Climate Change in **Selawik**, Alaska

Strategies for Community Health

ANTHC Center for Climate and Health

Funded by

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Through adaptation, negative health effects can be prevented.

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Cover Art:
Whale Bone Mask
by Larry Adams

SUMMARY

Rural Arctic communities are vulnerable to climate change and residents seek adaptive strategies that will protect public health. In the Inupiat community of Selawik, climate change is impacting the weather, land, river, wildlife, plants, and the lives of the people who live there. This report identifies health concerns related to food and water security, and community infrastructure including water and sanitation.

This report documents these issues as described by the local people and interpreted through the lens of public health. It is the fifth report in a series describing climate change in Northwest Alaska. Assessments have been performed in two coastal communities (Point Hope and Kivalina), and in two inland river communities (Noatak and Kiana). This is the first to look at a river delta, specifically the broad intertidal basin of the Selawik River. These reports were prepared by the Alaska Native Tribal Health Consortium, Center for Climate and Health in partnership with the Maniilaq Association, the Northwest Arctic Borough, Native Village of Selawik, and the City of Selawik. Funding was provided by the United States Indian Health Service, by the Environmental Protection Agency, and by a grant from the Arctic Landscape Conservation Cooperative. Information sources for this report include observations of local residents acquired through semi-structured interviews, detailed participant observations as well as on site observations by the authors. Other important sources include reports from government agencies, and scientific evidence gathered from published studies.

The Snyder kids are all smiles despite the sagging Arctic pipe that brings water to their home.
Mike Brubaker, 2011.

This Climate Change Health Assessment was performed based on requests from tribal health representatives and from local and regional leadership. Information about local climate, environment, and health conditions was gathered with the help of local and regional government, universities, industry, and state and federal agencies.

Selawik has experienced impacts from rapid climate change for at least the past 50 years, as evidenced by rising temperatures and increased precipitation in almost every month (SNAP 2012). Residents report increasingly variable seasonal weather, more frequent storms, and extreme temperature swings especially in winter. Thawing permafrost related impacts to community infrastructure is apparent throughout Selawik. A community guided, multiagency response will be required to prevent climate-driven damage to homes and other structures and to replace the aging infrastructure with new systems that are appropriate, durable, and sustainable given Selawik's new emerging climate and environment. A summary of the findings are as follows.

Jackie Snyder used a caribou skin to insulate the broken connection in his Arctic pipe.
Mike Brubaker, 2011.

1. Permafrost thaw has community-wide impacts.
Seasonal warming is increasing the thaw zone, resulting in subsidence. This sinking of the ground is damaging homes, utilities, infrastructure, board roads, and bridges. The impact is magnified because of different rates and amounts of land movement occurring between connected infrastructure, such as homes and water lines. A comprehensive survey of permafrost conditions is recommended along with on-going monitoring of vulnerable infrastructure. Greater local guidance and oversight of system design and construction, and collaboration between contractors would help encourage compatibility and increase resilience.

Anecdotal data was collected on the observations and experience from local experts in health, wildlife, Inupiat culture, weather, subsistence, education, sanitation, local governance, law enforcement and emergency services.

Predictions and projections on future conditions such as warming, flooding, and erosion are based on available information and limited by the quality of current scientific data and the uncertainties inherent in climate models.

The home of Daniel Foster Sr. is one of many threatened by bank erosion.
Mike Brubaker, 2011.

2. The riverbanks are eroding causing loss of property and threatening homes. An estimated 36 homes in Selawik are vulnerable to bank erosion, with some areas losing several feet of riverbank each year. Erosion prevention has been used successfully in the past and should be reconsidered for the future based on a bank soils study. Without immediate mitigation measures some houses will need to be moved before they flood or fall into the river. Further development in vulnerable areas of the river should be prevented unless effective mitigation measures can be applied or appropriate building systems developed.

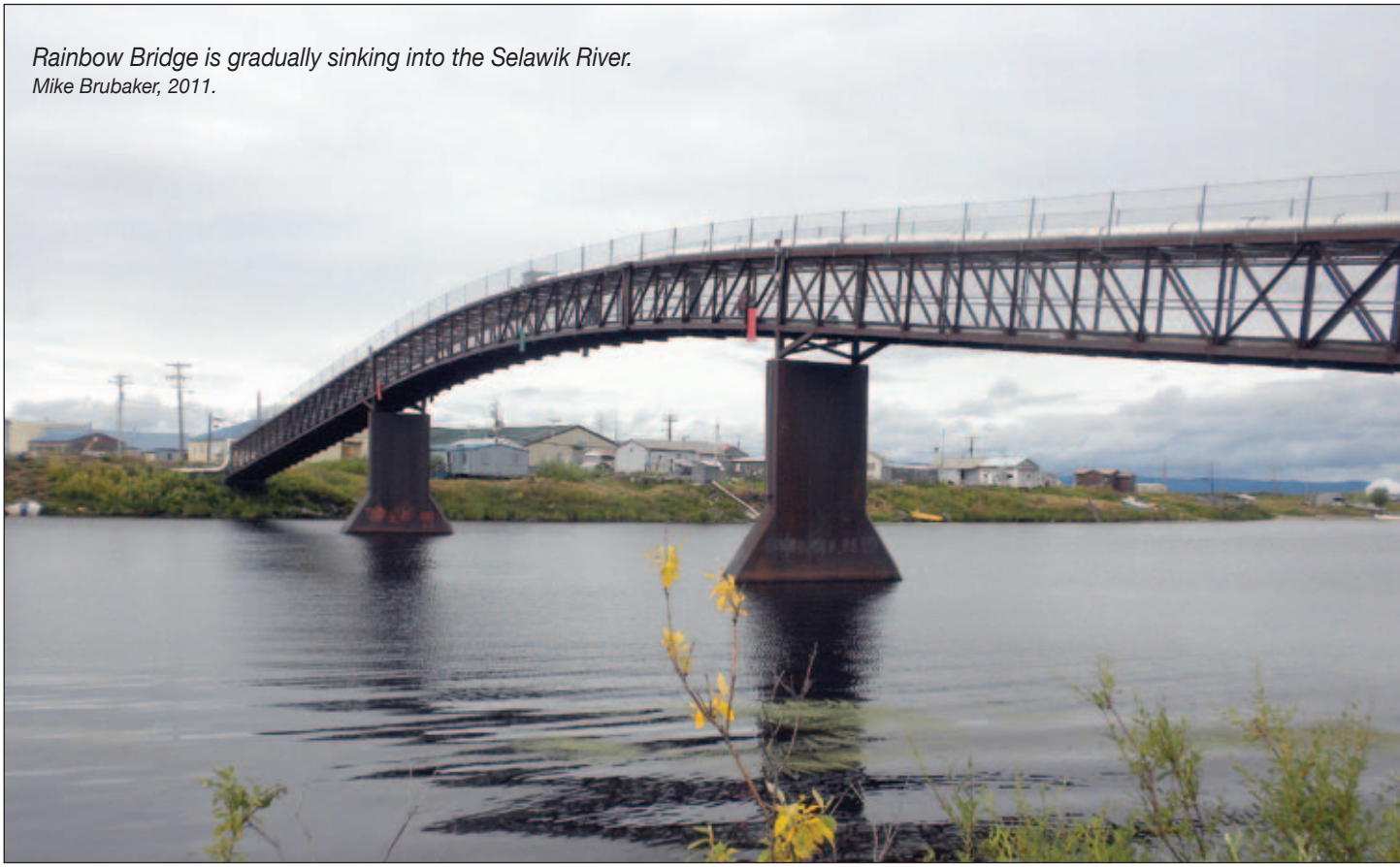
3. Climate change may be increasing the movement of pollutants into rivers. The Selawik River is the community water supply. Floods, permafrost, thaw and bank erosion are all environmental factors that may be mobilizing natural pollutants such as mercury and manmade pollutants such as dump waste, and delivering them into the river. Water quality in Selawik should be monitored and sources of pollution, such as the dump site, properly managed. Fish bio-accumulate mercury and so do people who consume fish. Mercury levels in human hair have very been very low in Selawik. However, because of rapid river change continued participation by Selawik residents in the State of Alaska hair monitoring program is encouraged.

"My home at Nuvugauraq Point is sinking. It is happening fast. I hope the point does not break off like a piece of cake."

Daniel Foster Sr.

4. River change is decreasing the ice season and increasing travel hazards. The primary transportation route for Selawik is the Selawik River, by snowmachine in winter and by boat in summer. Warming is making the season for ice travel shorter and more hazardous. Finding ways to reduce travel hazards is a priority.

5. Water from traditional sources should be treated before drinking. Traditional surface water sources including streams and springs are increasingly vulnerable to pathogens. To avoid waterborne illness, boiling water or the use of appropriate filters and treatment systems is recommend.



Rainbow Bridge is gradually sinking into the Selawik River.
Mike Brubaker, 2011.

"Both bridges have dropped by two and a half feet since 1981."

Raymond Ballot

6. River change is impacting navigability and increasing travel risks. The Selawik River is susceptible to permafrost thaw and related bank erosion. Community members have reported landslides from collapsing riverbanks and uprooted trees that sometimes pose a navigational hazard. Bubbles from methane seeps, the result of rapid permafrost thaw and organic decay, can cause thin ice conditions in some areas. Travelers should exercise caution with traveling in areas characterized by rapid bank erosion or methane seeps.

7. Riverbank erosion is contributing to periods of poor water quality. In 2004, the formation of the Selawik Slump caused the river to run cloudy for days. Like other Northwest Arctic rivers, the Selawik River is experiencing periods of high turbidity resulting from permafrost thaw driven erosion. This has contributed to boil water notices in Selawik and increased risk of waterborne disease. The ongoing water system upgrades will allow Selawik to provide adequate water treatment, but periods of increased turbidity are expected if current warming trends continue.

8. Climate change affects utility sustainability. Selawik has some of the highest water utility electrical costs in Alaska. Permafrost thaw driven damage to the water and sanitation infrastructure is a factor in the high cost. Widespread utility interruptions can undermine the sustainability of a utility. A system wide efficiency survey would help to identify strategies for reducing energy costs and improving utility reliability.

9. Permafrost conditions should be monitored in the vicinity of critical infrastructure including the distribution lines, sewage lagoon, fuel tank farms, bridges and homes. New infrastructure should be sited in stable land areas, built in a way to minimize permafrost disturbance, and designed to accommodate future projected conditions. Applying best practices for construction on permafrost is increasingly important. Leveling of infrastructure, if performed regularly, will help to prevent serious structural damage.

10. Selawik can become a model for community adaptation and resilience in the Arctic. A new climate must be accompanied by adaptation and new standards for community development. With attention to achieving appropriate infrastructure designs, greater coordination between development organizations, and careful community-guided planning, Selawik can become a model of resilience and adaptation and provide needed guidance to Arctic communities challenged by a changing climate.

Selawik can become a model of resilience and adaptation and provide needed guidance to Arctic communities challenged by a changing climate.

The sinking ground makes for a tall step to many homes.
Mike Brubaker, 2011.

INTRODUCTION

Selawik is an Iñupiat Eskimo community located about four miles north of the Arctic Circle and 70 miles east of Kotzebue. The Selawik Inupiat are river people, who live in the broad Selawik River delta because of its abundant food resources including whitefish, sheefish, caribou, moose, duck, ptarmigan, and various berries, bushes and other plants. Local knowledge about the weather, place locations, tides, and plants and wildlife make the Selawik people excellent observers of environmental change. Here people have experienced climate change effects to their homes, travel, food, water, public safety, and other aspects of their lives. This report documents some of the effects in Selawik based on the interviews of residents and others who work closely with the community, published research and reports, and the observations of the authors.

Climate change refers to change over time due to natural variability or as a result of human activity (IPCC, 2008). A review of historical weather data indicates that the average air temperature in Selawik is warmer in every month than it was in the past (SNAP, 2012). The weather tends to be increasingly unpredictable and extreme with decadal trends suggesting warmer summers, and generally warmer winters. The largest thermokarst formation in North America is located upriver from Selawik. Caused by thawing permafrost, it is an enormous crater where a sudden bank collapse can release enough sediment to turn the river brown. Thawing permafrost also results in slow, gradual impacts. The entire community rises and falls with the seasonal freezing and thawing of the ground. Over the long term, the community has also been gradually sinking. This causes damage to the infrastructure and increases the cost for operations and maintenance.

May ice in Selawik.
Lucy Snyder, 2006.

"We started talking about the weather changing in the late 1970s."

Ralph Ramoth Sr.

In July, August and November 2011 and April 2012, site visits were performed by ANTHC's Center for Climate and Health using a specialized health impact assessment process (Brubaker et al. 2011). Interviews were performed in offices of local government, in the health clinic, the school, during excursions into the countryside, and in visits to people's homes. Information was collected about impacts, potential health effects, data gaps, and adaptation measures. Local and regional partners reviewed the notes and provided comments on this report. Findings were presented to partner organizations in Kiana and in Kotzebue.

The climate impacts documented in this report are predominately negative. Positive health effects have also been identified such as the potential for new food resources, longer boating season, less ice jam flooding, and warm summer days.

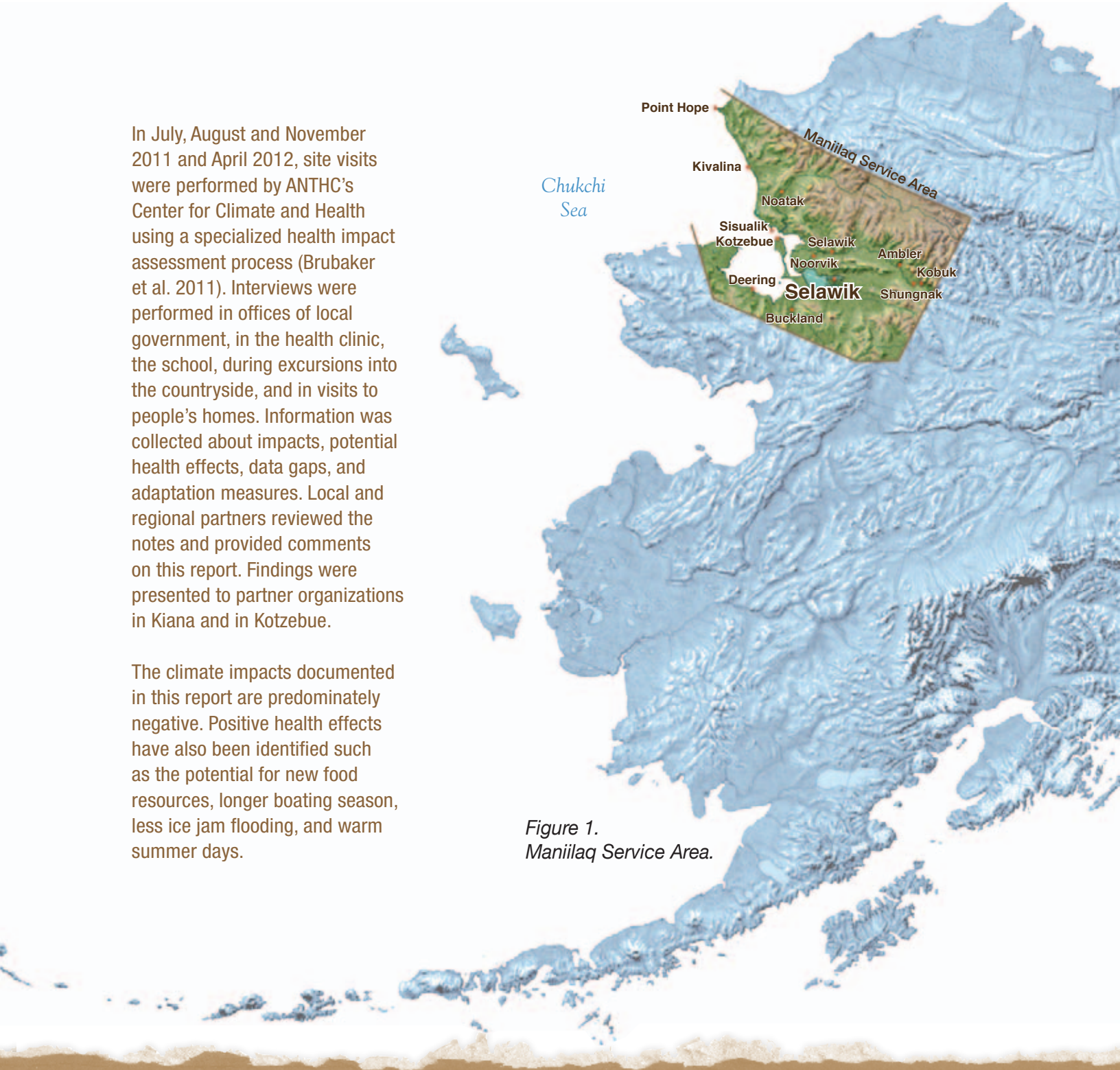


Figure 1.
Maniilaq Service Area.

"The ice is melting really quick in the Spring. Faster than it used to."

Ralph Ramoth Sr.

COMMUNITY

The Selawik area is known in Iñupiaq as "Akuligaq," which means "where the river meets together," and "Siktagvik," or "a place for shooting." Because of a rich year-round fishery, the area has been used as a winter camp for thousands of years. The written history begins in the 1840s with the record of the village "Chilvik" by a Russian naval officer. The 1880 census recorded 100 "Selawigamute" people living near the current site. Missionaries established a church and school in 1897. Reindeer herding was introduced during the 1920s and in 1926, Selawik was established under the Alaska Native Town Site Act (NANA, 2011).

The community incorporated in 1974. In 1980, the 3400 square mile Selawik National Wildlife Refuge was established under the Alaska National Interest Lands Conservation Act (ANILCA) to conserve the fish, wildlife, and habitat resources of the region. Selawik is the only community located within its boundaries. Over the past three decades Selawik has grown and expanded. In 2010, there was a population of 829 with over 85 percent of the residents Alaska Native. It is the second largest community in the Northwest Arctic region.

The town itself is built above marshy ground on pilings and pads. Raised board walks / roads connect the residential areas and there is a small island in the middle and three separate neighborhoods referred to as "school side," "church side," and "airport side". All are connected by two large structural bridges that span separate branches of the Selawik River. In all areas the elevation is quite low, ranging from sea level to as high as 60 feet above mean sea level (Google Earth, 2012). No roads lead to Selawik and the community relies on the river for transportation all year round. There is a 3,000 foot-long gravel runway and barge service provides summer fuel delivery and transport of other freight. In winter, the river serves as an ice road for snowmachine travel inland and downriver to Noorvik and Kotzebue.

Selawik's streets are a crowded with infrastructure.
Mike Brubaker, 2011.

Improving coordination between development agencies is important for compatibility between a complex array of community systems.

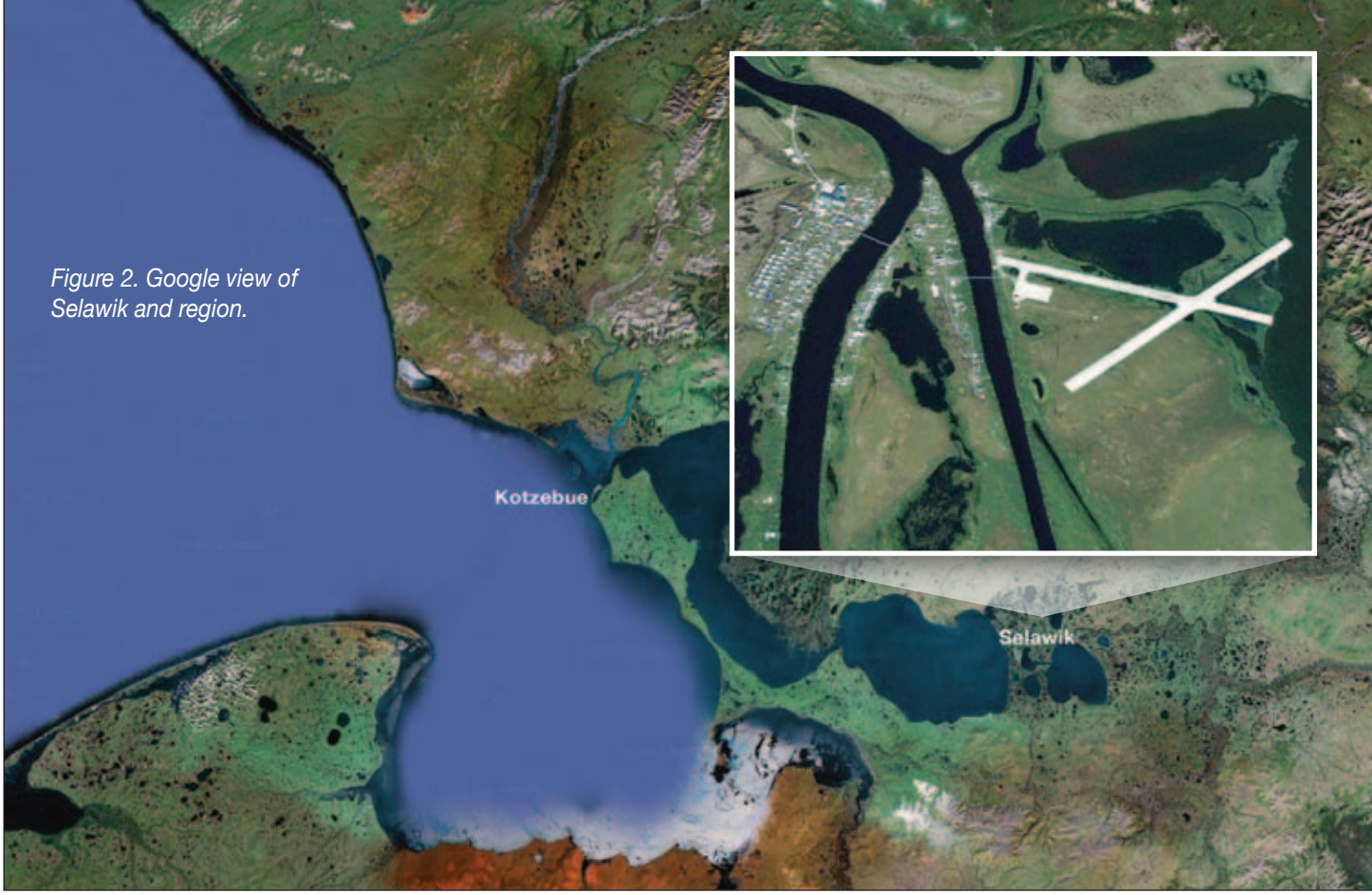


Figure 2. Google view of Selawik and region.

There are roughly 190 residential structures in Selawik, typically heated by fuel oil or wood stoves. The average family household size is 4.8 persons. Residents are employed in construction, mining, firefighting, long shoring, fishing, guiding, health care, education, traditional crafts, and the government services required to keep a rural Alaska community running. Electricity is provided by diesel generators and wind turbines. In February 2012, the per-gallon price for fuel oil was $7.14 and $7.00 for gasoline, plus tax. The community acquires water from the Selawik River and a piped re-circulating water system serves approximately 95 percent of the households plus public buildings and businesses (DCCED, 2012).

The Davis-Ramoth school is pre-kindergarten through 12th grade; attended by about 245 students. The Selawik Health Clinic is operated by Maniilaq Association and staffed by about eight employees including three certified community health aides. For more advanced health care, residents fly to the Maniilaq Health Center in Kotzebue or to the Alaska Native Medical Center in Anchorage.

The Selawik area is known in Iñupiaq as "Akuligaq," which means "where the river meets together."

CLIMATE

Observed change: *extreme weather, warmer in every month; more precipitation.*
Health concerns: *extreme weather injury.*
Potential adaptation: *local environmental observer network participation, weather monitoring.*

The climate in Selawik is getting warmer and wetter. Selawik is located in a transitional climate zone. Temperatures average -10 to 15°F during winter and 40 to 65°F during summer. Temperature extremes have been recorded from -50°F to 83°F with the lowest temperatures occurring during January and the highest in July. Annual snowfall averages 35 to 40 inches. Winds average 20 knots year-round. The Selawik River has historically been navigable from early June to mid-October. In recent years, delayed freeze-up has occurred more frequently and early break-up in the spring. Annually precipitation is

Margaret McCaslin in her drying house.
Mike Brubaker, 2011.

"Its only just June and already it is too hot for drying fish."

Margaret McCaslin

increasing and now is thought to be exceeding the conventional annual measure of 16 inches per year. The wettest month is August and the driest is November. Summers are increasingly hot and dry, and winters are more variable with sudden and dramatic temperature swings.

Down-scaled temperature and precipitation data and computer model-generated projections are available for Selawik (SNAP, 2012). Comparing two periods, 1961 to 1990 and 2001 to 2010, average temperatures have increased in every month of the year, with the biggest increase in winter; January temperatures increased by about 4°F. Precipitation shows increases year round, with the biggest increase occurring in the fall. Between 1961 and 2010, precipitation increased in every month except July. Projections through 2040 are for continued precipitation increases except in May, June, September, and October (SNAP 2012).

The amount of precipitation is important for community health and safety. With an elevation near sea level, Selawik is vulnerable to flooding. In the spring of 2011, flooding caused damage to local board-roads and riverbanks. Floods also contribute to water quality problems that have resulted in community-wide boil water requirements. In winter, Selawik relies on adequate

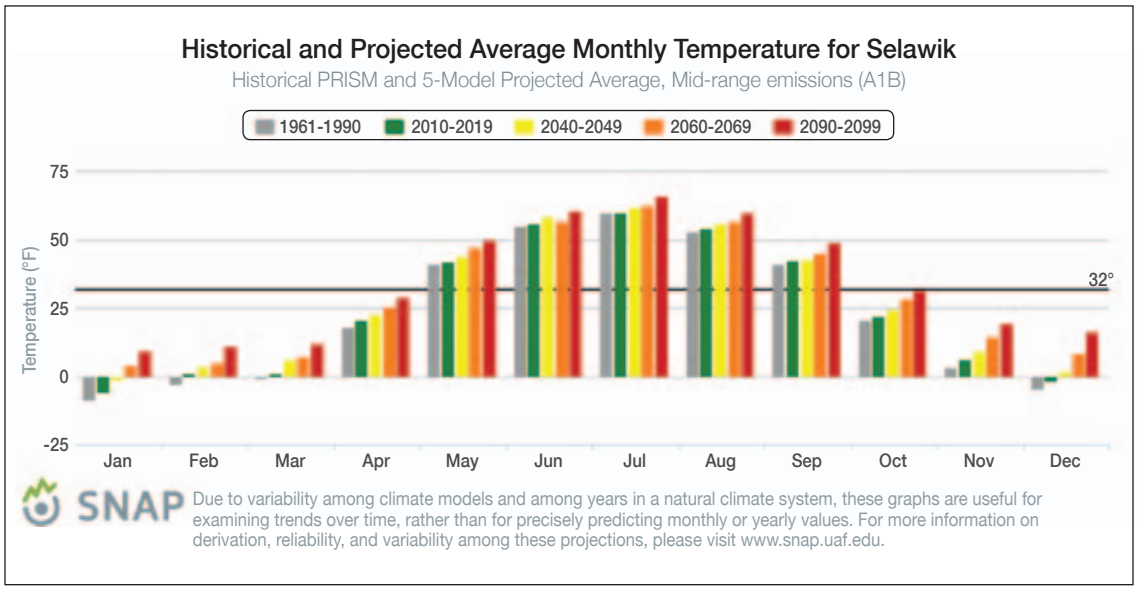


Figure 3. Historic & Projected Temperature, Selawik, Alaska.
UAF, Scenario Network for Alaska Planning 2012.

"I keep telling people to watch out where they are driving and not to go on the rivers because they may just fall through."

Daniel Foster Sr.

snowfall to cover the utilidors throughout the village. A utilidor is an insulated utility corridor built aboveground to carry utility lines such as electricity, water and sewer. When snow levels are low, the utilidors are more vulnerable to damage from vehicle traffic. One question not currently considered by climate models is whether the future will bring more snow or less. Developing snow projections is difficult, as daily precipitation data is not currently collected in Selawik.

Recommendation: Precipitation data is limited and a local observer would help improve weather forecasting. Extreme weather including flood, drought, wind storm, and blizzard are expected to increase in frequency and intensity. Emergency preparedness planning is recommended as are updated environmental parameters to ensure structures are constructed for emerging environmental (wind, freeze, snow load, etc.) conditions and for increasing warm year-round temperatures. Tribal environmental staff have enrolled as Local Environmental Observers (LEO) to record and share unusual weather events and climate and environmental impacts in their community.

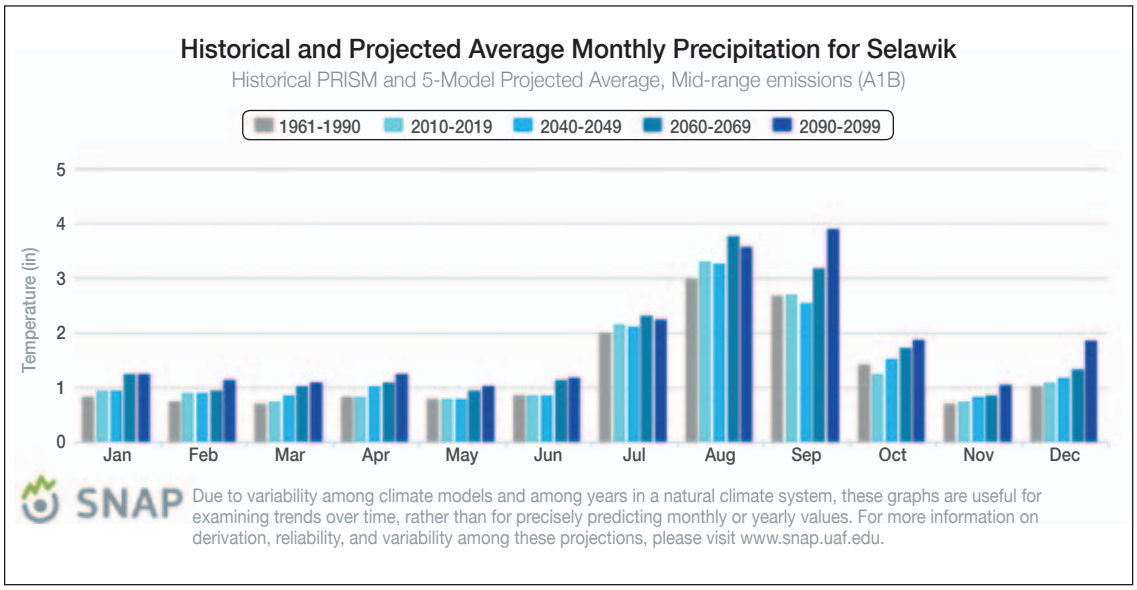


Figure 4. Projected Average Monthly Precipitation, Selawik, Alaska.
UAF, Scenario Network for Alaska Planning 2012.

"We have had really high water this spring and flooding."

Lucy Snyder

Boys riding their ATV over Arctic Pipe
Bob Hallinen.

"When there is a lot of snow it is easy to drive right over the pipes. But the last few years we have not had much."

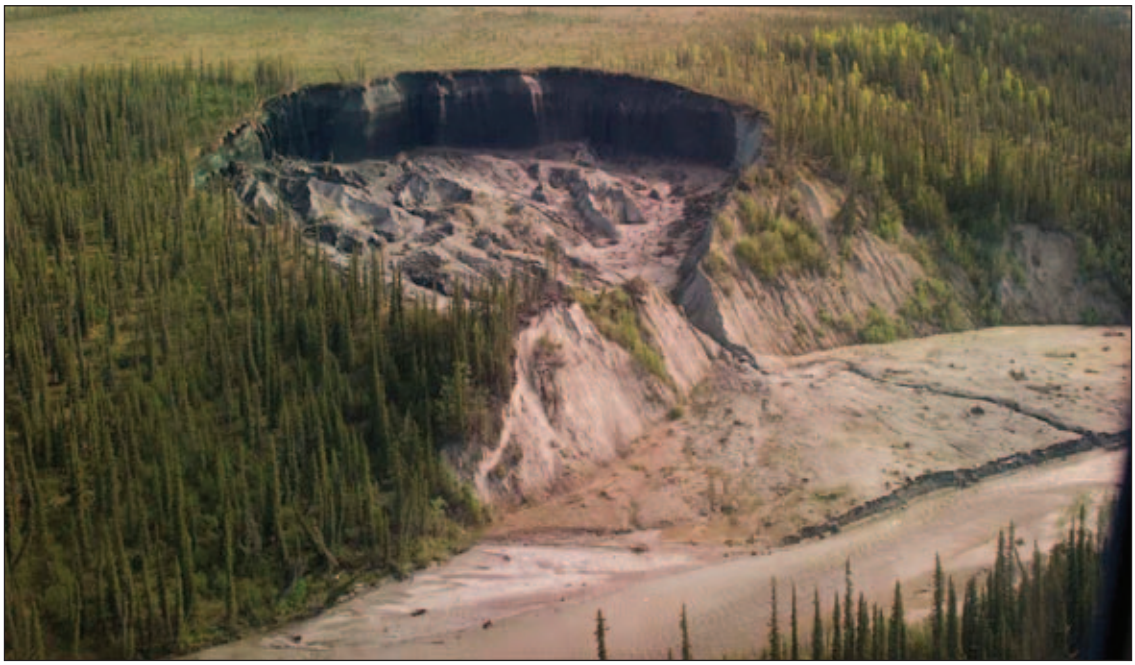
Lorraine Ticket

LAND

Observed change: *rapid permafrost thaw, erosion, subsidence.*
Health concerns: *hazardous travel conditions; damaged infrastructure, water quality change.*
Potential adaptation: *travel advisories, erosion prevention; permafrost and erosion monitoring.*

Warming air temperature is causing dramatic changes in the Selawik area.

Where once a largely frozen landscape was quite resilient, today a largely thawing landscape is increasingly fragile. Permafrost refers to soil that has been continuously frozen for at least two years. Selawik is at the margins of the continuous permafrost zone in Alaska and thawing soils are vulnerability to land change, subsidence (sinking), and flooding. Residents describe erosion on slopes and riverbanks, and subsidence as thawing ground is gradually compressed. The surface layer thaws and refreezes seasonally but the depth of thaw in the Selawik area has been increasing.



A huge thermocarst located upstream from Selawik.
Yuri Gorokhovich.

"The big slump at Aguik in August of 2006 caused a lot of sediment and has made the river smaller."

Raymond Ballot

One of the most dramatic climate change features has been the appearance of "thermokarsts," areas where thawing permafrost result in land failure, slides, slumps and gullies. Thousands of thermokarsts have emerged in the Northwest Arctic over the past decade. Starting in about 2004 a thermokarst at Aguik, about 35 miles upriver from Selawik, began to develop. Warming and thawing of permafrost is also associated with vegetation change. Over the past few years residents report rapid grass and tree growth including alder and willow, which act to capture snow, insulate the ground, and reduce ground freezing.

Thaw-related fracture line at an inland lake.
Yuri Gorokhovich.

New vegetation, thermokarsts, and riverbank erosion are all indicators of climate change and processes that are expected to continue in the future if warming trends continue. With change comes new vulnerability for damage and loss of infrastructure. When the tundra is disturbed or changed by new vegetation, the underlying permafrost is likely to change as well. An example is on the north side of the community where tundra was cleared for an airstrip. The disturbance accelerated thawing and the area has been transformed into a wetland.

In Selawik climate change is causing broad impacts on infrastructure and increasing the costs of operating and maintaining basic services. Climate-driven impacts also increase wear and tear and thus the cost of replacing infrastructure (Larson and Goldsmith, 2007).

Recommendation: The thawing in Selawik underlines the importance of monitoring permafrost conditions. A baseline study has been performed (Woodward, 2011) and a planned UAF permafrost observatory and ongoing monitoring of infrastructure would provide local government with information about permafrost conditions, the performance of foundations and best practices for new construction. Additionally, Selawik would benefit from baseline study of coastal processes and geo-hazards to help guide development decisions.

"We are constantly having to boil our water because of high turbidity."

Tanya Ballot

RIVERS

Observed change: *late freeze up, early spring breakup; high water and flooding; bank erosion.*
Health concerns: *infrastructure damage and or loss; reduced water quality.*
Potential adaptation: *erosion prevention, building relocation; restricted development zones.*

Riverbank erosion is resulting in damage and loss of infrastructure including homes. In Selawik the homes are built along the river with the boats pulled up on the bank like cars in a driveway. But some driveways have become shorter in recent years. Daniel Foster Sr. remembers being able to throw rocks to the other side. The river is too wide now, and deep cracks running parallel to the river indicate where several feet of thawing bank is becoming unhinged from the land each year. Erosion prevention is necessary to protect his home.

According to Raven Sheldon, the transportation director for the Native Village of Selawik, there are 36 homes on the banks of the Selawik River that are threatened by erosion, including homes on the airport, middle island and school side of the community. Additionally, utilities, infrastructure, and cultural sites are threatened, causing the Army Corp of Engineers to designate Selawik as a "Priority Action" community (USACE 2009). Despite the problem, no government programs have been identified that can assist homeowners with erosion prevention. Tree planting programs were successful in the past; but with warming soils, sinking ground and flood events, bank protection is becoming increasingly challenging. Another problem is construction in erosion

Shandon Foster shows the erosion next to his grandparents house.
Mike Brubaker, 2011.

"There are 36 homes that are threatened by erosion. These are homes on the banks of the Selawik River."

Raven Sheldon

vulnerable areas. Without erosion prevention measures, some areas of Selawik will be unsuitable for development.

Selawik floods – June 2011.
Lorraine Ticket.

Erosion is also occurring all along the Selawik River. In some places there is so much undercut bank hanging over the water that caretakers have taken to cutting fresh sod to cover graves. When the big thaw slump occurred in 2004, whole trees were uprooted and the water turned brown. High sediment levels disrupt water treatment but also contribute nutrients that may improve conditions for algae and some fish species, while diminishing conditions for others. Researchers from the University of Idaho have been monitoring river conditions for turbidity, temperature, conductivity, and pH since June 2011; including near the community water supply intake. The spring flood of 2011 was the highest in years, swamping parts of Middle Island and damaging board roads and buildings. Raven Sheldon is exploring the acquisition of funding for improvement and expansion or roads to a high ground facility know as Spud Camp, which would double as an evacuation route in times of extreme weather or flooding.

Recommendation: Strategies are needed that will protect vulnerable areas, and an engineering geo-hazards study is recommended. Some areas should be designated as "no development" zones. Developing relocation assistance services is encouraged for homeowners that must move their homes. Residents are concerned about recent and future flood risk. Regular observations of ice conditions and local advisories may help to prevent injury. Residents are also concerned about travel safety on the river. An improved evacuation route and community shelter would provide a safe, warm, dry, location where residents could ride out floods or other extreme weather events.

"We used to walk all along the river like a sidewalk. We don't anymore."

Lawrence Larkin

WATER

Observed change: *increasing turbidity in river water, subsidence and erosion under infrastructure.*
Health concerns: *reduced water quality, water system damage and disruption.*
Potential adaptation: *system monitoring, increased durability, use of climate models.*

Thawing is affecting water quality, damaging infrastructure and disrupting water service. Warming is increasing bank erosion and turbidity (Balser et al. 2009), and the amount of natural pollutants in the river (Bowden et al. 2008). The river is the community water source and residents have raised concerns about waterborne disease vectors, such beaver which can carry the parasite Giardia lamblia. Manmade pollutants are also a concern, as the open dump is vulnerable to runoff and flooding washing debris downstream and potentially into the water intake (Raymond Ballot, 2011). The intake, a raft with a small pump in an insulated box, is located near the shore alongside Rainbow Bridge. In recent years, high turbidity has compromised water treatment, contributing to long term, "boil water notices." The treatment plant improvements currently underway will help resolve most treatment issues although challenges will persist related to freeze-thaw cycles and subsidence of the distribution system.

The community water intake.
Mike Brubaker, 2011.

"We have had high turbidity because of the rain and the big slough up river."

Bruce Dexter

Arctic pipes, sagging as they sink into the ground.
Mike Brubaker, 2011.

Due to ice rich soil conditions, the water and sewer utilities in Selawik are located in an above ground network of insulated utilidors and arctic pipe. These are heavily insulated and must be heated in winter to prevent freezing. But freezing does occur, and there are seasonal water distribution failures effecting entire sections of town. This is in part due to the settling of supports and foundations in the thawing soil. The settling occurs at different rates causing stress and damage to the fittings that connect homes and other structures to the water system. Of particular concern are the junction boxes. Settling of either the pipeline supports or the home foundations cause the seals in the junction boxes to break. Once broken, cold air can infiltrate the seal and can freeze the water in the pipes. During the winter of 2011-2012, repeated freeze-up caused many households to be without water service for most of the winter. Turning up the heat is not always enough to prevent the lines from freezing, and has resulted in high energy bills for both the utility and individual homeowners. Many junction boxes have been wrapped with blankets or caribou skin to try and restore the insulating seal; and many homes have extended periods without water and sewer service due to frozen pipes.

Broken water pipes.
Mike Brubaker, 2011.

Recommendation: The Selawik River is undergoing rapid change. Understanding the effects of these changes on water quality is important to ensure that treatment is appropriate and optimal for community needs. To do this, new emphasis should be placed on monitoring source water conditions, and designing procedures that accommodate fluctuations in water quality. Monitoring could build on recent baseline studies performed by the University of Idaho (Ben Crosby, 2011). The community landscape is also rapidly changing and the infrastructure is in constant motion and experiencing stresses that exceed the design parameters for the system. The problems may be addressed by more frequent maintenance or by building systems that are more flexible and durable. Until the distribution system problems are addressed, Selawik will experience freeze-up related water insecurity in winter. Increased compatibility between systems and structures is also needed, and will require close collaborations and regular communication between government and housing and utility agencies.

"When the pipes settle they break and then freeze."

Ralph Ramoth Sr.

WASTE WATER

Observed change: *sagging mainlines, eroding lagoon shoreline, loss of fencing.*
Health concerns: *waste water system damage and disruption, health and safety risks.*
Potential adaptation: *system monitoring, increased durability, adaptive design for thawing soils.*

Permafrost thaw is damaging waste water infrastructure. Most homes in Selawik are serviced by a piped waste water system. Vacuum stations pump wastewater through an insulated and heated mainline to the sewage lagoon; a 200-acre tundra pond located about a half a mile outside of town. Some households rely on honey buckets and transport their waste to the lagoon on ATVs or snowmachines or dump their honey buckets at the old river dump or other places. This is a concern as the river is the community water supply, as there is no designated honey bucket disposal area at the lagoon, and because some residents may be dumping honey buckets at the open dump site.

The waste water system is vulnerable to similar kinds of settling-related stress and freezing that was described in the Water section. Monitoring the waste water lines and vulnerable areas such as junctions is important in order to prevent damage, freezing, and loss of service. Having a level home is also important for proper waste water service. Many homes in Selawik are in need of routine leveling. Some

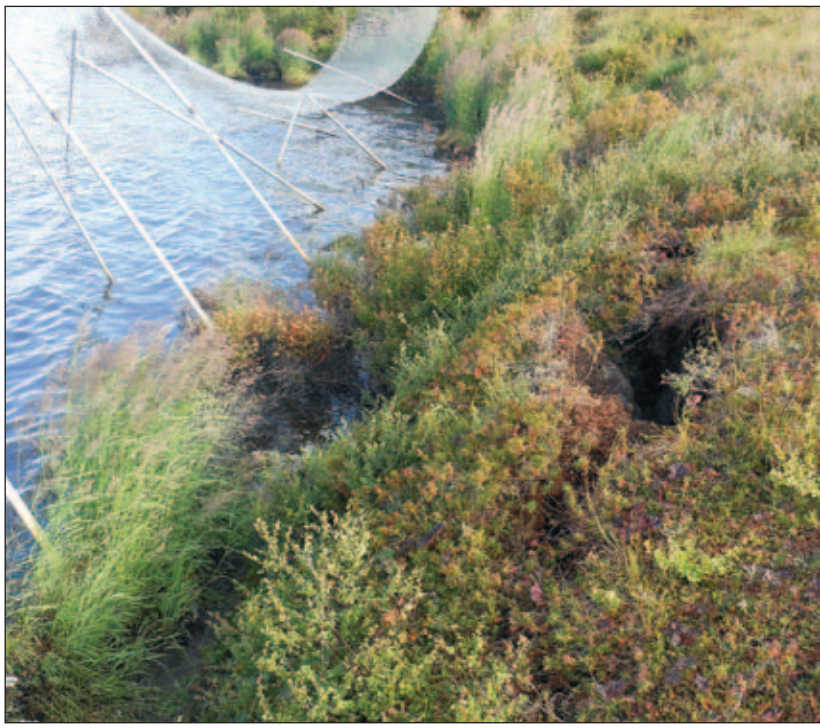
Sinking and erosion has damaged the sewage pond outfall.
Raj Chavan, 2011.

Permafrost thaw related damage to water and sanitation infrastructure is a factor in the high cost of services in Selawik, because of line breaks, increased costs for operation, and maintenance.

homes cannot flush toilets because the tilt of the house prevents toilet bowls from filling properly. Frequent leveling can resolve this problem. Problems were also observed with the sewer force main to the lagoon and with the utilidors located throughout the community. Differential movement caused by thawing permafrost has resulted in sagging sections of the force main and utilidor. The sagging force main may eventually result in breaks in the pipeline. Sagging of utilidor sections serving the vacuum sewer system are resulting in substantial increases in operating costs for the utility and the need for constant up-keep to maintain an operable system.

Another problem is the damage that has occurred to the sewage lagoon as a result of permafrost-thaw related erosion. The bank of the lagoon is vulnerable to thawing and subsidence. Near the outfall, the shoreline has eroded back 10 to 20 feet. As much as 100 feet of fence line is either leaning or collapsed. Where the ground level has dropped, the fence is hanging, and where the lagoon has expanded, the fence is now dropping into the water. The loss of continuity of the fence presents a health and safety hazard, as people and wildlife can now enter the area. The outfall is also damaged and in need of repair. The supports that hold the pipe over the lagoon have sunk, causing the end of the outfall to break and hang in the water.

Recommendation: Sinking of the sewer mains in some areas means that the system is vulnerable to freezing. This problem can be addressed by more frequent monitoring and maintenance. Developing connections that are durable and accommodate significant movement, and support (foundation) systems for soft thawing soils, may improve the long term performance of the system. Sections of the waste water line are in need of leveling, and repairs to fencing and the outfall are needed. Regular system-wide surveillance will help to catch developing problems before serious damage occurs.



Erosion at the sewage pond.
Raj Chavan, 2011.

Near the outfall, the shoreline has eroded back 10 to 20 feet. As much as 100 feet of fence line is either leaning or collapsed.

SOLID WASTE

Observed change: *dilapidated board road and trails, lack of collection service, open dump.*
Health concerns: *hazardous roads, environmental contamination, community water safety.*
Potential adaptation: *restore dump access, cleanup unregulated dump areas, assess water risk.*

The dump site in Selawik is a significant and growing community health concern. There is no collection service for solid waste in Selawik, so residents must haul their own refuse. The disposal site is an open dump located outside of town, spread across some 18 acres of tundra. There is a chain link fence to designate the main dump area, prevent trash from spreading, and discourage nuisance wildlife. There is no waste segregation and no regulated removal of hazardous wastes. Household honey bucket waste is also disposed of in the dump, especially during winter when many homes have no water services because of frozen pipes.

A damage section of the dump board road.
Raj Chavan, 2011.

One of the main problems is that the dump has in recent years been expanding beyond the fence line, largely because of access problems. Thawing permafrost, expedited by damage to the tundra, has turned summertime ATV trails into muddy bogs. An old board road once provided seasonal access to the dump and protected the tundra. But the board road is now impassible and some residents have taken to dumping their refuse on the roadside. The waste piles have spread and blowing trash now covers the landscape and at times blows trash into town. The construction of a gravel road nearby has

"We don't have any regulations for waste. Everything that goes in the dump ends up in the river."

Raymond Ballot

opened a new route to the dump site. However, travel overland by ATVs has damaged the tundra and resulted in unofficial dumpsites that extend from the gravel road overland to the dump.

The dump is near the river and vulnerable to flooding.
Mike Brubaker, 2011.

The expansion of the dump and lack of adequate access is widely viewed as an aesthetic concern. Hauling waste to the site is a responsibility shared by the entire community, and made difficult and even dangerous due to the poor board road and trail conditions. But the open dump also raises important environmental and health concerns. The dump has hydrological connections with the adjacent ponds and potentially the river through flood events, groundwater flow, and by runoff. Thawing permafrost is affecting the solid waste problem by increasing the mobility of groundwater and making the trails more vulnerable to deterioration. Residents have raised concerns about recent high water and flooding. Whether flooding risk is an increasing trend, however, is unknown. What is known is that solid waste is being washed into adjoining tundra lakes, and ultimately could enter the Selawik River. Whether solid waste is affecting the community drinking water supply is unknown.

Recommendation: Restoring a functioning solid waste system is a top environmental and health priority. Addressing the access problem is the first step, and local government is actively seeking funds to construct a new board road. A major cleanup effort will be needed to transfer all of the waste into a managed and fenced area. A water study is recommended to assess the risk of potentially harmful or hazardous components of the waste stream entering the community water supply. Selawik would benefit from funding and technical assistance in each of these areas. Native Village of Selawik has applied for a landfill grant to help cleanup and close the old site, and open a new landfill.

"Our dump is too close to the main river. When the water is high we get waste getting washed into the river or flooding."

Raymond Ballot

TRANSPORTATION

Observed change: *sinking of bridge, increased vibration on board roads.*
Health concerns: *safety, disruption of bridge associated utilities.*
Potential adaptation: *Engineering evaluation of transportation infrastructure.*

Selawik spans two sides of the Selawik River with a small island in the center. Raised board roads connect three residential areas, "school side," "church side," and "airport side." All three areas are connected by two large structural bridges that span two branches of the river. Residents and local government leaders have in recent years observed changes in community bridges and board roads that may be related to thawing permafrost and erosion.

Several homeowners expressed concerns about an increase in the amount of vibration in their homes each time a vehicle passes on the board road. Homeowners found this disturbing and wondered whether the combination of vibrations from vehicle traffic and thawing permafrost may be contributing to less stable conditions in the ground, increased vibrations and sinking home foundations. Some of the board roads are in need of replacement after only two or three years. The amount of damage occurring to exposed above ground water and sewer lines raise

One of many board roads in Selawik.
Mike Brubaker, 2011.

"The wind and ATV traffic cause vibration on the board walk. It is causing the land to settle."

Burt Greist

questions about whether there are adequate ramps to allow for travel in the community, in particular during low snow accumulation winters.

Rainbow bridge is one of two large bridges that are thought to be sinking.
Mike Brubaker, 2011.

Another transit concern is the condition of Selawik's two structural bridges, Rainbow Bridge and Airport Bridge. The bridges were constructed using Bureau of Indian Affairs funds in the 1980s. Because there are no roads leading to these bridges they do not qualify for regular inspections by the State of Alaska Department of Transportation, and no inspection schedules or reports were identified. City of Selawik officials are concerned that Airport Bridge may be sinking as a result of thawing permafrost. Evidence of ice jacking was observed on the church side of the bridge. According to city officials, both bridges have dropped by as much as two-and-a-half feet since they were constructed. A visual inspection of Rainbow Bridge identified erosion around the foundation on either end of the span, and evidence of settling and shifting. Of special concern is the condition of utilities including power, water and sewer, that are connected to the bridges and may be under increasing stress.

Evidence of movement on Rainbow Bridge ramp.
Mike Brubaker, 2011.

Recommendation: Residents have raised important questions about possible changing conditions of board roads and the implications for homes, and water and sanitation infrastructure. An engineering study is needed to further understand the mechanisms and options for appropriate response. As the riverbanks in Selawik are particularly vulnerable to erosion and thawing, regular inspections of the bridges are advised, and associated utilities. Both bridges in Selawik have funding for an engineering evaluation under the State Transportation Improvement Plan (STIP), as per a funding request from the City of Selawik and the Northwest Arctic Borough.

"Both of the bridges have dropped by about 2½ feet since 1981."

Raymond Ballot

HOUSING

Observed change: *sinking foundations related to rapid permafrost thaw and erosion.*
Health concerns: *water security, slips and falls, building safety, indoor environment conditions.*
Potential adaptation: *monitoring foundations, better leveling systems, durable utility service lines.*

Permafrost thaw is causing structural damage and resulting in unhealthy homes. Seasonal rising and falling of the land caused by freeze thaw cycles, and longer term land sinking is resulting in damage and disruption of services. Some homes have pad foundations that essentially float on the ground; while others are on wood or steel posts. Each type of foundation responds differently to the changing ground conditions. The ground beneath some homes has sunk by as much as two feet, creating hanging staircases and increasing the risk of injury. Residents report an array of problems including ceiling gaps that allow cold air inside during winter and insects in summer. Many homes have broken windows, doors and utility junction boxes, collapsing decks, unreliable water and sewer service and other symptoms of compromised structures.

Homes experiencing these kinds of problems need to be frequently re-leveled, which is difficult, labor intensive requiring training, materials and specialized equipment. In Selawik, leveling could keep crews busy year round, but there is frequently a lag time of years or decades before some homes are leveled. Monitoring of home foundations can be performed inexpensively

Lawrence Larkin point to original ground level under his home.
Mike Brubaker, 2011.

"My house is sinking. You can see the cracks in the ceiling."
Clarence Snyder

by using simple leveling systems (Personnel communication, Allison Woodward, 2012).

Alice Smith at her old home near Nuvugauraq Point.
Mike Brubaker, 2011.

The fact that the climate is rapidly changing poses new challenges for all Arctic infrastructure. Engineers and architects rely on local design engineering parameters to help define the environment and design requirements, but the historical parameters for Selawik and many other Alaska communities are no longer valid. Along with the temperature, the freezing and thaw indexes have changed; snow load is projected to increase as is snow depth (ANTHC 2011). Until there is a published update of the Alaska Environmental Atlas, the design parameters in Alaska will remain in question. Selawik decision makers should carefully evaluate the design engineering parameters planned for all new infrastructure.

Another concern is homes located adjacent to erosion vulnerable areas along the river. There are areas of Selawik that are vulnerable to riverbank erosion, and some homes will need to be pulled back from the bank or relocated. This is a major challenge in Selawik and planning is necessary to develop new stable home construction areas, and to relocate homes.

Recommendation: Homes need to have good, level foundations in order to be safe, comfortable, healthy, and efficient. Improved home systems with foundations that are resilient to permafrost thaw, and that are easily leveled are needed in Selawik. Homeowners need instruments that allow them to monitor foundation performance, so that adjustments can be made before damage or loss of service occurs. Additionally, homeowners need regular access to affordable home leveling services, whether through public assistance programs or private business. Homes located in areas that are vulnerable to subsidence or erosion may need assistance to ensure a safe and healthy living environment.

"I finally am going to have a new house. But it is right next to the river. It is going to erode away."

Alice Smith

ENERGY

Observed change: *increasing costs for homeowner, businesses, and utilities.*
Health concerns: *high costs may compromise utility and limit access for some customers.*
Potential adaptation: *a systems approach to more compatible and resilient infrastructure.*

Thawing permafrost is contributing to high energy costs. Land settling, land movement and the resulting impacts on utilities and infrastructure have contributed to rising energy costs. Despite the development of innovative energy systems including four 65 kilowatt wind generators, Selawik residents and businesses are paying some of the highest rates for utilities of any community in Alaska. The cost for water and sewer service now exceeds the five-percent of median household income threshold established by the State of Alaska (Bill Griffiths, personal communication, 2012). Understanding the reasons for high energy costs is a critical step in reducing consumption and making changes that can improve operations, reliability and affordability.

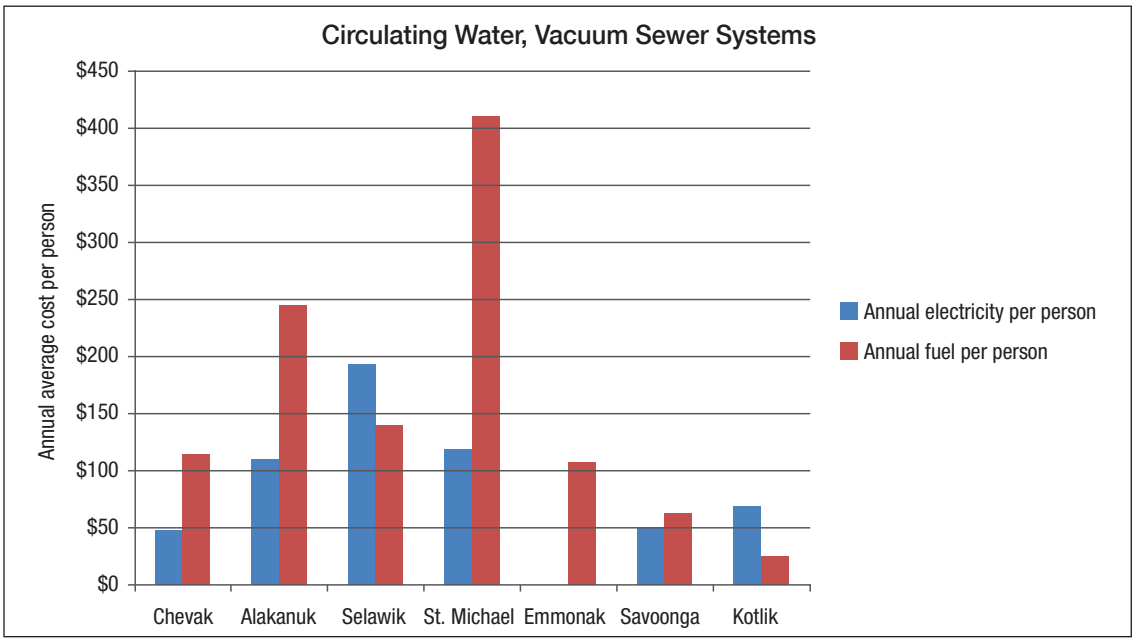


Figure 5. Circulating Water, Vacuum Sewer Systems cost per person.
ANTHC, 2011.

According to a recent audit, the total energy cost for operating the water and sewer system in Selawik exceeded $264,000 per year.

A big part of the cost is the electricity needed to run the communities extensive above ground water distribution and vacuum sewer systems. These systems are heavily insulated and must be heated during cold periods in order to prevent freeze-up. Ground settling is causing stress and in many instances, breaks in the connections between the piped systems and buildings. Where the insulation is compromised, the increased use of heat tape by homeowners and operators is significantly increasing energy costs. Another factor is damage caused by snowmachines and other vehicles. Residents must navigate across and around the distribution lines. Impacts and vibrations to the lines from vehicles cause damage to utility lines, connection boxes, and other junctions, and increase vulnerability to freeze-up. Frequent freeze-up in some areas of Selawik is already undermining the health and quality-of-life benefits of piped systems. Snow depth is a contributing factor. During periods with adequate snow, pipe systems are covered and thus better protected. However, in low snow periods the pipes are exposed and can be more easily damaged.

A vehicle damaged Arctic pipe.
Mike Brubaker, 2011.

According to a recent audit, the total energy cost for operating the water and sewer system in Selawik exceeded $264,000 per year (ANTHC, 2011). The cost per kilowatt hour ranged from as low of $0.15 cents in October to as high as $0.33 in December, exceeding the state power cost equalization subsidy. Over 50 percent of the energy costs were related to the use of heat tape. Some home owners also pay higher winter electrical rates for water and sewer, because of the heat tape used to thaw service lines. These electrical costs are paid for by homeowners. Heat tape aside, the cost of residential water and sewer service in Selawik is $180 per month.

Recommendation: A recent energy audit outlined 14 measures that could result in a 66 percent reduction in the cost of operating the water and sewer utility in Selawik (ANTHC, 2011). Additional measures would include repairs to the damaged sections of the water distribution and sewer collection system, and an assessment of steps that would prevent future thaw, subsidence, and vehicle-related damage and disruption. This may require new engineering practices, and increased design and monitoring coordination between various infrastructure development agencies.

AVEC's 65kw wind generators help power Selawik and control energy costs.
Mike Brubaker, 2011.

Understanding the reasons for high energy costs is a critical step in reducing consumption and making changes that can improve operations, reliability and affordability.

FOOD

Observed change: *warming temperatures, difficulty drying fish, changing caribou migration patterns.*
Health concerns: *risk of illness from inadequate food preservation, possible increase in contaminants.*
Potential adaptation: *regular harvest surveys; fish health monitoring, mercury monitoring.*

Climate change is affecting food availability and traditional preservation practices. The most important subsistence species in Selawik are large land mammals and fish. Over 50 percent of the annual harvest is composed of large land mammals, mostly caribou. The rest is non-salmon fish species including pike, sheefish and white fish. In 2006 fish harvest for Selawik exceed 115,000 lbs, comprising over 40 percent of the total wild food harvest (ADF&G 2006). The high cost of market foods underlines the economic importance of subsistence. As of April 2012 a box of milk in Selawik costs $3.69, a dozen eggs is $4.09, a loaf of Wonder bread is over $2.00 and a large container of Tang is $20.00.

Jack and Nathanial Snyder work a seine net in Selawik.
Mike Brubaker, 2011.

"When fish dry well they dry white. Now the fish dry yellow and sometimes we have to give it to the dogs. We pray about this in Church. Last summer we lost 1/4 of the fish."

Emma Ramoth

Fish rack.
Mike Brubaker, 2011.

Residents report a shorter season for drying fish and increasingly having to discard fish because of warming related spoiling (Moerlein and Carothers, 2012). Fortunately, the Selawik is a very productive river system, with an enormous fish population that is available for harvest in the community year-round. But the river is changing and permafrost thaw, erosion, and wildfires are among the mechanisms that are introducing large amounts of organic material and nutrients into the system; and raising questions about the long term impacts on fish and other aquatic life. Climate impacts on subsistence include changes in distribution, abundance, accessibility to resources, and unpredictable weather for processing food (Moerlein and Carothers 2012). As river conditions change, some fish species become vulnerable to infection and illness, while other species benefit. An expanding beaver and muskrat population may be contributing to river change (Anne Orlando, USF&W, personal communication) and raising concerns about impacts on fish species and risk of waterborne illness such as giardiasis. Concerns were also raised about the health and behavior of caribou. Daniel Foster, Sr. described migratory changes in timing and rate of travel, and raised concerns about caribou that appear small and skinny from not grazing enough in their rush to cross the Colville River (Personal communication Daniel Foster Sr. 2012; Hannah Loon, 2007).

Blueberry patch.
Craig Scola, 2011.

With erosion occurring along the Selawik River, levels of natural contaminants may increase (USGS 2009, Schuster et al. 2011) and accumulate in fish and other foods. Naturally occurring mercury has been documented in Selawik River pike. Fortunately, hair samples from Selawik volunteers have been found to have very low levels of mercury; averaging .075 ppm which is far lower than the 15 ppm allowable level for consumption (ATSDR). Fish populations are healthy and an important part of the diet in Selawik.

Recommendation: Periodic harvest surveys, such as currently being performed by the borough and ADF&G will provide important insights into food harvest and consumption patterns. On-going participation in the State Department of Health and Social Services mercury hair monitoring program is encouraged for women of child bearing age in Selawik. Health aides should be aware that warming climate could result in food preservation problems, such as botulism.

"My wife and I used to pick cranberries at our camp up by Noorvik. Not any more. It is too dry."

Clarence Snyder

CONCLUSION

Public health considers climate change based on effects to mental health, injury, disease, and food and water safety and security. In Selawik, climate change is resulting in widespread changes to the landscape and community. Climate change is increasing the risk of injury from unsafe infrastructure, travel hazards, and slips and falls. It is also increasing the cost of living because of damage and disruption to local infrastructure. Water insecurity is experienced by many Selawik households due to damaged water distribution lines. Food safety and security may be affected by the changing health of wildlife, food storage and preservation practices, and changes to the river environment. Community water safety and security may be affected by natural and man-made pollutants in the Selawik River.

Selawik can become a model for community adaptation and resilience in the Arctic. Warming is causing a variety of challenges in Selawik and a new climate must be accompanied by adaptation and new standards for development. With attention to achieving new appropriate designs, greater coordination between development organizations, and careful community guided planning Selawik can become a model of resilience and adaptation providing needed guidance to other Arctic communities. This report raises awareness about current, emerging, and potential future climate change. It is hoped that this will help the people of Selawik make informed planning decisions, find community appropriate development strategies, and pursue a safe, healthy, and sustainable future.

For more information, contact the Center for Climate and Health by e-mail at akaclimate@anthc.org or by phone (907) 729-2464.

Winter walk past drying fish.
Bob Hallinen.

It is hoped this report will help Selawik make informed decisions and find community appropriate adaptation strategies.

Figure 6. Climate Change Health Assessment Findings, Selawik, Alaska

Topic	Observation	Impact	Potential Health Effect	Adaptation / Recommendation
Climate	Increased temperature since the 1950s, mostly in winter.	Warmer in every month. Spring ice thaw, rather then "breakup."	Falls through ice. Extreme weather impacts.	Travel advisories. Local Environmental Observers (LEO).
Land	Erosion and subsidence related to permafrost thaw.	Fragile land, erosion.	Damage to infrastructure. Interruption of services.	Monitor erosion rate and permafrost conditions.
River	Permafrost thaw and erosion. Increasing flood risk.	Loss of property, threatened infrastructure.	Mental stress, Infrastructure damage, and travel hazards.	Erosion prevention. Relocate homes from vulnerable areas.
Water	Increase in disease vectors. Permafrost thaw, erosion, subsidence.	Lower water quality. Interruption of water services.	Exposure to waterborne disease. Increased cost for operation and maintenance.	Treat water from traditional sources. Prevent runoff related erosion.
Sewer	Permafrost thaw and erosion.	Damage to collection system and lagoon.	Freeze-up, spills, service disruption.	Monitor system, level and repair as necessary.
Solid Waste	Permafrost thaw.	Deterioration of ATV trails.	Water pollution.	Repair access, clean up area.
Transit	Permafrost thaw and erosion.	Sinking foundations. Bridge and road damage.	Injury risk. Infrastructure damage.	Engineering evaluation.
Housing	Permafrost thaw and erosion.	Sinking, building damage, freeze-up.	Loss of water service. Injury, illness.	Structure monitoring. Durable construction. Frequent leveling.
Energy	Permafrost thaw and erosion.	Damage to water and sewer system.	High energy cost undermining utility sustainability.	Structure monitoring. Durable construction. Frequent leveling.
Food	Changing climate, seasonality, and environment.	Change in subsistence timing, quality and availability. Seasonal change in harvest and preservation.	Potential for decreased food security and safety. Some new food resources.	Regular harvest survey updates. Surveillance of wildlife for disease. Continue human hair mercury testing.

River view.
Raj Chavan, 2011.

APPENDIX A

Community and Regional Contributors

Anecdotal data was collected on observations and experiences from local experts in health, wildlife, Inupiat culture, weather, subsistence, education, sanitation, local governance, law enforcement, and emergency services.

	Type	Name	Position / Topic	Association
1	Community	Margaret McCaslin	Resident, subsistence, erosion	Resident
2	Community	Amelia Ballot	Misc.	Resident
3	Community	Leo Berry	Housing issues, boardwalks	Resident
4	Community	Mary Foster	Housing	Resident
5	Community	Barry Foster	Housing	Resident
6	Elder	Daniel Foster Sr.	Subsistence, land, community	Resident
7	Elder	Bert Greist	Subsistence, land, community	Resident
8	Elder	Jack Snyder	Subsistence, land, community	Resident
9	Elder	Emma Ramoth	Subsistence, drying fish,	Resident
10	Elder	Ralph Ramoth Sr.	Subsistence, climate, tundra	Resident
11	Elder	Alice Smith	Elder	Resident
12	Environmental	Lucy Snyder	Coordinator	NV of Selawik
13	Environmental	Susan Clark	Education Coordinator	NV of Selawik
14	Environmental Health	Bruce Dexter	Assistant Water Operator	ARUC / City
15	Environmental Health	Lori Larkin	Utility Manager	ARUC / City
16	Governance	Clyde Ramoth	Tribal Council President	NV of Selawik
17	Governance	Tanya Ballot	Tribal Administrator	NV of Selawik
18	Governance	Diane Ramoth	Tribal Council (former)	NV of Selawik
19	Governance	Hannah Loon	Tribal Council	NV of Selawik
20	Governance	Bessie Foster	Tribal Council (former)	NV of Selawik
21	Governance	Amelia Ballot	Tribal Council	NV of Selawik
22	Governance	Vida Coltrain	Tribal Council Vice President	NV of Selawik
23	Governance	Ellenore Jackson	Tribal Staff – JTE- (former)	NV of Selawik
24	Governance	Raymond Ballot	Mayor (former)	City of Selawik
25	Governance	Roger Clark	City Administrator (former)	City of Selawik
26	Governance	Carrie Skin	City Clerk	City of Selawik
27	Governance	Lori Larkin	City Staff	City of Selawik
28	Governance	James Beylund	City Council	City of Selawik
29	Governance	George Sheldon	City Council	City of Selawik
30	Governance	Lawrence Larkin	City Council	City of Selawik
31	Governance	Vincent Foxglove	City facilities maintenance	City of Selawik
32	Health / Clinic	Esther Tickett	Health Aide / CHAP	Maniilaq
33	Health / Clinic	Krystal Ballot	Health Aide / CHAP/ Supervisor	Maniilaq
34	Health/Clinic	Leo Ballot	Facilities, water service	Maniilaq
35	Health / Social	Lorraine Ticket	Patient Advocate	Maniilaq
36	Health / Social	Millie Greist	Patient Advocate	Maniilaq
37	Housing	Henry Harris	Level and weatherizing	RurALCap
38	Public Safety	Richard Solomon	VPO	City of Selawik
39	Public Safety	Clarence Snyder	VPA	City of Selawik
40	Transportation	Raven Sheldon	IRA Transportation Coordinator	NV of Selawik
41	Wildlife	Frank Berry Jr.	Housing, subsistence	USF&W

APPENDIX B

Selawik Climate and Health Web Resources

Topic	Resource	Location
Selawik Profile	State of Alaska Community Database	http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm
Selawik Erosion Data	USACE Community Erosion Report, 2009	www.poa.usace.army.mil/AKE/Home.html
Selawik Permafrost	UAF Permafrost Laboratory	www.gi.alaska.edu/snowice/Permafrost-lab/
Selawik Flood Data	USACE Flood Hazard Database	http://www.poa.usace.army.mil/en/cw/fld_haz/kivalina.htm
Selawik Temperature Precipitation Projections	Alaska Center for Climate Assessment & Policy	www.uaf.edu/accap/
Selawik Precipitation Frequency Events	National Oceanographic and Atmospheric Administration	http://hdsc.nws.noaa.gov/hdsc/pfds/
Selawik Climate and Health Impacts Reports	ANTHC, Center for Climate and Health-	www.anthc.org/chs/ces/climate/links.cfm
Climate change event observations	Local Environmental Observer (LEO) Network	http://www.anthc.org/chs/ces/climate/leo/
Local Weather Observations	NWS Extreme Weather Spotter Program	http://www.weather.gov/skywarn/ Contact: Harry Lind, NWS in Kotzebue (training & equipment)
Local Weather Observations	Community Collaborative Snow Rain and Hail Program	http://www.cocorahs.org/ Contact: Harry Lind, NWS in Kotzebue
Regional Climate Data	Temperature and Precipitation Data, Kotzebue 1930s-present	climate.gi.alaska.edu/
Regional Climate Data	Center for Global Change and Arctic System Research (UAF)	www.cgc.uaf.edu/
Regional Climate Data	Global Climate Research Center (Barrow)	www.arcticscience.org/
Regional Climate Data	Google Earth climate impact layers	earth.google.com/intl/en/index.html
Regional Weather Data	Extreme Weather Watches, Warnings Advisories, National Weather Service	www.arh.noaa.gov/
Regional River Flood Data	Advanced Hydrologic Prediction Service National Weather Service	http://aprfc.arh.noaa.gov/ahps2/index.php?wfo=pafg3
Regional Health Profile	Alaska Native Tribal Health Consortium EpiCenter	www.anthc.org/chs/epicenter/upload/Regional_Health_Profile_Maniilaq_0408.pdf
Federal Climate Response	Alaska Climate Change Response Center	http://alaska.usgs.gov/
State Climate Response	State of Alaska Climate Strategy	www.climatechange.alaska.gov/
Community Based Monitoring - Coastal	National Weather Service Weather/Coastline Observer Program	www.nws.noaa.gov/om/coop/index.htm
Community Based Monitoring - Diet	Nutritional and Food Security Baseline Survey	www.anthc.org/chs/epicenter/upload/ traditional_diet.pdf
Community Subsistence Harvest	Alaska Department of Fish and Game Harvest Surveys	http://www.adfg.alaska.gov/sb/CSIS/index.cfm?ADFG=harvInfo.harvestCommSelYear

APPENDIX C

General Climate Change Adaptation Guidelines

Local and regional government is challenged with preparing for climate-related impacts, and the need to develop comprehensive adaptation plans. The following are 10 principals for integrating climate change planning into local decision-making. Other principals may be developed by the community in the planning process.

1. Protection of human life and health is the top priority.
2. Local and traditional values should guide local and regional decision making.
3. Development should meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).
4. Community adaptation plans should identify valued and vulnerable local resources, such as infrastructure, subsistence and cultural areas, and water sources.
5. Critical ecological systems, wetlands, and subsistence resource areas should be protected.
6. Consideration for climate impacts should be incorporated into planning, infrastructure siting and design.
7. Cost-benefit analyses should be applied to evaluate the social and environmental costs of building and maintaining climate vulnerable structures.
8. Phased abandonment of at-risk areas should be considered.
9. Extreme weather events are inevitable and disaster response and recovery capacity, including evacuation, emergency response, and availability of shelter, should be reviewed.
10. Building local capacity to participate in climate change monitoring, assessment, and planning is critical to facilitate development of effective adaptation strategies.

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Homes by the river.
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Find this report and other information about climate and health at our website:
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