-specific and long-time-scale, which is complementary to remote sensing and other observation methods that are difficult to downscale (Berkes and Folke, 2002). Additionally, MEB brings the potential to improve the credibility of results by enabling triangulation where the use of multiple knowledge systems in concert compensates for their individual weaknesses and leverages their respective strengths (Shenton, 2004). Triangulation as part of an MEB approach should acknowledge the inequities involved in relating TK with Western knowledge and ensure that evaluation is multidirectional. The MEB peer-review process acknowledges that different criteria of validation should be applied to data and information that originate from different knowledge systems. When conflicting or contradictory evidence is encountered, it should be acknowledged and not ignored. As a given, some aspects of diverse knowledge systems will remain incompatible. Accepting and exploring these contradictions can benefit further knowledge generation (Tengö *et al.*, 2014).

4 Results and Discussion

4.1 Current performance in relation to good governance principles

Interview participants shared their experiences engaging with DoD and other Federal agencies. Interactions with all referenced agencies are included to the extent that the takeaways are also of relevance to DoD research efforts. Strengths and weaknesses in Federal interactions with Tribes (the Native Village of Kaktovik and the Native Village of Point Lay) and Indigenous communities are organized in relation to good governance principles below and in Table 7.

Rule of law: One interviewee spoke positively of the DoD for the role it plays in national security and protecting the Arctic.

“We tend to want to work with them. They have the responsibility of guarding Alaska from [for example] the Russians who like to fly over our island... which tends to happen quite a lot. We’d like to be of help in that kind of situation since we consider ourselves Americans too.” (K2)

However, several representatives expressed that DoD has not sufficiently fulfilled its obligation to remediate contaminated sites resulting from past military activities (K1, K2, PL1, PL6). The exorbitant cost of removing contaminated soil and debris from remote locations like Kaktovik and Point Lay is a perceived barrier to effective remediation (*i.e.* many assume the government does a better job of remediation in locations where there are less logistical and financial barriers). Similarly, the perceived unfairness in the application of policy is also questioned in relation to the unequal distribution of funding in Alaskan communities. Kendall Campbell, USACE Alaska District Tribal Liaison, acknowledged that many communities in Alaska perceive an imbalance in the distribution of civil works funding given a small percentage of communities receive a large share of funds. This imbalance typically stems from barriers on the USACE side, often because a particular area doesn’t fit into a currently funded authority (*ibid.*).

The level of **transparency** demonstrated by the federal government in its interactions with Tribes is reported to be inconsistent from agency to agency, and can also change from year to year when there is a change in administration (PL1). Kaktovik borders the Alaska National Wildlife Refuge (ANWR) and, as a result, has relatively frequent interactions with various agencies. Kaktovik representatives indicated positive impressions of federal transparency within the government-to-government consultation process, particularly with the U.S. Fish and Wildlife Service. One participant noted:

“The U.S. Fish and Wildlife Service meets with the community to inform on all the current projects that they have planned for the year in and around the area. We tend to have good communications with them. They tend to hear what we say and take proper actions.” (K1)

In contrast, the same interviewee expressed frustration in relation to the Department of the Interior (DOI) which had been unresponsive to the Tribe’s inquiries regarding the ANWR Coastal Plain Oil and Gas Program environmental impact statement (EIS). Similarly, one Point Lay interviewee described their general experience with the government-to-government consultation process as “a black box” and expressed that local voices were “in one ear and out the other... they tell you what you want to hear and nothing changes” (PL2). Without evidence that Tribal input has influence on decision-making, the interviewee questioned the value of consultation as a meaningful way to participate (**Equity & Inclusiveness**).

Interview participants in both Kaktovik and Point Lay spoke highly of researchers that come back year after year to share information and get to know the community (K4, PL2). These researchers were contrasted to others that quickly fly in and out of the community and were perceived to “take what they want and leave” without giving back (*ibid.*). **Responsiveness** was demonstrated by researchers who dedicated time to cultivating reciprocal relationships and learning about local ways of life. Taking the initiative to come back year-after-year also demonstrated the willingness of the researchers to be held accountable by the community.

Table 7: Observations of agency performance in relation to good governance principles

Observation	Good Governance Principal
Good relationship with DoD: The Tribe has a long history with the Air Force and, for the most part, the relationship has been good (K1, K2). The Tribe generally wants to work with DoD. The military is responsible for guarding Alaskan airspace from threats and the community would like to be of help in those situations (K2).	+ Rule of law: Community members recognize and appreciate the role DoD plays in protecting Alaskan airspace.
Restoration Advisory Board (RAB) meetings were useful while they were active. The RAB provided a way for community members to give advice to the DoD regarding its Environmental Restoration Program.	+ Equity & Inclusiveness: The RAB meetings were a useful way for community members to be informed about and provide feedback on DoD's efforts to remediate contaminated sites.
Remediation: Community representatives report that, while DoD believes its clean-up efforts in Kaktovik are complete, contamination and debris are still present due to inadequate remediation efforts.	- Rule of law: Perception that remote communities are unfairly being forced to live with contaminants because of the exorbitant cost of remediating them. - Accountability: DoD believes its obligations have been fulfilled, but community members disagree.
Government-to-government consultation (Kaktovik): Kaktovik is surrounded by the Arctic National Wildlife Refuge and is accustomed to engaging in consultations with multiple agencies. The consultations are described as generally well-coordinated and useful.	+ Transparency: The Tribe has seen evidence that its input had an influence on agency plans. + Equity & Inclusiveness: The consultation process provides a forum for local voices to influence agency decision-making.
Government-to-government consultation (Point Lay): In Point Lay, the government-to-government consultation process was described as “a black box”. One participant perceived that local voices were “in one ear and out the other... they tell you what you want to hear and nothing changes.” (PL2)	- Transparency: No evidence that Tribal input influences agency decision-making. - Equity and Inclusiveness: The consultation process is not perceived as a meaningful way to participate.
The pandemic derailed discussions: Discussions with the air force that were initiated before the COVID-19 pandemic are currently stalled and there is no indication that they will be re-initiated (K2, PL5).	- Transparency: The status of previous discussions that were stalled by the pandemic is unknown. - Responsiveness: There is a lack of continuity between pre- and post-pandemic activities.
Some interactions with agencies have lacked transparency and responsiveness: The Native Village	- Transparency: The Tribe does not have

Observation	Good Governance Principal
of Kaktovik has been waiting over a year to receive a response from the Department of the Interior regarding a request for information explaining the need for a Supplemental Environmental Impact Statement (EIS) for the Coastal Plain Oil and Gas Program (K1).	access to information explaining the deficiencies in the original EIS. - Responsiveness: The Tribe's inquiry is reported to have gone unanswered for over a year.
Relationship building: It's ideal when scientists come back year-after-year to share information and get to know the community. Some groups do a good job of it while others seem to just take what they want and leave (K4, PL2).	+ Responsiveness: Building reciprocal relationships demonstrates a willingness to learn about local ways of life and contribute value to the community. + Accountability: Researchers who return regularly to share information and receive feedback show their willingness to be held accountable.

4.2 Considerations for growing and maintaining relationships in Arctic research

In the following section, government-wide guidance for growing and maintaining relationships (OSTP and CEQ, 2022) is adapted to the context of Arctic research based on guidance from local leaders in Kaktovik and Point Lay, as well as *Circumpolar Inuit Protocols for Equitable and Ethical Engagement*.

Acknowledge historical context and past injustice.

It is important to learn about historical interactions that continue to negatively impact and shape the relationship between DoD and Alaska Native people today. Through open communication, DoD leadership and staff can learn these histories from an Indigenous perspective and work together with Tribes and communities to find paths forward with the ultimate goal of healing (ALCOM, 2020).

Practice early and sustained engagement

Engage with Tribal governments and relevant Indigenous organizations **prior to initiating** proposals, research, or other work on or near Tribal lands. This requires **familiarity** with Indigenous institutions, particularly at the local and regional scale (See Attachment C for Kaktovik and Point Lay logistical information). Maintain a regularly updated list of contacts for Tribal governments and other Indigenous organizations involved in ongoing or recently completed projects. Sustained engagement with contacts throughout research will facilitate this process.

It is advisable to develop an intentionally structured **communications and engagement strategy** for interactions with Tribal governments and Tribal members before work begins (USACE Institute for Water Resources, 2020). For each community, seek local guidance on their desired level of involvement, appropriate lines of communication and frequency, use non-technical language, and make translation and interpretation services available if desired by local collaborators (ICC, 2022). Sustaining and increasing engagement are not necessarily equivalent. Be cognizant of the potential for excessive engagement to overwhelm local resources. Engage Tribes on their terms and seek guidance from local advisors when

developing timelines to ensure flexibility, adequate time, and recognition of seasonal calendars so that project activities are not in conflict with Iñupiat lifestyles (ICC, 2022).

Turnover, both within Tribal administration and within agencies, presents challenges for maintaining sustained engagement. This may be addressed within the agency by developing a continuity program that formalizes conversations between departing staff and their replacements, when possible, to ensure transfer of information about ongoing programs and Tribe-specific issues (USACE Institute for Water Resources, 2020).

Earn and maintain trust

Practice good governance principles including transparency, responsiveness, and accountability. Share information about research objectives, project scope, how the information will be used, potential benefits and potential to cause harm, how information will be disseminated, and other relevant details related to the engagement (ICC, 2022). Respond in a timely manner and demonstrate a willingness to be held accountable for research activities and outcomes. Attend meetings in-person when possible. Meeting face-to-face is essential to establishing relationships and building trust (USACE Institute for Water Resources, 2020). Interviewees from both Kaktovik and Point Lay expressed that their preferred way to receive and share information is via in-person meetings (K4, PL2, PL6). They also spoke positively regarding the efforts of researchers who make return visits, build relationships with the community, and share what they have learned from their research (K4, PL2). Information should be shared in appropriate formats and with accessible language.

Demonstrate reciprocity by giving back to the community rather than expecting one-way transfers of knowledge, local time, and expertise (ICC, 2022). Benefits to the community may include, among other things, providing information in accessible formats, equipment, training, and job opportunities. One interviewee expressed a desire for researchers to involve students in their work “to peak students’ interests in science” (PL2). Researchers can also give back by supporting Indigenous organizations and governments in determining and fulfilling their funding needs (ICC, 2022). This may require allocating additional time and resources to assist Tribes and Indigenous organizations with interpreting and leveraging data in support of community priorities.

Respect different processes and worldviews

It is important to **understand the cultural and historical context** of working with each Iñupiat community (ICC, 2022). Some characteristics and values are held in common among North Slope Iñupiat while others may be unique to a community. Understand that Iñupiat view the world holistically, paying close attention to the connections between everything that makes up the Arctic ecosystem. The people and their way of life (*e.g.* hunting, feasts, education) are part of that ecosystem (ICC, 2022). Furthermore, solutions to problems are not considered in isolation, but rather within the cultural context of a community (Climate and Traditional Knowledge Workgroup, 2014). North Slope residents honor their cultural connections to the land and to their ancestors through the continued practice of traditional Iñupiaq values (NSB, 2019). A summary of North Slope Iñupiaq values is provided in Attachment D.

Recognize challenges

Several factors impact the ability of Tribal governments and Tribal members to collaborate equitably. In addition to the pervasive challenges of limited administrative capacity and internet service, interview participants from Kaktovik and Point Lay also noted challenges related to information sharing and storage.

Capacity: Tribal offices are often understaffed and overburdened with requests. Lack of coordination and communication between research teams can compound this. Follow guidance from Tribal staff and other relevant contacts regarding the preferred frequency and means of communication (See Attachment C – Kaktovik and Point Lay Logistics). To mitigate the challenge of limited capacity consider coordinating with other relevant groups working in the same community or region, when possible, to schedule combined meetings or distribute shared informational materials. This may require additional project staff tasked with managing coordination across teams and compiling shared communications.

Technological limitations, including lack of broadband internet, can limit local ability to participate in remote meetings or receive electronic communications. A best practice is to provide presentation materials in advance of meetings to allow participants to follow along offline (K1). Also, be mindful of file size when emailing attachments and, for large files, consider mailing hard copies or content uploaded to flash drives.

Disseminating information to Indigenous community members requires extra effort beyond presenting at a Council meeting. While it is a good idea to present information to the Native Village Council during their monthly meetings, attendance of community members that are not part of the Council is typically low (PL1). Hard copy materials can be made available in local offices and flyers can be posted on message boards around town. However, the reach of these methods is limited (ibid.). Consider hosting a community meeting (refreshments and door prizes are recommended). Also consider creating mailers that can be distributed to each household via U.S. Postal Service (K4). Another strategy is hiring a local resident to serve as a village liaison who, among other things, communicates project information to the community along with distributing flyers and information packets (PL4). The liaison is also the first point of contact if community members have questions or concerns.

The **longevity of information** is also a barrier given the limited storage capability of most local offices. Neither Kaktovik nor Point Lay maintains a central repository for reports. Hard copies are stored in respective community offices where it's easy for things to get lost or damaged (PL1, PL2). In an ideal world, there would be one main information bank or library that stores all the data, reports, photos, etc. that are sent and keeps each community updated as new files arrive (PL2).

Pursue co-production of knowledge⁴

Procure funding for co-production of knowledge whenever feasible to ensure that TK and multiple ways of knowing are included in all stages of research. This will help to ensure reciprocal benefits, and research results that are relevant to both agencies and Tribes (OSTP and CEQ, 2022).

4.3 Best practices for applying Traditional Knowledge

Government-wide guidance on Indigenous Knowledge (2022) offers several practices to guide the way Agencies engage with TK to ensure the interests of Tribal governments and Tribal members are

⁴ For further reading on co-production of knowledge, see:

Ellam Yua, Raymond-Yakoubian, J., Daniel, R. A., & Behe, C. (2022). A framework for co-production of knowledge in the context of Arctic research.

Norström, A. V., Cvitanovic, C., Löf, M. F., West, S., Wyborn, C., Balvanera, P., ... & Österblom, H. (2020). Principles for knowledge co-production in sustainability research. *Nature sustainability*, 3(3), 182-190.

respected, and that engagement considers TK where relevant and appropriate. The guidance advises agencies to plan ahead and develop a TK plan, conduct initial meetings, Include TK into Federal decision-making and research, and regularly coordinate with other Agencies to facilitate information sharing. These practices are discussed in relation to Federal Arctic research activities below.

Plan ahead and consider developing a Traditional Knowledge plan

A TK plan should describe engagement between Agencies and Tribal governments and Tribal members, including early and sustained engagement to ensure TK is applied in a manner consistent with the expectations of the Tribes involved (OSTP and CEQ, 2022). Agencies should seek guidance from involved Tribes during an initial meeting (see below) to determine if and how TK could be relevant to the proposed research activities (ibid.). Additionally, discuss beforehand with TK holders and other Indigenous collaborators how they would like to be acknowledged or receive credit for the knowledge and expertise they provide (ICC, 2022). The TK plan should consider the questions:

1. What are the goals and objectives of the project?
2. How will TK holders be identified?
3. How will TK holders be involved?
4. What qualitative methods will be used to document TK?
5. How will TK be shared within the project team? Who will have access to the information?
6. How will TK be stored for safekeeping? What confidentiality measures are necessary and who will oversee them?
7. Who is accountable for ensuring agreed standards are upheld?

Regarding the identification of TK holders, agencies should be mindful of Tribal sovereignty and engage only with people designated by Tribal leadership (OSTP and CEQ, 2022), or identified through processes approved by Tribal leadership. One interview participant noted that it is important for researchers to “do the planning and identify the right people for the type of information that is being sought” (K1). Also, compensate knowledge holders, collaborators, and research participants for their knowledge, expertise, and time (ICC, 2022). Local governments and Tribal organizations can provide guidance regarding appropriate skills and fair compensation (ibid.). Related to the protection of sensitive information, agencies should consult with legal counsel regarding the agency’s obligations under the Freedom of Information Act (FOIA) and other public disclosure laws. Mechanisms to address the concerns of Tribes regarding privacy or potential threats to sensitive resources should be identified and adopted (OSTP and CEQ, 2022). Furthermore, agencies should also anticipate that TK freely shared by one community may be closely guarded by another (ibid.). See Attachment C – Kaktovik and Point Lay Logistics for specific TK considerations in Kaktovik and Point Lay.

Conduct initial meetings

An initial meeting should allow for reciprocal exchange. It is an opportunity for Tribes to specify conditions or interests that are important to the community and for agencies and Tribes to explore together the specific ways TK can inform Arctic research. Agencies should clearly communicate the potential benefits and risks of sharing TK, including the potential for public release under FOIA and other public disclosure obligations. Approach Tribal engagement through Free (not coerced), Prior (engaged from the beginning), and Informed (including costs, benefits, risks, and opportunities) Consent (Climate and Traditional Knowledges Workgroup, 2014). Consent should be obtained from relevant Tribal Nations

prior to including their TK in Federal research. Indigenous peoples have the right to decline sharing TK without legal repercussions (OSTP and CEQ, 2022).

Include TK in Federal decision-making and research

With consent from Tribal Nations to utilize TK, Agencies should ensure TK is appropriately applied in Federal research. The Government-wide Guidance on Indigenous Knowledge (2022) was founded on the understanding that “multiple lines of evidence or ways of knowing can lead to better-informed decision-making.” The multiple evidence base (MEB) approach is congruent with this guidance given it seeks to identify potential synergies across knowledge systems and processes for validating knowledge that recognize and respect differences in theoretical and methodological approaches (Tengö *et al.*, 2014). In Phase 1 of the MEB approach, the focus of inquiry and the relevance of TK to proposed research activities are defined in a collaborative manner. In Phase 2, following data collection and initial analysis, knowledge is brought together in equal standing. At this phase, it is important to acknowledge existing power dynamics given preferences for Western science in conventional settings largely overshadow other relevant sources of information, including TK (Lemos, 2008). In Phase 3, Western scientists, and TK holders both participate in the analysis and evaluation of knowledge and insights to generate multi-scale synthesis and identify opportunities for generating new knowledge. Ensure use of Iñupiat TK and final products are peer reviewed and validated by Iñupiat (ICC, 2022).

One interviewee relayed a positive experience sharing TK with Federal scientists attempting to document changing caribou migration patterns in a parallel process akin to MEB.

“When Tribe worked with the Department of the Interior on the Coastal Plain Environmental Impact Statement, we provided information about the Porcupine Caribou Herd and our traditional observations of that herd and their migration route. Changes that have occurred in the past and continue to occur. They pointed to their own science and data that they have of migration routes and showed that migration routes have indeed changed... before we informed them of those changes they just had a map of the entire range where caribou would migrate” (K1).

In the example, multi-scale synthesis was enabled through the concurrent analysis of largescale maps of caribou migration with TK providing local and regional scale understanding of change from historic to current time periods (Table 8).

Table 8: An Example case from Kaktovik demonstrating a parallel process akin to the MEB approach

Issue investigated	Multiple evidence base	Reflections on scale and complementarity
Porcupine caribou herd migration related to the Coastal Plain Oil and Gas Leasing Program Environmental Impact Statement (2019)	Data sharing between Department of the Interior and Native Village of Kaktovik regarding changes in caribou migration. Able to triangulate using different data sources in agreement that the Porcupine caribou migration routes have changed.	Traditional knowledge at the local and regional scale spanning historic changes to current changes. Western science at the regional scale (map of the entire range) spanning a shorter timeframe.

Regularly coordinate with other agencies and researchers to facilitate information-sharing

Research what work is ongoing or has already been done in the communities and regions you will perform work. Avoid duplicating efforts, which can lead to research fatigue within communities and Indigenous organizations (ICC, 2022). Where possible, coordinate with other agencies or researchers studying similar phenomena in the same region.

5 Conclusion

This Part 2 report presents a framework to guide Arctic research and engagement activities aligned with Department of Defense (DoD) efforts to enhance Arctic domain awareness, meet trust obligations with Tribes, and apply multiple sources of evidence for decision-making. It also reports on recommendations from Kaktovik and Point Lay leadership regarding best practices for community engagement, and observed strengths and shortcomings related to Federal interactions with Tribal Nations and community members. These recommendations are framed through the lens of foundational theory and guidance including Good Governance Principles, the Multiple Evidence Base approach to engaging diverse knowledge systems, and Circumpolar Inuit Protocols for Equitable and Ethical Engagement. These resources provide the basis through which Federal guidance on Indigenous Knowledge and Engagement (2022) is adapted to the Alaskan Arctic context. This initial research is submitted to advance the development of formal guidance for CRREL research and engagement efforts in service of National and Tribal priorities in the Alaskan Arctic. Further engagement with Tribal representatives and DoD components is necessary to advance a formal, validated framework.

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Bibliography

Abrams, P. *et al.* (2003) 'Evaluating Governance: A Handbook to Accompany a Participatory Process for a Protected Area.' Parka Canada and TILCEPA.

ALCOM (2020) 'Alaska Implementation Guidance for DoD Alaska Native Related Policies and Instructions'. US Air Force Alaska Command.

Berkes, F. (2012) *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. 3rd edn. Philadelphia: Taylor and Francis.

Berkes, F. and Folke, C. (2002) *Back to the Future: Ecosystem Dynamics and Local Knowledge*. Washington, D.C.: Island Press (Panarchy: Understanding transformations in human and natural systems).

Chaffin, B.C., Gosnell, H. and Cosens, B.A. (2014) 'A decade of adaptive governance scholarship: synthesis and future directions', *Ecology and Society*, 19(3).

Climate and Traditional Knowledges Workgroup (2014) *Guidelines for Considering Traditional Knowledges in Climate Change Initiatives*. Available at: <http://climatetkw.wordpress.com/>.

DoD (2019) 'Report to Congress: Department of Defense Arctic Strategy'. Office of the Under Secretary of Defense for Policy.

ICC (2022) *Circumpolar Inuit Protocols for Equitable and Ethical Engagement*.

Kendall Campbell (USACE Alaska Tribal Liaison) (2021) 'phone interview'.

Lemos, M.C. (2008) 'Whose water is it anyway', in J.M. Whiteley, H.M. Ingram, and R. Perry (eds) *Water, place, and equity*. Cambridge, MA: MIT Press, pp. 249–270.

Lockwood, M. (2010) 'Good governance for terrestrial protected areas: A framework, principles and performance outcomes', *Journal of Environmental Management*, 91(3), pp. 754–766.

NSB (2019) *North Slope Borough Comprehensive Plan 2019-2039*. Prepared by Eskimos, Inc. and UMIAQ Environmental. Available at: https://www.north-slope.org/wp-content/uploads/2022/02/NSB_Comprehensive_Plan_2019-2039.pdf.

OSTP and CEQ (2022) 'Guidance for Federal Departments and Agencies on Indigenous Knowledge'. White House Office of Science and Technology Policy, White House Center on Environmental Quality.

Shenton, A.K. (2004) 'Strategies for ensuring trustworthiness in qualitative research projects', *Education for information*, 22(2), pp. 63–75.

Tengö, M. *et al.* (2014) 'Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach', *Ambio*, 43(5), pp. 579–591.

US GAO (2014) 'CLIMATE CHANGE ADAPTATION: DoD Can Improve Infrastructure Planning and Processes to Better Account for Potential Impacts'. US Government Accountability Office.

USACE Institute for Water Resources (2020) *Strengthening USACE Collaboration with Tribal Nations for Water Resources Management*. 2020-R-06. USACE, p. 105.

Annotated Bibliography

The following is an annotated bibliography of materials addressing landscape change and/or infrastructure in areas near or pertaining to the villages of Kaktovik and Point Lay on the North Slope of Alaska.

Relevant materials were sorted into three categories: 1) General, including items of relevance to both Kaktovik and Point Lay; 2) Kaktovik, for items specifically related to Kaktovik; and 3) Point Lay for items specifically related to Point Lay. This review was limited primarily to materials publicly available in online repositories. For this reason, internal documents and independently commissioned studies are likely underrepresented in the literature collected.

The annotated bibliography was prepared for the U.S. Army Corps of Engineers (USACE), Cold Regions Research and Engineering Lab (CRREL) operating out of Fairbanks, Alaska, by Northern Social-Environmental Research based in Fairbanks, Alaska. It is a product of fact-finding activities for the project *Engaging Local Knowledge to Inform Measures Protecting Alaskan Coastal Communities from Erosion and Permafrost Thaw*.

GENERAL (Titles with relevance to North Slope Alaska)

1. Denali Commission. (2019). *Statewide threat Assessment: Identification of threats from erosion, flooding, and thawing permafrost in remote Alaska communities*.

In 2019, a report was prepared by the UAF Institute of Northern Engineering and US Army Corps of Engineers identifying the individual threat level for 187 Alaska communities against erosion, flooding, and permafrost thaw using publicly available data. This study is a follow-up to the 2003 and 2009 US GAO reports. Each community was grouped into high, medium, or low relative threat rankings, and the combined threat for each community was analyzed and given an overall rank. Rankings are to be used as snapshots in time to help guide the selection of sites for further investigation. Appendix A provides tables of the rankings, with Kaktovik and Point Lay at the highest threat level for permafrost thaw.

Recommendations/research needs: Outside of the scope of the report to provide recommendations for mitigation actions, but recommends further data collection with community involvement.

2. Ferrians Jr., O. J., Kachadoorian, R., & Greene, G. W. (1969). *Permafrost and related engineering problems in Alaska* (Report No. 678; Geological Survey Professional Paper). USGS Publications Warehouse. <https://doi.org/10.3133/pp678>

This report presents a survey of important aspects of permafrost and was written to draw attention to problems likely to result from improper construction practices in a variety of applications (e.g. railroads, roads, buildings, pipelines). The report was produced to facilitate the development of the natural resources of northern Alaska while minimizing disruption of the natural environment.

Recommendations/research needs: Ten key guidelines are suggested to minimize the adverse effects of permafrost and frost action upon structures.

3. Gibbs, A. E., & Richmond, B. M. (2015). *National assessment of shoreline change: Historical shoreline change along the north coast of Alaska, US-Canadian border to Icy Cape*. US Department of the Interior, US Geological Survey Reston, VA, USA.

In 2017, the USGS updated calculations of long- and short-term rates of shoreline change for the north coast of Alaska between the Canadian border and Icy Cape for the National Assessment of Shoreline Change Project. The updated calculations incorporate additional shoreline position data while reducing the uncertainty from previous reports by using refined georeferencing techniques. Table 6 includes updated maximum shoreline change rates for the 10 coastal areas assessed. Erosion was found to be occurring at a long-term average rate of 1.8 meter per year along the Beaufort Sea Coast, and at a considerably lower 0.3 meters per year along the Chukchi Sea Coast, but 84% of coastal areas mapped experience shoreline erosion.

Recommendations/research needs: None provided.

4. Impact Assessment, Inc. (1990). *Northern institutional profile analysis: Chukchi Sea: final technical report*. Alaska OCS Social and Economic Studies Program (U.S.).

In 1990, the NIPA project published a report in the form of an overview of each of the communities of the North Slope using existing published information supplemented by brief fieldwork. This report is limited to the communities along the Chukchi Sea coast, including Point Lay, while a companion report includes the communities along the Beaufort Sea Coast, including Kaktovik. The objectives of the NIPA project are to provide accessible and updatable information on population, economy, sociocultural institutions, and infrastructure for all communities of the North Slope. No direct relation to erosion or permafrost thaw, but intent of report is to have baseline data in case future comparisons are needed for monitoring purposes.

Recommendations/research needs: None provided.

5. Kanevskiy, M., Connor, B., Schnabel, B., Shur, Y., Bjella, K., Trochim, E., Dean, K., & Ellison, A. (2019). *Risk Evaluation for Permafrost-Related Threats: Methods of Risk Estimation and Sources of Information* (INE 2019.10; p. 40). UAF Institute of Northern Engineering.

Evaluation of permafrost-related threats affecting Alaska communities based on available information including scientific publications, maps, satellite imagery and aerial photographs, geotechnical reports, personal communication, community plans and reports, and other sources. Five criteria were included in the evaluation including: permafrost occurrence, permafrost temperature, thaw susceptibility of frozen soils, massive ice occurrence, and existing permafrost-related problems. Threat levels were evaluated for 187 Alaska villages, which received rating scores from 0 to 15 (No risk to High risk). Thirty-four communities received high risk scores.

Recommendations/research needs: Given that permafrost conditions in Alaskan communities are very diverse, detailed studies are required for more precise evaluation of potential permafrost-related threats associated with permafrost degradation and/or thawing of ground ice.

6. Liew, M., Xiao, M., Farquharson, L., Nicolsky, D., Jensen, A., Romanovsky, V., Peirce, J., Alessa, L., McComb, C., Zhang, X., & Jones, B. (2022). *Understanding Effects of Permafrost Degradation and Coastal Erosion on Civil Infrastructure in Arctic Coastal Villages: A Community Survey and Knowledge Co-Production*. *Journal of Marine Science and Engineering*, 10(3), 422.
<https://doi.org/10.3390/jmse10030422>

Community surveys were conducted in Wainwright, Point Lay, Utqiagvik, and Kaktovik to better understand how infrastructure is affected by permafrost degradation and coastal erosion in the Arctic region, and to develop a process to Co-produce knowledge with residents of the area of interest through the integration of indigenous knowledge with science and engineering, as well as to identify high resolution targets for continued study by utilizing the knowledge and experience of the community residents. Each community surveyed was asked to report on a variety of issues related to infrastructure, thought to be caused by permafrost degradation and erosion, as well as to report on locations where coastal erosion, surface water ponding, ground surface collapse, or differential ground settlement can be observed. Using the reported data, heatmaps were created to identify locations most frequently reported, which can be used to further Co-produce knowledge.

Recommendations/research needs: include additional observation and reporting by indigenous residents that is integrated with scientific and engineering research and policy making to prioritize the most urgent issues related to infrastructure performance in the context of climate change. Heatmaps as an effective visualization tool for the selection of monitoring stations.

7. Liljedahl, A. K., Boike, J., Daanen, R. P., Fedorov, A. N., Frost, G. V., Grosse, G., Hinzman, L. D., Iijma, Y., Jorgenson, J. C., Matveyeva, N., Necsoiu, M., Reynolds, M. K., Romanovsky, V. E., Schulla, J., Tape, K. D., Walker, D. A., Wilson, C. J., Yabuki, H., & Zona, D. (2016). *Pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology*. *Nature Geoscience*, 9(4), 312–318. <https://doi.org/10.1038/ngeo2674>

A study was conducted in 2016 on ice wedge degradation within Arctic permafrost and the effects it could have on tundra hydrology using remote sensing observations of 10 locations across the entire Arctic, supplemented by on-site observations at key locations, including sites in Arctic Alaska. Ice wedges, which make up approximately 20% of the uppermost permafrost volume, have a characteristic polygonal shape. During the initial melt, following a period of vegetation changes in the soil above the ice wedges, the center of the polygon drains to form a trough, and with continued ice wedge degradation, troughs become interconnected, leading to an overall draining of the landscape. The formation of troughs is predicted to cause changes to snow distribution which can then lead to reduced inundation and increased runoff. These changes are being observed at a sub-decadal time-scale.

Recommendations/research needs: None provided.

8. Overbeck, J. R., Buzard, R. M., Turner, M. M., Miller, K. Y., & Glenn, R. J. (2020). *Shoreline Change at Alaska Coastal Communities*. State of Alaska, Department of Natural Resources, Division of Geological and Geophysical Surveys

In 2020, a report was published, following up on prior reports by the US GAO in 2003 and 2009, providing consistent and quantitative data on shoreline change in Alaska's coastal communities to be

used to further assess each community's erosion risk. 48 coastal Alaska communities were studied using historical data, with findings indicating that 57% of communities experience erosion at a rate greater than 1 meter per year, and some communities with slow rates of erosion may still face high risk due to proximity to erosion mitigation structures that could eventually fail.

Recommendations/research needs: A follow-up phase to the study will be to map out the vulnerability of infrastructure based on its location relative to nearby erosion.

9. Pewe, T. L. (1975). *Quaternary geology of Alaska* (Report No. 835; Professional Paper). USGS Publications Warehouse. <https://doi.org/10.3133/pp835>

This report summarizes results of studies in many areas of Quaternary geology. The report is intended to contribute to a better understanding of the Pleistocene and Holocene Epochs in Alaska and will also be a useful resume of the progress of investigations in Quaternary geology in this important section of North America. The report covers many topics in the field of geology. The section on permafrost and periglacial deposits begins on page 43. This report only includes studies published before 1972.

Recommendations/research needs: As of 1972, there was little extensive work investigating the extent and origin of offshore permafrost in Northern Alaska. The study of offshore marine permafrost in North America was considered a "pressing problem". Also, at the time there was almost a complete lack of information about permafrost thickness in the mountainous areas.

10. Romanovsky, V. E., Smith, S. L., Isaksen, K., Shiklomanov, N. I., Streletskiy, D. A., Kholodov, A. L., Christiansen, H. H., Drozdov, D. S., Malkova, V., & Marchenko, S. S. (2017). Terrestrial Permafrost: In Arctic Report Card Update for 2017. NOAA Arctic Program. <https://arctic.noaa.gov/Report-Card/Report-Card-2017/ArtMID/7798/ArticleID/694/Terrestrial-Permafrost>

Changes in mean annual thermafrost temperatures and active layer thickness are summarized for a number of sites throughout the Arctic (including Kaktovik [2019]) at http://gtnpdatabase.org/boreholes and http://gtnpdatabase.org/boreholes. In general, the increase in permafrost temperatures observed since the 1980s is more substantial in the higher latitudes where the largest increase in surface air temperature is also observed. The average active-layer thickness in 2016 for 20 North Slope sites was .52 meters, which is 4cm greater than the 1996-2016 average.

Recommendations/research needs: None provided.

11. Stark, N., Eidam, E., Franke, K., Rosado, A., Markert, K., & Hall, J. (2021). Summary of Results of Arctic Riverine and Coastal Interaction with Community Infrastructure (AR(CI)2) First Workshop.

Synthesis report from a project workshop intended to engage communities and stakeholders in developing research hypotheses and questions that will lead to an improved understanding of the relationship between coastal and riverine processes, and the Arctic built environment.

Recommendations/research needs: While our understanding of the coastal effects of climate change in the Alaskan Arctic is greatly increasing, we know very little about the riverine effects of climate change. Data gaps are a key limitation to modeling of Arctic systems. In some regions there is a need for more topographic data, bathymetric data, and time series of water level and wave energy. There is also a lack of historical data about storms. Additionally, scientists have historically worked independent from the local communities that are directly being affected by climate change effects, and generational and institutional knowledge of the locals is not being considered or incorporated to the extent that it could.

12. US GAO. (2003). Alaska Native Villages: Most are affected by flooding and erosion, but few qualify for federal assistance. US Government Accountability Office.

In December 2003, the Government Accountability Office published a report on Federal Assistance programs and their responses to flooding, which occurs in 184 out of 213 Alaska villages. Villages are expected to increase in flood susceptibility as temperatures rise and protective sea ice diminishes. The U.S. Army Corps of Engineer's Continuing Authorities Program, and the Dept of Agriculture's Natural Resources Conservation Service, are the principal programs tasked with providing assistance for prevention and control of flooding and erosion. The report finds that most Alaska Native villages needing assistance do not meet a requirement of the assistance programs that the costs of the project not exceed the benefits. Furthermore, Alaska Native villages needing assistance that do meet that requirement, often are unable to meet the cost-sharing requirements.

Recommendations/research needs: The report recommends special measures be taken to ensure that Alaska Native villages receive the assistance that they need, including the following: expand the responsibilities of the Denali Commission to include flood and erosion assistance, allow the use of social and environmental factors in the cost/benefit analysis, and waive the cost-sharing requirement for Alaska Native villages. A fourth possible recommendation is to bundle all funding from various sources for flood and erosion assistance.

13. US GAO. (2009). Alaska Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion. US Government Accountability Office (GAO), Report to Congressional

In June 2009, the Government Accountability Office published a report on Federal Assistance programs, following up on a 2003 GAO report entitled "Alaska Native Villages: Most are affected by flooding and erosion, but few qualify for federal assistance". Since 2003, 31 villages have been identified as being in imminent threat from flooding and erosion. A 2009 study by the US Army Corps of Engineers identified erosion risks but did not evaluate flooding impacts; the report recommends that evaluation be conducted. The report found that most Alaska Native villages needing flood and erosion assistance do not meet FEMA requirements because they lack disaster mitigation plans or have not been declared federal disaster areas. They also found that Alaska Native villages often do not qualify for Dept of Housing and Urban Development's Community Development Block Grant program because unincorporated villages located in Alaska's unorganized borough are not recognized; the report recommends that the 1974 Housing and Community Development Act be amended to correct that oversight. The report identified 12 Alaska Native villages in the process of relocating, and found that, due to the lack of a lead entity to help guide, coordinate, and prioritize

relocation assistance, efforts by Alaska Native villages at relocation are impeded, raising uncertainty around meeting assistance program requirements.

Recommendations/research needs: The report highlights a need for an evaluation of potential flooding impacts for imminently threatened villages. The report also recommends that the federal government assign a lead entity for relocation assistance, as the State of Alaska had done in 2008.

14. US GAO. (2014). CLIMATE CHANGE ADAPTATION: DoD Can Improve Infrastructure Planning and Processes to Better Account for Potential Impacts. US Government Accountability Office.

In 2012, the Dept of Defense released its Fiscal Year 2012 Climate Change Adaptation Roadmap, which identified several potential climate-change impacts to infrastructure at its sites, including melting permafrost, decreasing sea ice, and rising sea levels, which have caused damage to roads, seawalls and runways. In response, the Dept of Defense has initiated a vulnerability assessment of its stations from the effects of climate change, and has directed its planners to consider climate change data in its installation planning efforts. The Government Accountability Office was tasked with assessing the DOD's actions taken to adapt infrastructure and project planning to climate change phenomena.

Recommendations/research needs: Recommendations include developing a plan and key milestones to assess progress of Dept of Defense's vulnerability assessment to 704 installations. Also recommended is the clarification of the planning actions that should be taken when accounting for climate change in individual site Master Plans and Integrated Natural Resources Management Plans. The final recommendation is clarification on the process for approving installation projects, allowing climate change adaptation to be more strongly considered as a project component.

15. Walker, H. J. (1994). Environmental impact of river dredging in Arctic Alaska (1981-89). *Arctic*, 176–183.

In 1981, the North Slope Borough launched a dredging program and follow-up monitoring to investigate the impact of using dredges to provide communities on the Arctic Coastal Plain with sand and gravel needed for infrastructure while minimizing disturbance of tundra and ice wedges during transport between gravel source and construction site. In the 1970s, restrictions were placed on surficial mining due to the impact it can have to permafrost and ice wedges when the active layer is disturbed during mining operations and transport. Dredging gravel from the thalweg channel of rivers or lakes adjacent to the communities was found to be a feasible solution and dredging commenced in 1981 in Nuiqsut, followed by the Kaktovik Lagoon in 1983 and the Kokolik River near Point Lay in 1984. Monitoring continued until 1989. The program was considered a success as impact to tundra was minimal, and the excavated channels slowly filled back up while providing extra habitat for fish. The dredging could potentially be used in the future to combat coastal beach erosion due to beach mining.

Recommendations/research needs: None provided.

16. Williams, J. R. (1970). Ground water in the permafrost regions of Alaska (Report No. 696; Geological Survey Professional Paper). USGS Publications Warehouse.
<https://doi.org/10.3133/pp696>

The reported study was undertaken to provide information for more economical and effective methods of appraising and developing the ground water resources of Alaska. The report emphasizes the occurrence of ground water in relation to permafrost and the geologic environment. The material is presented in sections on each of the major geologic environments in the permafrost region.

Recommendations/research needs: Information on subsurface geology, permafrost, and ground water in Alaska is sparse.

17. Yoshikawa, K. (2013). Permafrost in Our Time. Community-Based Permafrost Temperature Archive (p. 300).

The Permafrost/Active Layer Monitoring Program builds on work began in 2005 to keep track of ground temperature and the active layer depth. This baseline information is important because changes in permafrost conditions affect local ecosystems and can influence the severity of natural disasters. Monitoring sites were set up near communities throughout Alaska and in other countries where there is permafrost. Students and teachers in local schools participate in the research by reading measurements at the monitoring sites and recording data. As of 2013, over 200 schools in Alaska communities were involved.

Recommendations/research needs: Continued monitoring to track changes in permafrost conditions.

KAKTOVIK (Titles with relevance to Kaktovik, Alaska)

18. Arctic Strategic Transportation and Resources. (2021). *Kaktovik Project Fact Sheet*. AK Department of Natural Resources.

The Department of Natural Resources, in partnership with the North Slope Borough, is working with communities and regional stakeholders to identify which projects and project areas offer the greatest benefit to the region by prioritizing community and cultural connectivity, regional support, reduced cost of living, increased safety, and responsible infrastructure development. A database of project opportunities has been developed that includes three project categories: Community, Regional and Resource Development projects. A list of 29 projects proposed by various sources for the community of Kaktovik. A brief description of the project including a map, as well as the projected benefit for the community is included on each fact sheet. Project 1 describes the need to relocate the airstrip off the gravel spit due to periodic inundation from the sea.

19. Buzard, R. M., Miller, M. M., Antrobus, K. Y., & DC Overbeck, J. R. (2021). *Erosion exposure assessment of infrastructure in Alaska coastal communities—Kaktovik*. Alaska Division of Geological & Geophysical Surveys.

In 2021, the State of Alaska Division of Geological & Geophysical Surveys published an erosion exposure assessment for 48 communities along the Bering and Chukchi Sea coasts, including for Kaktovik. A summary of Kaktovik's erosion exposure over the course of the next 60 years forecasts that coastal erosion will undercut the northern road and will also impact a sewer outfall and 53 ft of water pipes. The associated costs of replacement by 2079 will be \$1.2 million. The summary describes the loss of shoreline by a rate of 1 to 27.9 feet per year on the northern shore, and 1 to 3.3 ft per year on the eastern shore, but describes the shoreline on Pipsuk Bight as having an erosion protection structure constructed by US Army Corps of Engineers.

Recommendations/research needs: None provided.

20. Gibbs, A. E., Erikson, L. H., Jones, B. M., Richmond, B. M., & Engelstad, A. C. (2021). *Seven Decades of Coastal Change at Barter Island, Alaska: Exploring the Importance of Waves and Temperature on Erosion of Coastal Permafrost Bluffs*. *Remote Sensing*, 13(21), 4420.

A study was conducted in 2021 on the rates and possible drivers of retreat of the shoreline and coastal bluffs of Barter Island and Bernard Spit by analyzing maps, aerial photographs and satellite imagery dating from 1947 to 2020. Cumulative wave power, ocean surface temperatures, and ambient air temperatures were analyzed to evaluate the primary drivers of bluff retreat. The analysis found that Barter Island and Bernard Spit have been steadily retreating southward and extending westward, with rates correlated to wave power, measured using a SWAN wave model, and to ocean surface temperature and ambient air temperature, with measurements taken at 17 time periods at 5 sites. Over the time span of 1950 to 2020, the average retreat rate was found to be 1.6 meters per year but the analysis showed 3 distinct phases. Between 1950 and 1975, the rate of retreat was 1.1 meters per year, increasing slightly to 1.4 meters per year between 1975 and 2000, before jumping to 2.7 meters per year from 2000 to 2020, which correlates to a positive phase of cumulative wave power associated with a longer duration of open water in the Beaufort Sea.

Recommendations/research needs: Recommendation for continued monitoring and a more comprehensive evaluation of the drivers of coastal change.

21. Harcharek, Q., George, J. C., Pederson, M., & Sims Kayotuk, C. (n.d.). *Qaaktuḡvik/Kaktovik Subsistence Harvest Report 2007-2012* [Technical Report]. Dept of Wildlife Management, North Slope Borough.

In 2018, the Dept of Wildlife Management of the North Slope Borough published a subsistence harvest report for the community of Kaktovik which included a complete inventory of all fish and game caught by those households surveyed during the period of 2007 to 2012. One objective of the report is to contribute to a better understanding of trends that show increases or decreases in wildlife and fish populations. The report is not directly relevant to thermal erosion or permafrost thaw, and does not ask the respondents to report on climate change impacts.

Recommendations/research needs: None provided.

22. Kanevskiy, M. Z., Stephani, E., Shur, Y. L., Jorgenson, M. T., Ping, C.-L., Fortier, D., & Dillon, M. (2011). Permafrost of Northern Alaska. The Twenty-First International Offshore and Polar Engineering Conference.

A conference paper submitted to the 2011 International Offshore and Polar Engineering Conference with data collected from field sites over a 20-year research span including data on the saturated active layer atop the ground ice and the effects of its disturbance and/or removal through natural and human induced causes. An indicator of disturbance of the active layer, and its potential to induce thawing of the permafrost and triggering of thermal erosion, is the thickening of the saturated active layer which averages 0.5 meters thick under normal circumstances. The paper describes the conditions of the 4 main permafrost regions in northern Alaska: the Arctic Coastal Plain east of Utqiagvik which includes Prudhoe Bay and the village of Kaktovik, the “Silt Belt”, the Arctic Foothills, and the Brooks Range.

Recommendations/research needs: The paper makes a series of infrastructure engineering recommendations to mitigate permafrost related hazards, which include avoiding areas with natural hazards already present, keeping ventilated space beneath structures built on piles, use of coarse material and culverts on all embankments to allow surface drainage, avoiding any disturbance of the surrounding tundra surface, and a call to closely consider all impacts to the permafrost.

23. Mikow, E. (2010). Third time and counting: Remembering past relocations and discussing the future in Kaktovik, Alaska. *Alaska Journal of Anthropology*, 8(2), 33–42.

In 2010, an anthropological study was conducted about the history of three relocations by the community of Kaktovik between 1947 and 1964, at the direction of the US Government, from a social and historical context. Barter Island, the study states, was uninhabited year-round until the 1920's, when a fur-trading post was moved to the island for better hunting opportunities and access to a harbor. By 1947, with a handful of residents still remaining on the island following the 1936 fur-trade collapse, the US Air Force decided to build a 5000 ft runway on the eastern spit of Barter Island at the very location where the residents lived, in order to have military installations closer to potential

Soviet attack routes, when previously most stations had been located in the Aleutians. The village, along with some personal possessions and ice cellars, was razed in the process, with the inhabitants forced to rebuild without assistance, using US Air Force castaway lumber and materiel, about a mile from the original site. A second move in 1953 to accommodate a DEW-Line installation was smaller in scale and less memorable, as the relocation consisted of moving a few structures further from the beach. The final move occurred in 1964, again at the direction of the US Air Force to accommodate further expansion of the military installations. This time, following complex negotiations, the community of Kaktovik was able to choose the location of their village site, and the US Air Force granted the rights to the plot of land the village sat on, despite the continued presence of military into the 1970's. With a 4th relocation potentially becoming necessary again due to environmental factors, the community of Kaktovik may once again have to negotiate with the US Government about where they live.

Recommendations/research needs: None provided.

24. North Slope Borough. (2021). Kaktovik Comprehensive Plan, 2021-2041.

In 2021, the North Slope Borough Assembly adopted a comprehensive plan to help guide the community of Kaktovik over the next 20 years. It includes a detailed cataloging of many aspects of life in Kaktovik including its history and census information. It includes goals for the period of 2021-2041, including Goal 3.1.1, 3.1.4, 4.4.2, which deal with the identification of utilities, facilities and infrastructure that are vulnerable to damage caused by climate related impacts. Appendix B lists climate-related changes that are occurring now or are predicted to occur, how they may impact Kaktovik, and provides adaptation strategies for some scenarios, some of which make recommendations for further study of permafrost conditions in the area.

Recommendations/research needs. Appendix B highlights a number of recommended adaptation measures and research needs including; 1) flyovers of traditional sea ice routes with specialized equipment to measure the depth of ice and then informing the village of the safest routes to take for expeditions; 2) creation of a village adaptation plan specific to Kaktovik; 3) man-made water reservoir with an impenetrable lining and cover to store fresh water; 4) alternative, locally produced material to replace gravel; 5) study of the impacts of methane on food sources for tundra-dependent animals; and 6) continued monitoring of subsistence foods for health benefits and also for potential toxins.

25. Osterkamp, T. E., & Jorgenson, J. C. (2006). Warming of permafrost in the Arctic National Wildlife Refuge, Alaska. *Permafrost and Periglacial Processes*, 17(1), 65–69.

Reports borehole temperature measurements made in permafrost over a period of two decades (1985, 1998, and 2004) at sites on Barter Island and in the Arctic National Wildlife Refuge (ANWR). Ground surface temperatures were also measured using miniature automatic temperature loggers from 2002 to 2004. Measurements indicate that the century-long warming documented for the central and western Arctic has also occurred in the region near Barter Island and in northern ANWR. At Kaktovik, the warming occurred during the 2nd quartile of the 20th century or earlier and its magnitude exceeded 0.8 °C. A more recent warming (since the mid to late 1980s) similar to that in the central and western Arctic is also occurring on Barter Island and in northern ANWR. Near Kaktovik, the permafrost warmed about 2 to 3 °C from 1985 to 2004. In northern ANWR, on a line extending

southward from Tapkaurak Point, it warmed about 1 ½ to 2 °C from 1985 to 1998. If air temperatures warm 5 °C over the next century, as predicted, some of the permafrost in northern ANWR would be expected to thaw.

Recommendations/research needs: None provided.

26. Pedrazas, M. N., Cardenas, M. B., Demir, C., Watson, J. A., Connolly, C. T., & McClelland, J. W. (2020). Absence of ice-bonded permafrost beneath an Arctic lagoon revealed by electrical geophysics. *Science Advances*, 6(43), eabb5083.

In 2014, a geophysical study was conducted at the Kaktovik Lagoon, with follow-up data-collection in 2019, measuring the underwater soil/sediment composition using electrical resistivity imaging (ERI) to investigate the interface between terrestrial permafrost and relict permafrost, an ancient terrestrial permafrost, submerged by the melting of the last ice age, and found throughout the Arctic Coastal Shelf. The study found that the edge of the terrestrial permafrost on the coast of Barter Island, exposed by coastal erosion, formed an abrupt drop-off down 22 meters to the ice-bonded floor of a large talik, contradicting the broadly-held idea of a gradual slope. The study hypothesizes that the cause for the lack of relict permafrost beneath Kaktovik Lagoon could be the persistent remnants of a talik associated with a thermokarst lake, but is more likely an existing on-land cryopeg, being overtaken by the landward shift of the lagoon due to the processes of coastal erosion. Lower-likelihood hypotheses were also listed but not discussed further. The results cannot definitely show the reason for the extensive talik and lack of relict permafrost.

Recommendations/research needs: Recommends further investigation into the impacts of the liberation of organic matter previously trapped in ice-bonded sediment under the lagoon and the potential impacts of the mixture of the saline groundwater of the cryopeg with surrounding freshwater.

27. Peterson, R. A., & Wendler, K. (2011). Preservation of traditional ice cellars in permafrost.

A study was conducted in from 2009 to 2011 on possible solutions for the preservation of traditional permafrost ice cellars, used for the storage of food, due to degradation, including from saline water intrusion. A finite element numerical model was developed using Comsol Multiphysics software, the results of which were then compared to data collected from the Rexford family ice cellar in Kaktovik from 2009 to 2010. Three possible solutions were tested: passive air convection, surface insulation in the form of extruded polystyrene insulation, and thermosyphons, both buried in the ground and air-ground surface installed. Air convection was not found to have a significant effect on ice cellar temperatures. Insulation installed directly above the permafrost layer was found to shield the ice cellar from surface conditions, keeping the cellar warmer in the summer and cooler in the winter. Below-ground thermosyphons were found to lower temperatures by 0.5 degrees Celsius if installed 3.0 meters apart, and 1.1 degrees Celsius if the thermosyphon is installed 0.75 meters apart. Above-ground thermosyphons lowered temperatures by 1.3 to 3.3 degrees Celsius, at the 3.0-to-0.75-meter installation ranges. The study found that the combination of surface insulation that extends 1 meter beyond the ice cellar perimeter, along with above-ground thermosyphons installed 0.75 meters apart, maintained a temperature range of -9.5 degree Celsius in the summer to -22 degrees Celsius in the

winter, an average of –10 degrees Celsius cooler than the unmodified Rexford ice cellar, but still not cool enough to meet the USDA recommended safe food storage temperature of –17.7 degrees Celsius year-round.

Recommendations/research needs: Recommendations for existing ice cellars include the installation of above-ground thermosyphons, but NOT the installation of insulation due to the required disturbance of the ground. For the construction of new ice cellars, all findings can be utilized to construct an ice cellar with insulation and thermosyphons installed to aid cooling of both the ice cellar and the surrounding permafrost.

28. US Air Force, JBER, Alaska, & HDR. (2011). Final Record of Decision, Landfill LF001, Barter Island Long-Range Radar Site, Alaska (p. 48). US Air Force.

In 2011, a Final Record of Decision was entered into the JBER Administrative Record regarding the remedial actions taken at LF001, the former landfill site on the Barter Island Long-Range Radar Site, Alaska, near the community of Kaktovik. Use of the landfill was discontinued in 1978, but due to coastal erosion, the northern edge of the landfill area became exposed. This prompted the US Air Force to conduct a complete excavation of the site, relocating material to a recently constructed, ADAC Class 3 compliant landfill, with all hazardous waste shipped off-site. The report includes an inventory and summaries of prior LF001 reports dating back to 1992, as well as a summary of contaminants found.

Recommendations/research needs: Recommends site closure and potentially the return of the land for recreational use.

POINT LAY (Titles with relevance to Point Lay, Alaska)

29. Arctic Strategic Transportation and Resources. (2021). Point Lay Project Fact Sheet. AK Department of Natural Resources.

The Department of Natural Resources, in partnership with the North Slope Borough, is working with communities and regional stakeholders to identify which projects and project areas offer the greatest benefit to the region by prioritizing community and cultural connectivity, regional support, reduced cost of living, increased safety, and responsible infrastructure development. A database of project opportunities has been developed that includes three project categories: Community, Regional and Resource Development projects. A list of 39 projects proposed by the Point Lay Comprehensive Plan, 2017-2037, adopted by the North Slope Borough Assembly. A brief description of the project including a map, as well as the projected benefit for the community is included on each fact sheet. Project 17 and 20 address permafrost related damage mitigation.

30. Beauparlant, A. M. (2014). Climate change and its impact on the Iñupiat of Point Lay, Alaska: A case study of resilience [Master's Thesis]. University of Alaska Anchorage.

A 2014 anthropological Master's thesis based on field work conducted in Point Lay. The purpose of the study was to investigate community resilience in the context of climate change, defined as the capacity for the community members of Point Lay to continue a subsistence lifestyle in the face of forced adaptations to changes to weather and landscape. The study conducted a survey, where respondents were asked to identify changes to the environment that have an impact on subsistence activities, the results of which included descriptions of changing sea ice conditions and unpredictable weather patterns. The study also identified several key factors supporting resilience, including the resumption of bowhead whaling, with its associated cultural institutions, including the return of the position of Umialiq as a source of "cultural capital" and as an aspirational goal for youth. However, the study questions the likelihood of the members of Point Lay to be able to successfully continue resilient adaptations in the future, as the issue of climate change has reached a magnitude where outside political and economic forces, beyond the control of Point Lay residents, may dictate whether they can achieve a sustained subsistence way of life.

31. Bjella, K. (2015). Point Lay Geophysical Exploration (p. 29). Cold Regions Research and Engineering Laboratory (CRREL), Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers (USACE).

In April of 2015, a geophysical investigation was conducted at the Village of Pt. Lay, Alaska, to obtain broad scale permafrost ice content information via the use of earth resistivity methods, and subsurface feature and distortion information via the use of ground penetrating radar. This information is designed to aid the understanding of the particular cause of thaw settlement of permafrost sediments, which is causing severe distress to a buried central water and sewer project. Two types of permafrost soils exist at Point Lay. An ice- and organic-rich upper strata and an ice-poor lower strata. The sections of pipeline installed in the upper strata have seen the most stress most likely attributable to thawing of wedge ice located in this layer. The sections installed in the lower section have suffered little stress due to differential thaw-settlement.

Recommendations/research needs: It is unknown if ice wedge features that exist in the upper strata extend into the relatively ice-poor lower strata. Suggests a detailed thermal analysis be conducted to understand what thermal parameter was exceeded during design, construction, or operation to cause the thawing of permafrost. This analysis may reveal possible remedies to avoid abandonment and replacement of the system.

32. Buzard, R. M., Miller, M. M., Antrobus, K. Y., & DC Overbeck, J. R. (2021). Erosion exposure assessment of infrastructure in Alaska coastal communities—Point Lay. Alaska Division of Geological & Geophysical Surveys.

In 2021, the State of Alaska Division of Geological & Geophysical Surveys published an erosion exposure assessment for 48 communities along the Bering and Chukchi Sea coasts, including for Point Lay. A summary of Point Lay's erosion exposure over the course of the next 60 years forecasts minimal infrastructure impacts, with the only associated costs being the replacement of a single sewer line by 2059, for a total predicted cost of \$67,000, but mentions the 2016 erosion and drainage of Point Lay's water source. The summary describes the loss of shoreline by a rate of 3 to 6 feet per year south of the airport, but describes the shoreline as stable nearest the bulk of Point Lay's infrastructure.

Recommendations/research needs: None provided.

33. Duane Miller & Associates (DMA). 1993. Soil Investigation, 1,600,000 Gallon Water Tank. North Slope Borough Contract No. 93-301. Point Lay, Alaska: DMA.

Referenced in (Bjella, 2015).

34. Duane Miller & Associates (DMA). (1995). Geotechnical Exploration, Water and Sewer Improvements. Point Lay, Alaska: DMA.

Referenced in (Bjella, 2015).

35. Galginaitis, M., Downs, M. A., & VanStone, J. W. (1989). *Point Lay Case Study: Social and Economic Studies* (Technical Report No. 139; p. 600). Minerals Management Service.

In 1989, the Dept of the Interior's Minerals Management Services published a technical report in the form of a broad-based ethnographical case study of the village of Point Lay, with data gathered during periodic field research conducted between Sept 1987 and May 1989. The purpose of the case study was to gather detailed baseline sociocultural-dynamics information from Point Lay. Additionally, the study was intended as a framework for similar studies in other Arctic Slope communities, motivated in part by oil-related development as a primary driver of sociocultural change in the era (1970s to 1989). Point Lay was chosen due to its relatively small population which allows for a total sample of the community, along with the likelihood of nearby oil exploration post-1989. A goal of the ethnography is to provide baseline data in order to measure the impacts of oil-related development as it relates to the dynamics of change in North Slope communities.

Recommendations/research needs: None provided.

36. ICF Technology Incorporated. (1996a). United States Air Force 611th Air Support Group Civil Engineering Squadron, Elmendorf AFB, Alaska. Final Risk Assessment Point Lay Radar Installation, Alaska (p. 313).

In conjunction with the 1996 Remedial Investigation and Feasibility Study prepared by ICF Technology Inc for the US Air Force, this risk assessment was intended as an aid to the implementation of future final actions under the Air Force Installation Restoration Program with regard to the Point Lay Radar Installation. The risk assessment sought to identify any chemical contaminants in the area of concern that could pose health risks to humans. The study concludes that no significant amounts of contaminants that could pose health risks to humans were found in the soil/sediment and recommends no further action. The study found that there were elevated levels of manganese found on surface water at multiple sites that was at the upper limit of the range of safe toxicity levels developed by the EPA; any higher levels would trigger further investigation or remedial action. However, due to the stated reasoning that the risk was contained, and future settlement over the contamination was unlikely, no further action was recommended. The study also found that no significant risk was posed to other species associated with the installation, with the note that chemical contaminants were considered individually, and there was a level of uncertainty in the assessment of the risks associated with exposure to mixtures of chemical contaminants which occurred together on site.

Recommendations/research needs: Recommended no further action.

37. ICF Technology Incorporated. (1996b). United States Air Force 611th Air Support Group Civil Engineering Squadron, Elmendorf AFB, Alaska. Remedial Investigation and Feasibility Study Point Lay Radar Installation, Alaska. Defense Technical Information Center.
http://archive.org/details/DTIC_ADA312129

In conjunction with the 1996 Final Risk Assessment prepared by ICF Technology Inc for the US Air Force, study sought to identify contaminants on sites located at the Point Lay Radar Installation, and to investigate the risks posed to human health and the ecology and to make recommendation on remediation. No significant risks were found to human health, and all ecological risks were determined to be minimal, however all 4 sites investigated were determined to warrant remedial action to address migration of contaminants from on-site to further downgradient.

Recommendations/research needs: Recommended remedial actions included – offsite incineration to reduce unsafe levels of volatile organic compounds and diesel and gasoline hydrocarbons for the deactivated landfill, enhanced bioremediation to remove petroleum compounds from the gravel around the Garage, monitoring of solvent levels flowing along the drainage pathway of the POL tanks, and enhanced bioremediation to reduce petroleum compounds from the Crushed Drum Area.

38. Jones, B., Peirce, J., Connor, B., Kanevskiy, M., Shur, Y., Curry, T., Bolz, P., & Tracey, B. (2022, September 27). *Point Lay Permafrost*. ARCUS Witness Community Highlights; Arctic Research Consortium of the U.S. <https://www.arcus.org/witness-the-arctic/2022/9/highlight/2>

In June 2022 a team of physical scientists, social scientists, and engineers traveled to Point Lay to observe, study, and discuss the effects of thawing permafrost on homes and critical infrastructure in the village. Based on our field measurements of excess ground-ice content, the thaw subsidence potential of the ice-rich permafrost is estimated to be nearly 40 percent of its volume in the upper several meters. Melting of ice wedges caused more than two meters of differential subsidence in and around infrastructure. Elevated areas and adjacent slopes underlain by Yedomas (ice-rich silt penetrated by large ice wedges) have wedge-ice content that probably exceeds 50 percent by volume, and the vertical extent of ice wedges at the higher elevations may reach ten to twelve meters. Most ice wedges within all terrain units were encountered at depths 0.4–0.8 m below the surface, which makes them vulnerable to thermokarst and thermal erosion. Initial estimates indicate that thermokarst troughs and ponds underlie at least 25 percent of the building footprint of more than half the homes in the village. By comparing the built-up areas to the undisturbed areas north of the village located within the same terrain units, it is clear that the cumulative impact of infrastructure and climate change on thawing is considerably greater than the impact of a changing climate alone.

Recommendations/research needs: (1) engineering solutions to permafrost-related problems exist, but they must be applied soon; (2) filling troughs and depressions with fine-grain soil can help protect ice wedges against further degradation and thermokarst; (3) when building new construction, remove the upper portion of the ice wedges and replace it with thaw-stable soils; (4) piling embedment should be at least six meters, but deeper when founded in ice wedges; (5) when possible, place pilings in mounds between ice wedges; (6) ensure adequate drainage to minimize ponding; and (7) implement an active maintenance program that includes snow removal from areas at greatest risk from ponding and thermokarst.

39. Native Village of Point Lay. (2017). *Point Lay Comprehensive Plan, 2017-2037*. North Slope Borough.

In 2017, the North Slope Borough Assembly adopted a comprehensive plan to help guide the community of Point Lay over the next 20 years. It includes a detailed cataloging of many aspects of life in Point Lay including its history and census information. It includes goals for the period of 2017-2037, including goals 4.1 c and g, which deal with the identification of utilities, facilities and infrastructure that are vulnerable to damage caused by climate related impacts. Appendix B lists climate-related changes that are occurring now or are predicted to occur, how they may impact Point Lay, and provides adaptation strategies for some scenarios, some of which make recommendations for further study of permafrost conditions in the area.

40. Nitze, I., Cooley, S. W., Duguay, C. R., Jones, B. M., & Grosse, G. (2020). The catastrophic thermokarst lake drainage events of 2018 in northwestern Alaska: Fast-forward into the future. *The Cryosphere*, 14(12), 4279–4297. <https://doi.org/10.5194/tc-14-4279-2020>

A study on thermokarst lake drainage was conducted in the northern Seward and Baldwin peninsulas following the winter of 2017/2018, using Sentinel-1 SAR and Planet Cube-Sat optical remote sensing data to analyze 192 identified lake drainage events that occurred during Spring breakup 2018, a drainage rate 10 times the 1999 to 2014 average and twice that of previous drainage event extremes in 2005 and 2006. Using weather data, climate model outputs and lake ice growth

simulations to analyze lake drainage drivers and future pathways, the study theorized that abundant rain and snowfall driven by reduced winter sea ice, and the subsequent melt from breakup, along with a mean annual air temperature close to 0 Celsius, caused adjacent permafrost destabilization and sudden lateral breaches at formerly stable lake shores. The study hypothesizes that, if mean annual air temperatures persist at or near 0 Celsius and the loss of sea ice continues, permafrost destabilization and lake drainage will further intensify, driving a reshaping of the landscape, a transition from continuous to discontinuous permafrost and significant changes in hydrology and ecology.

Recommendations/research needs: None provided.

41. Taylor, J., Poleacovschi, C., & Perez, M. (2019). Alaska Native Responses to Climate Change: The Role of Community Values in Housing Adaptation. Engineering Project Organization Conference.

In 2019, a project design was presented at the Engineering Project Organization Conference that seeks to close the gap of knowledge on how cultural and community values can impact the success of adaptation strategies as research is mainly devoted to physical and technical adaptive measures. The project plans to utilize a community based participatory research method to conduct interviews and focus groups to gather data, including in Point Lay, on values-based adaptation strategies to housing issues caused by climate change.

42. Wolken, G. J., Liljedahl, A. K., Brubaker, M., Coe, J. A., Fiske, G., Christiansen, H. H., Jacquemart, M., Jones, B. M., Kääb, A., & Løvholt, F. (2021). Glacier and Permafrost Hazards. Arctic Report Card.

In 2021, the NOAA published a technical report on Glacier and Permafrost hazards, defined as a natural physical process that may adversely impact human or ecological systems. They list a series of hazards caused by glacial retreat and permafrost thaw that include threats to human health and life, as well as highlighting historical examples including the catastrophic draining of the village of Point Lay's drinking water reservoir in 2016 caused by thermal erosion.

Recommendations/research needs: Recommendations include more extensive baseline data (e.g., ground ice content), via remote sensing, field observations, and community science, to identify hazards and evaluate potential landscape change for adaptation and mitigation planning. Additionally, the report recommends utilization of existing permafrost and glacier monitoring networks to assist in identifying areas of concern, while also guiding the formation of new monitoring networks; long-term observation of mountain permafrost in the Arctic and refined understanding of how permafrost degradation and glacier retreat processes impact slope stability. Calls for a Co-production approach to find effective adaptation and preparedness options to enhance resilience.

Environmentally Threatened Communities Data and Risk Assessment Status

Kaktovik

AK DNR. (02/21). ETC Data and Risk Assessment Status—Dashboard. AK DNR, Alaska Division of Geological and Geophysical Surveys.
[Data Portal](#)

Baseline Data

Historical Aerial Imagery:	Complete
Time Period:	1947, 2003,
Date Completed:	2018
Source:	USGS
Link:	

Modern Imagery:	Complete
Date:	2019, 2021
Note:	fixed-wing
Source:	NOAA, USACE
Link:	Ortho

Topography:	Complete
Date:	2018, 2021
Note:	lidar, topobathy lidar
Source:	USGS, USACE
Link:	View

Bathymetry:	Complete
Date:	2021
Source:	USACE
Note:	topobathy lidar
Link:	

First Floor Elevation Survey:	Not recommended
Date:	
Source:	

Statewide Threat Assessment

Flood Group	3
Erosion Group	2
Permafrost Group	1
Combined Group	1

Monitoring

Coastal Elevation Profile Status	Recommended
Date:	
Source:	

Community Based Erosion or Flood Monitoring	Recommended
Date	
Source	

Water Level Data

[Alaska water-level watch](#)

NOAA Real-Time Water Level ID	None
Alternative Water Status	Recommended
Date	
Source	

NOAA Tidal Datum ID	9499176
Date	2008
Duration	1 month
Datum Tie PID	BBBG90
Status	Not
Source	
Link	View

Risk Assessment

Historical Shoreline Change Rate:	Complete
Date:	2020
Source:	Denali
Link:	Shoreline Chng

Historical Flood Assessment:	Funded
Date:	2023
Source:	State of Alaska
Link:	

Baseline Erosion Forecast:	Complete
Date:	2021
Source:	State of Alaska
Link:	View

Hydrodynamic Flood Model:	In progress
Date:	2024
Source:	USGS
Link:	

Sediment Transport Model:	Not recommended
Date:	
Source:	

Permafrost Assessment:	Recommended
Date:	
Source:	

Engineering Assessment

Engineering Analysis:	Recommended
Date:	
Source:	

Engineering Report:	Recommended
Date:	
Source:	

Environmentally Threatened Communities Data and Risk Assessment Status

Point Lay

AK DNR. (02/21). ETC Data and Risk Assessment Status—Dashboard. AK DNR, Alaska Division of Geological and Geophysical Surveys.
[Data Portal](#)

Baseline Data

Historical Aerial Imagery:	Complete
Time Period:	1949, 1982, 2011
Date Completed:	2018
Source:	USGS
Link:	

Modern Imagery:	Complete
Date:	2019, 2021
Note:	fixed-wing
Source:	NOAA
Link:	Ortho

Topography:	Complete
Date:	2019, 2021
Note:	lidar
Source:	USGS, USACE
Link:	View

Bathymetry:	Complete
Date:	2021
Source:	USACE
Note:	topobathy lidar
Link:	

First Floor Elevation Survey:	Not recommended
Date:	
Source:	

Statewide Threat Assessment

Flood Group:	3
Erosion Group:	3
Permafrost Group:	1
Combined Group:	1

Monitoring

Coastal Elevation Profile Status	Recommended
Date:	
Source:	

Community Based Erosion or Flood Monitoring	Recommended
Date	
Source	

Water Level Data

[Alaska water-level watch](#)

NOAA Real-Time Water Level ID	None
Alternative Water Level Activity	
Status	Recommended
Date	
Source	

NOAA Tidal Datum ID	9493291
Date	2021
Duration	1 month
Datum Tie PID	DM5174
Status	Complete
Source	State of Alaska
Link	View

Risk Assessment

Historical Shoreline Change Rate:	Complete
Date:	2020
Source:	Denali
Link:	Shoreline Chng

Historical Flood Assessment:	Funded
Date:	2023
Source:	State of Alaska
Link:	

Baseline Erosion Forecast:	Complete
Date:	2021
Source:	State of Alaska
Link:	View

Hydrodynamic Flood Model:	Not recommended
Date:	
Source:	

Sediment Transport Model:	Not recommended
Date:	
Source:	

Permafrost Assessment:	Recommended
Date:	
Source:	

Engineering Assessment

Engineering Analysis:	Recommended
Date:	
Source:	

Engineering Report:	Recommended
Date:	
Source:	

Attachment C: Logistics

1 Kaktovik

Points of contact:

The first local point of contact to initiate discussions about research should be the Native Village of Kaktovik. The Corporation should also be engaged if research activities will take place on Corporation lands. It is also advised to engage the City government. The Tribal Council meets on the third Tuesday of every month. A trilateral meeting involving the Tribe, the Corporation, and the City is convened at least once a year to address important issues.

Native Village of Kaktovik (Tribal office)	Kaktovik Iñupiat Corporation (KIC)	City of Kaktovik
Tribal administrator: Matthew Rexford Email: nvkaktovik@gmail.com Phone: 907-640-2042 The Tribal Council meets the 3 rd Tuesday of each month at 7pm.	Phone: 907-640-6120 Fax: 907-640-6217 P.O. Box 73 Kaktovik, AK 99747	Email: office@cityofkaktovik.org Phone: 907-640-6313 Fax: 907-640-6314 P.O. Box 27 Kaktovik, AK 99747

Preferred means of contact and information sharing (Native Village of Kaktovik)

Email, regular mail, and phone are all good methods of communication and are best used in combination. The Tribe's email was described as "inundated" with spam and other inquiries. It can be easy to miss emailed communications.

Both hard copies and email work well for information sharing. However, file size can be an issue given Kaktovik does not have broadband internet. Sharing large files by CD or flash drive is an acceptable alternative.

Considerations for engaging Traditional Knowledge

The Native Village of Kaktovik has not adopted any formal guidelines regarding the use of TK, but instead considers each inquiry on a case-by-case basis. One participant indicated that some knowledge is sensitive, like how the community deals with polar bears and how animals are treated when harvested (K1). Another participant noted that, while it is helpful to share knowledge with Western researchers, some are wary of the potential to lose control of proprietary knowledge once it is in the public domain (K2).

Meeting planning

Preferred times and days of week to schedule meetings depend on the season. In general, the best times to meet are around 7pm on weekdays or in the afternoon on weekends. The community center is the main meeting venue. There is a rental application and fee for its use. community center rental is coordinated through the City office. The school facility is typically also a good venue for meetings, but the building was destroyed by fire in 2020 and has yet to be repaired.

Technological capabilities

Kaktovik doesn't have broadband internet so videoconference meetings do not work. Instead, remote meetings rely on teleconference. A best practice is to send presentations beforehand so that meeting

participants can follow-along without being connected to internet. The Community Center and school are both equipped with projectors and speakers.

Lodging

There are two hotels in Kaktovik, the Kaktovik Inn (operated by Kaktovik Iñupiat Corporation) and Waldo Arms Hotel. Room and board per night is \$300 and \$365 respectively (2022, before bed tax).

Equipment rental

KIC is the main resource for vehicle and other rentals. KIC's rate for a 4-wheel drive truck is \$200 per day (year 2022). You may also find community members that are willing to rent equipment.

Local hires

The most common way to advertise for local hires is through job postings on bulletin boards in the community. Bulletin boards are located in the post office, community center, and the KIC building.

2 Point Lay

Points of contact:

The first local point of contact to initiate discussions about research should be the Native Village of Point Lay. The Tribal Council meets once a month. The village Corporation, Cully, should also be contacted if research activities will take place on Cully lands.

Native Village of Point Lay (Tribal office) Tribal administrator: Kimberly Ferreira Email: ptlay.ira@gmail.com Phone: 907-833-5052 P.O. Box 59031 Point Lay, AK 99759	Cully Corporation Phone: 907-569-2705 Fax: 907-569-2715 5001 Eagle Street, Unit B Anchorage, AK 99503	NSB Village Communications Liaison Sophie Tracey Phone: 907-833-2428 Fax: 907-833-2528
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Preferred means of contact (Tribal office)

A combination of phone call and email is best so there can be a record of the communication. The Native Village office may refer certain inquiries to the NSB Village Communications Liaison, Sophie Tracey. Even so, an email to the Native Village is necessary for record keeping.

Both hard copies and email work well for information sharing. However, file size can be an issue given Point Lay's poor internet connectivity. Sharing large files by CD or flash drive is an acceptable alternative.

Considerations for engaging Traditional Knowledge

The Native Village of Point Lay has not adopted any formal guidelines regarding the use of TK. One participant noted that, while people like to share information and have their voices heard, they are wary of having pictures and video taken of hunting (PL4). It is easy for those types of images to be spun in a negative way or e taken out of context. Another participant noted that research findings involving TK

should be reviewed by the Tribal Council so they have an opportunity to provide revisions, make sure knowledge is presented in an accurate way, and flag anything that is sensitive and not to be shared (PL6).

Meeting planning

The Tribal office is the best point of contact for organizing meetings. Meetings are typically held in the community center, which is equipped with a projector and screen. There is a rental application and fee for its use.

Technological capabilities

Though Point Lay has limited internet capability, video conference meetings have been successful. A best practice is to send presentations beforehand so that meeting participants can follow-along without an internet connection if needed.

Lodging

Hotel accommodations are not currently available in Point Lay. Teacher housing or classroom space may be arranged through the Kali School and NSB School District during summer months when school is not in session. Additionally, the Borough maintains itinerant lodging used by employees and contractors on assignment in Point Lay. It is possible to arrange for use of this lodging through the Borough when it is vacant. The lack of accommodations constrains the potential for in-person meetings. One interviewee noted: "Without a hotel it's really hard to invite people to our meetings, which is why the air force RAB meetings are held for just a couple hours in the afternoon. They fly in and they're gone. Other communities have the option for late night meetings or a meet and greet the next day" (PL1).

Equipment rental

The Native Village of Point Lay or the local Search and Rescue are the primary resources for equipment rental. Community members may also be open to renting their personal equipment.

Local hires

The Tribal office is the best point of contact for identifying local resources. A common way to advertise for local hires is through job postings on bulletin boards in the community. Bulletin boards are located in the community center and the village teleconference center.

Attachment D: Iñupiaq Values⁵

Value	Description
Paaqłaktautaiññiq Avoidance of Conflict	The Iñupiaq way is to think positive, act positive, speak positive and live positive.
Nagliktuutiqaḡniq Compassion	Though the environment is harsh and cold, our ancestors learned to live with warmth, kindness, caring and compassion.
Paammaaḡigñiq Cooperation	Together we have an awesome power to accomplish anything.
Iłagiigñiq Family and Kinship	As Iñupiat people, we believe in knowing who we are and how we are related to one another. Our families bind us together.
Qinuiññiq Humility	Our hearts command that we act on goodness. We expect no reward in return. This is part of our cultural fiber.
Quvianḡuniq Humor	Indeed, laughter is the best medicine.
Aḡuniallaniq Hunting Traditions	Reverence for the land, sea, and animals is the foundation of our hunting traditions.
Iñupiuraallaniq Knowledge of Our Language	With our language, we have an identity. It helps us to find out who we are in our mind and in our heart.
Piqpakkuḡtiqaḡniq sulī Qiksirsautiqaḡniq Utuqqanaanun Allanullu Love and Respect for our Elders and One Another	Our Elders model our traditions and ways of being. They are a light of hope to younger generations. May we treat each other as our Elders have taught us.
Qiksirsautiqaḡniq Iñuuniaḡvigmun Respect for Nature	Our Creator gave us the gift of our surroundings. Those before us placed ultimate importance on respecting this magnificent gift for their future generations.
Aviktuaqatigiigñiq Sharing	It is amazing how sharing works. Your acts of giving always come back.
Ukpiqqutiqaḡniq Spirituality	We know the power of prayer. We are a spiritual people.

⁵ NSB. (2019). *North Slope Borough Comprehensive Plan 2019-2039*. Prepared by Eskimos, Inc. and UMIAQ Environmental. https://www.north-slope.org/wp-content/uploads/2022/02/NSB_Comprehensive_Plan_2019-2039.pdf