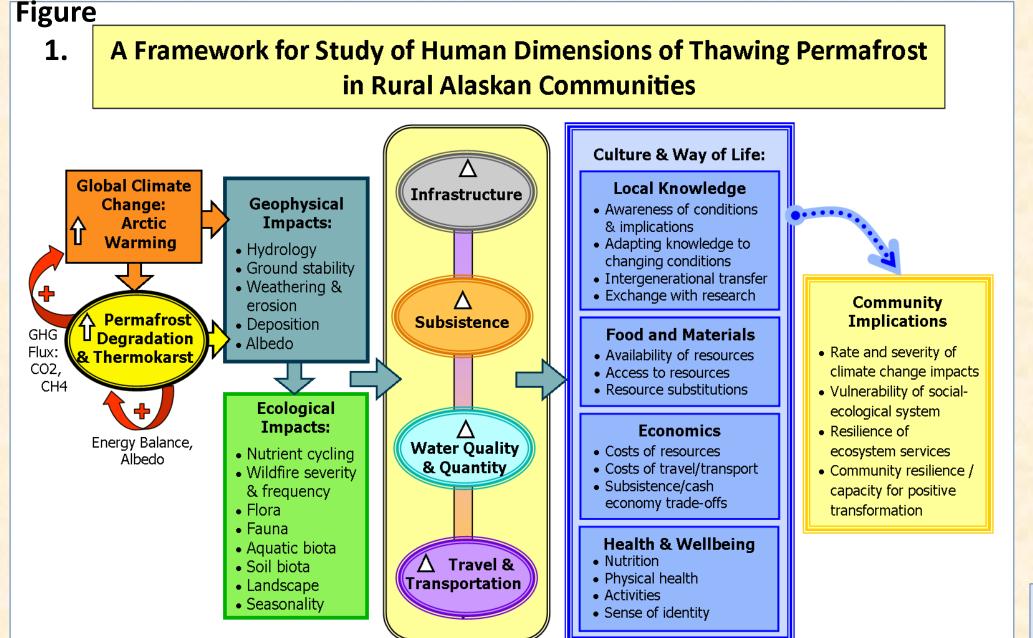




# Climate Change and Thawing Permafrost in Iñupiat Communities of Alaska's Arctic: **Observations, Implications, and Resilience**





### Abstract

Permafrost is thawing in many regions of Alaska. As climate warms social-ecological systems that co-evolved in colder regimes are exposed to new conditions and unpredictable feedbacks. Heavy reliance on local ecosystems for material and cultural resources makes Iñupiat communities particularly vulnerable to climate change impacts. Using the transdisciplinary approach of resilience theory, we investigated current and potential effects of thawing permafrost in two Iñupiat communities in Alaska's Arctic. Anaktuvuk Pass is situated on consolidated gravel permafrost in the mountains. Selawik rests on ice-rich permafrost in lowland tundra. We hypothesized that residents of both villages will report permafrost change, and that the impacts and perceived implications of thawing permafrost will be greater in Selawik. We measured active layer thaw depths and documented residents' local knowledge about climate and permafrost change. Thaw depths were greater overall in Selawik. Most research participants in both communities reported changes in climate and permafrost. Selawik residents expressed higher degrees of certainty that change is occurring, and anticipate larger and more negative impacts. Of the two villages, Selawik faces greater and more immediate challenges to the resilience of its social-ecological system.



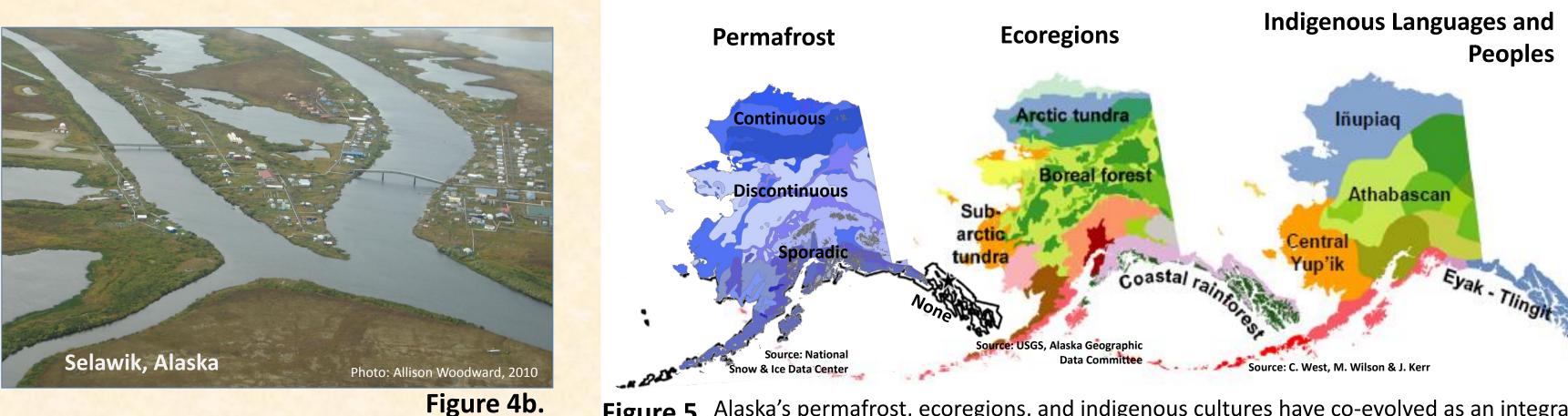


Figure 4a.

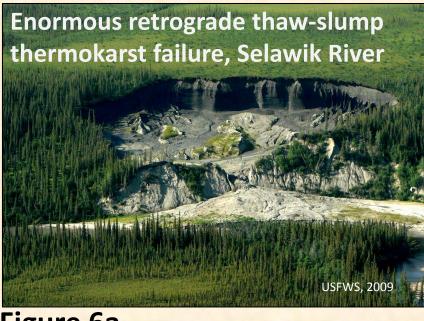


Figure 6a.



Figure 6b. Tuŋġaum Anivai: The Devil's Birthplace **USGS 1955** is an old thermokarst feature that

as entered into local lore? Figure 7. Local knowledge map



Figure 8a & b. repeat photos

### Introduction

The Iñupiat have adapted to and coevolved with the northern Alaskan landscape (Fig. 5), demonstrating great resilience and adaptability for millennia. Now, rapid warming is transforming both permafrost and social-ecological systems in northern Alaska. As permafrost warms, subsidence and thermokarst erosion of thaw-susceptible soils may destabilize infrastructure and affect hydrology, travel on land and waterways, and subsistence activities vital to rural Alaskan communities. Many Iñupiat communities may soon need to employ new adaptation strategies to cope vith impacts of thawing permafrost. Two Iñupiat communities collaborated in this research (Fig. 4a & b). Anaktuvuk Pass is built on thaw-stable consolidated gravel in a broad pass high in the Brooks Range. Selawik lies in a region of thaw-susceptible ice-rich permafrost on lowland tundra interwoven with rivers and lakes. We hypothesized that changes in climate and permafrost would be 1) observed by residents and cause concerns about implications to subsistence, hydrology, and travel in both villages, and 2) perceived as greater threats to infrastructure and livelihoods in Selawik, due to its higher vulnerability to erosion, subsidence, and other effects of thawing permafrost. Objectives of the research were to 1) learn from residents' observations and perceived effects of climate and permafrost change; 2) obtain baseline permafrost thaw depth data; 3) assess current and potential impacts of permafrost change on communities; 4) share relevant information among residents and researchers; and 5) provide useful information to aid rural Alaskan communities in adapting to thawing permafrost. This research is the human dimensions component of the collaborative project, Spatial and Temporal Influences of Thermokarst Failures on Surface Processes in Arctic Landscapes, sponsored by the National Science Foundation's Arctic System Science Program. pproximate locations of

# **Research Methods**

Active layer thaw depths were measured at 1 - 1.5meter intervals to a maximum probe depth of 2.5 meters along transects ranging from 40 to 400 meters, depending on location-specific questions and constraints. When possible, comparative transects were run through relatively undisturbed areas versus similar areas with various human disturbances including buildings, roads, ATV trails, and boardwalks.

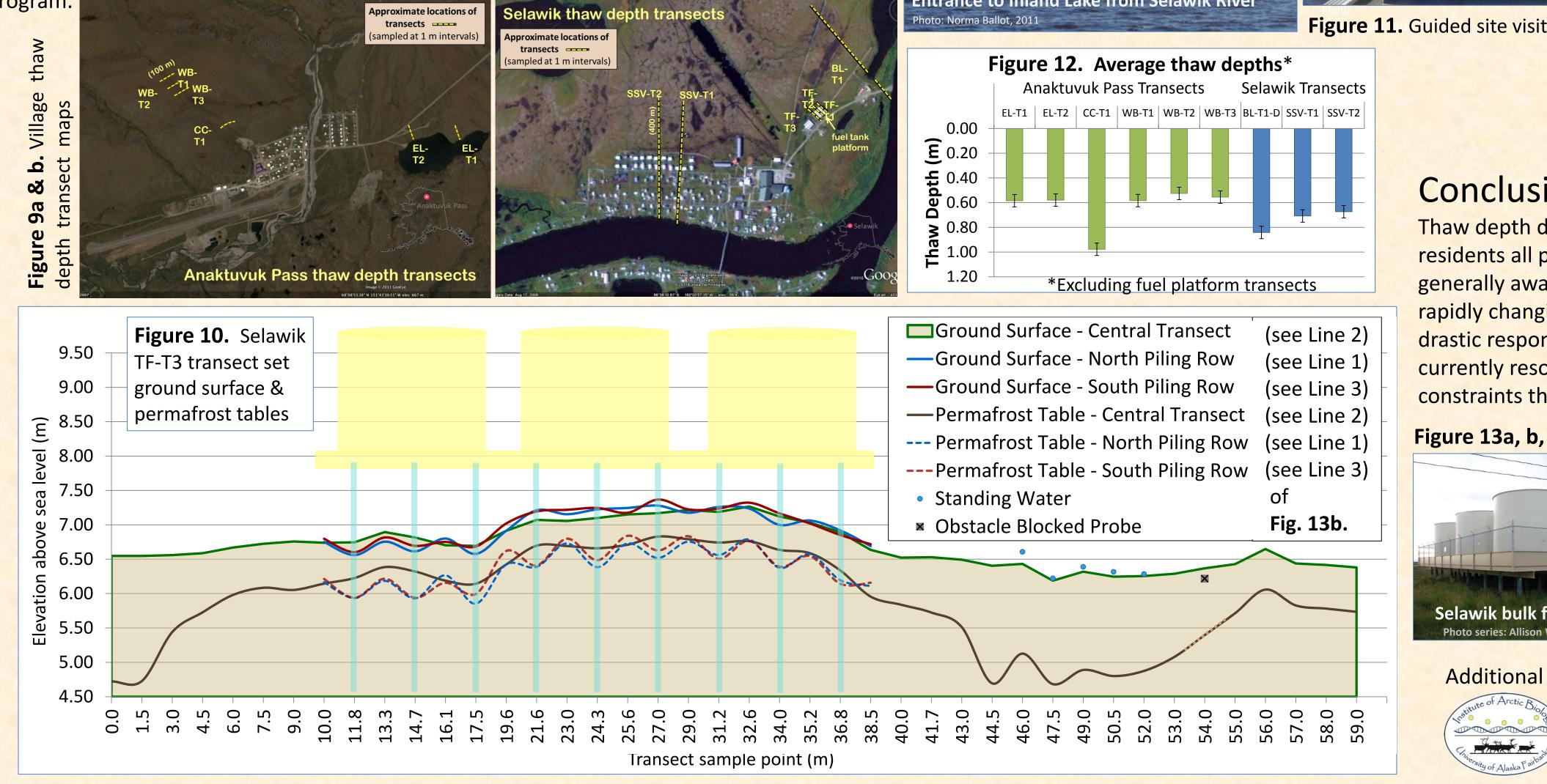
Surveys and semi-structured interviews were administered to village residents, asking about climate and permafrost changes and their influences on land, water, flora, fauna, subsistence activities, infrastructure, local travel, transportation, and other aspects of community life. In Selawik (n=13) active subsistence users and/or Elders were interviewed, with spatially-referenced data recorded on local maps (Fig. 7). Surveys were given in Selawik (n=42) and Anaktuvuk Pass (n=39). Repeat photography (Fig. 8a & b) was used to document temporal change at recognizable locations. Videography was used to capture residents' narratives and to document physical examples of change observed on site visits led by key informants in both villages.

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It's a lot of different than it was back in the 70's. The river is getting wider, and the lakes are eroding. Like that big lake - Inland Lake - eroding real bad. I was thinking about maybe from too much wind, or something like that. But then I believe that global warming is melting away all this permafrost and start eroding away. - Selawik resident, b. 1932

Change is too fast - too much turmoil. Land, animals, everything is changing. Even time is faster and faster.

Figure 5. Alaska's permafrost, ecoregions, and indigenous cultures have co-evolved as an integrated complex system in which all components are now being affected by climate change.



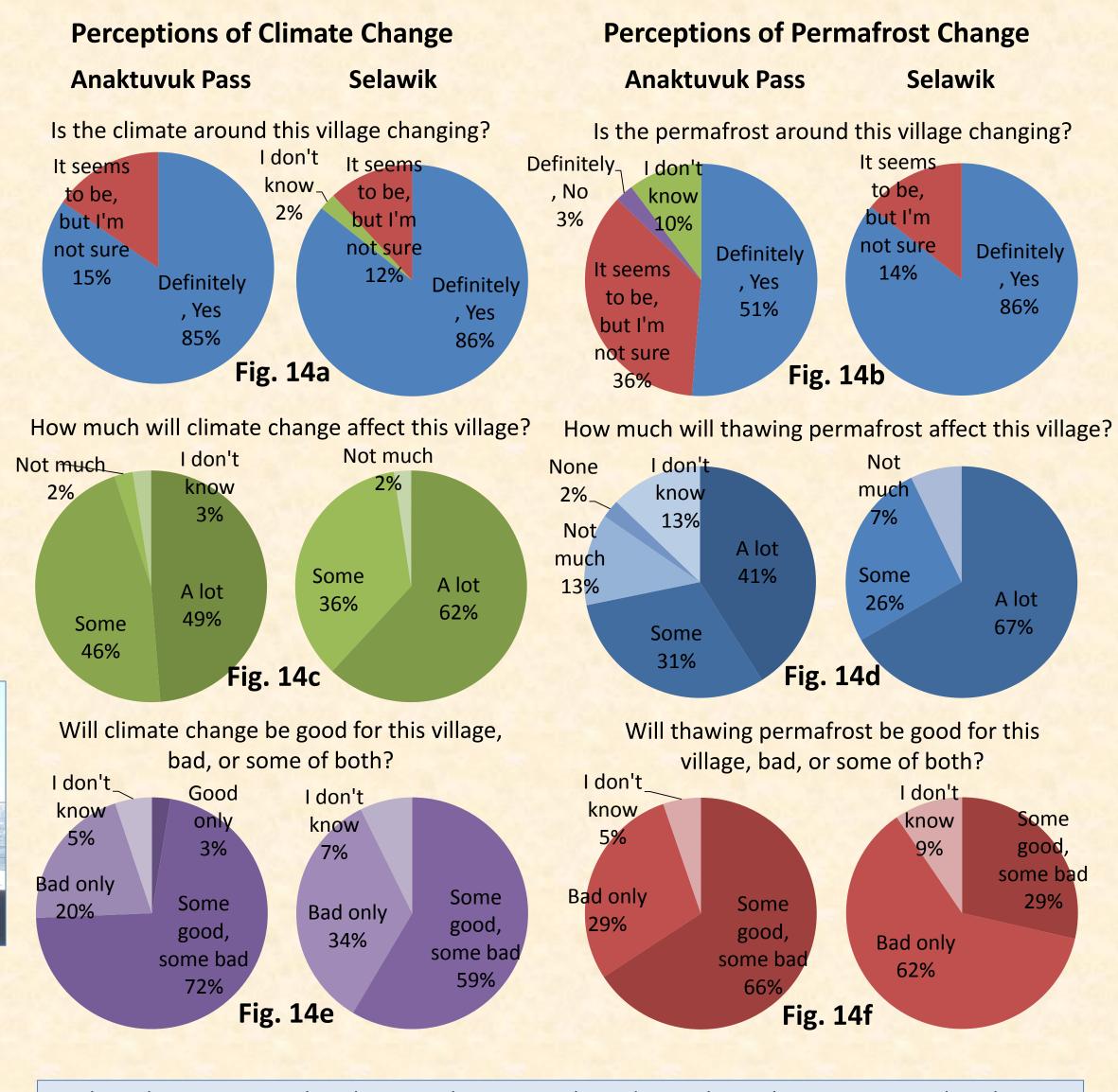
*I know it's there – thawing permafrost and climate change – and we see the* changes. Makes me concerned and scared. We have no sure way of dealing with it. All we live on is permafrost. - Anaktuvuk Pass resident, b. 1972

Anaktuvuk Pass resident, b. 1930

**Research Results & Interpretations** 

Active layers were shallower overall in Anaktuvuk Pass (Fig. 12), with the exception of a southeastwardly facing slope. In Anaktuvuk Pass, the substrate beneath the village proper resisted all reasonable efforts to probe for permafrost – a strong indicator of densely consolidated gravel and rock providing thaw stability for infrastructure. In Selawik the active layer is deeper along transects crossing built and trafficked areas of the village than adjacent tundra, and in both villages deepening of the active layer was found under established ATV trails (Fig. 3). Findings suggest that surface disturbance from human activity is accelerating permafrost degradation due to loss of insulating surface vegetation and decreased albedo of bare ground. Conversely, shallower active layers were found directly beneath raised boardwalks and a fuel storage platform versus adjacent tundra in Selawik (Fig. 10). These above-ground structures provide summer shading and reduce winter snow accumulation, resulting in lower mean annual ground temperatures. Heat conduction into the ground by the metal pipes beneath the tank platform thawed pits in the permafrost table immediately surrounding them. Boardwalks sinking at their pilings suggests a similar process. Baseline thaw depth data provide opportunities for comparisons in future monitoring.

Survey respondents and interviewees expressed high degrees of certainty that climate is changing in each of their homelands. Selawik residents anticipate more significant and more negative effects of climate change than residents of Anaktuvuk Pass (fig 14a). All Selawik respondents and 98% in Anaktuvuk Pass reported that permafrost is changing locally. Selawik residents expressed greater certainty about permafrost change and expect more pronounced and negative effects (fig 14b). Residents in both communities voiced concerns about the impacts climate and permafrost changes may have on their subsistence practices. Both communities reported increased shoreline erosion and turbidity of water bodies, with greater concern in Selawik. Most Selawik respondents believe their community will need to modify drinking water systems, change ways of local travel, and relocate buildings to adapt to thawing permafrost (figs 15a-c). "We are sinking" was a phrase commonly expressed in Selawik. Only Selawik residents voiced concerns about the potential need to relocate their settlement due to subsidence and inundation (fig. 15d).

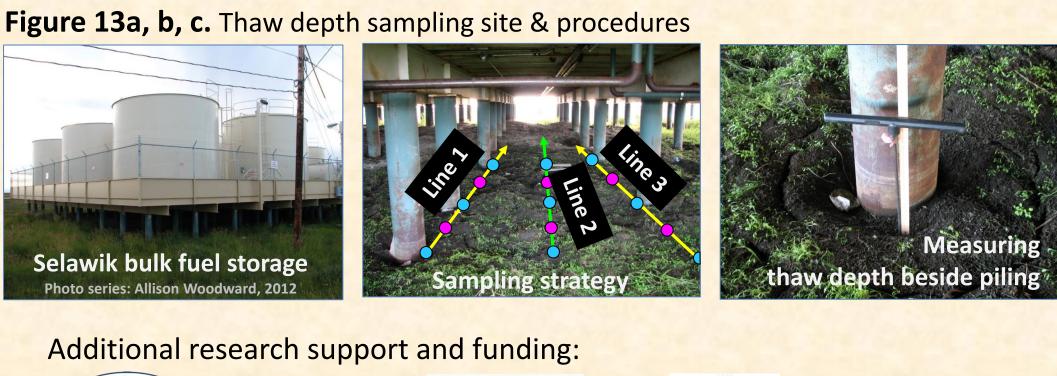


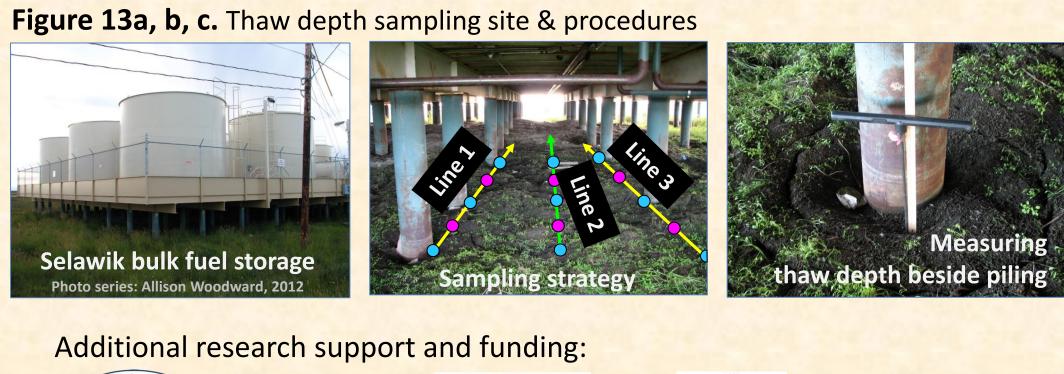
Anaktuvuk Pass is not sinking because there are rocks underneath. But low areas are sinking because of permafrost. Here there's some areas where we traveled straight, but now it's dropped. Now ice underneath is melting because it's exposed. - Anaktuvuk Pass resident, b. 1940

# Conclusions

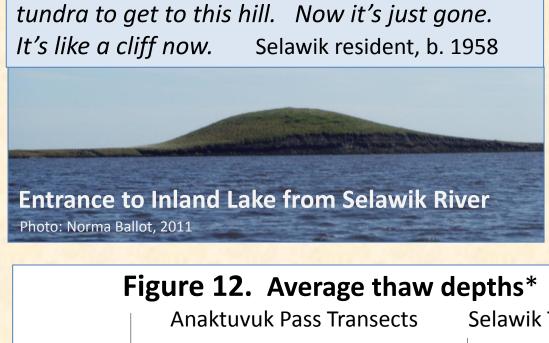
Thaw depth data, observations, high degrees of certainty, and anticipated negative impacts voiced by residents all point to Selawik's greater vulnerability to thawing permafrost. Residents of both villages are generally aware of the level of thaw stability of their communities and recognize the need for adaptation to rapidly changing conditions. Due mostly to thaw instability, Selawik will be forced to make earlier and more drastic responses, including planning for relocation. Selawik is fortunate to have a suitable site nearby, but currently resources for relocation are not available. Selawik's adaptive capacity is more limited by financial constraints than Anaktuvuk Pass, where oil revenues play a large role in supporting the community.

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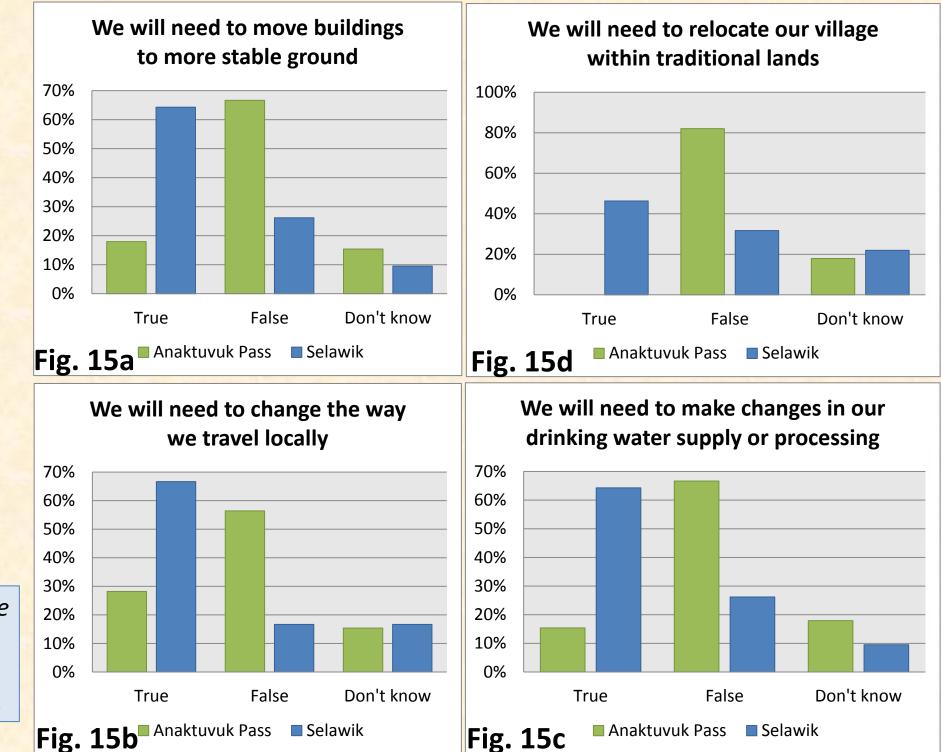


When you parked your boat on this side, you

used to have to walk a long way across the







More and more, because of climate change, our river system and the ice will be dangerous for a long time. We're forever trying to teach the kids, "don't go out there with your 4-wheeler." But they do. That current will eat that ice from the bottom. It's simply because the water is not as cold as it used to be. That's the thing that we're having to deal with now. - Selawik resident, b. 1941