Climate Change in **Noatak**, Alaska

Strategies for Community Health

ANTHC Center for Climate and Health

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Report prepared by:

Michael Brubaker, MS (Lead Author)
Jake Bell, MGH
James Berner, MD
Mike Black
Raj Chavan, PE, PhD
Jeff Smith, MS
John Warren, PE

ANTHC recognizes all of our technical advisors for this report. Thank you for your support:

Wanda Sue Page, Noatak Tribal Council
Carol Wesley, Noatak Tribal Council
John Chase, Northwest Arctic Borough
Paul Eaton, Maniilaq Association
John Monville, Maniilaq Association
Millie Hawley, Maniilaq Association
Jackie Hill, Maniilaq Association
Desirae Roehl, ANTHC
Moses Tcheripanoff, ANTHC
Oxcenia O'Domin, ANTHC
Jay Butler, M.D, ANTHC
Elizabeth Alstrom, ANTHC
Coleen Sutton, ANTHC
Steven Weaver P.E., ANTHC
Eric Hanssen P.E., ANTHC
Vladimir Romanovsky PhD, UAF
Kenji Yoshikawa, PhD UAF
Katie Morlein, UAF
Courtney Carouthers PhD, UAF
Ben Crosby PhD, Idaho State University
Ben Jones, USGS
Harry Lind, NWS
Bruce Sexauer, USACE
Anne Orlando, USF&W
Rachael Lee, NPS

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Through adaptation, negative health effects can be prevented.

Cover Art:
Whale Bone Mask
by Larry Adams

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SUMMARY

Rural Arctic communities are vulnerable to climate change

and residents seek adaptive strategies that will protect health and health infrastructure. In the Inupiat community of Noatak, climate change is impacting the weather, land, river, wildlife, plants, and the lives of the people who live there. Examples of potential health effects from climate change include injuries from falling through ice, heat stroke from extreme summer temperatures, respiratory ailments from wildfire smoke, gastrointestinal infections from waterborne pathogens, chronic diseases in the absence of food security, and damage to critical infrastructure.

This report documents climate change impacts as described by the local people and interpreted through the lens of public health. It is the third report in a series describing climate change in Northwestern Alaska. The first two reports focused on the coastal whaling communities of Point Hope and Kivalina. This is the first to look at an upriver community characterized by a different climate, environment, and cultural practices. It was prepared by the Alaska Native Tribal Health Consortium, Center for Climate and Health in partnership with the Maniilaq Association, the Northwest Arctic Borough and the Noatak Traditional Council. Funding was provided by the United States Indian Health Service.

Thawing river bank and low water on the Noatak.
Ryan Brubaker, 2010.

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.

Information sources for this report include observations of local residents, reports from government agencies, and scientific evidence gathered from published sources. Noatak has experienced change for at least the past 50 years, as evidenced by warming temperatures in every month of the year. Residents also report increasingly hot and dry conditions in summer, more frequent storms, and extreme temperature swings in winter.

Climate change is resulting in new challenges that need to be addressed. It is hoped that this report will facilitate informed decision making, and help Noatak and other communities in the Northwest Arctic region pursue a healthy future. A summary of the finding are as follows.

River and sea change are increasing travel hazards. The primary transportation route to Noatak is the Noatak River by snowmachine in winter and by small boat in summer. Warming temperatures are making the season for sea ice and river ice travel shorter and more hazardous. In summer, low water in the Upper Noatak and Kotzebue Sound decrease navigability, while increasing equipment damage and travel-related risk and cost. Finding ways to reduce travel hazards is a priority. *Point of contact: Northwest Arctic Borough.*

One of the costs of low water.
Ryan Brubaker, 2010.

Understanding changes in the Noatak River is a priority. Better understanding of how temperature, precipitation, permafrost thaw, erosion, human activities, and plants and wildlife affect the Noatak River basin would benefit public health by increasing understanding about water security, projections for river change, and potential for negative health impacts. *Points of contact: UAF, USGS.*

The community water supply is vulnerable to changes in the river. Shallow wells in the Noatak River provide community water. The water level in the river has been decreasing in recent years, as has the seasonal distance from the wells to the river. The primary well has occasionally run dry, and there is no known viable ground water alternative. Monitoring the water level in community wells is recommended to better understand source water trends. *Points of contact: Maniilaq, ANTHC.*

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.

Leaning utility poles.
Ryan Brubaker, 2010.

River water level changes are reducing accessibility and increasing the cost of living. Low river level has prevented barge service to Noatak for over a decade. Now the travel season for even small vessels is decreasing and threatening community sustainability. Factors affecting river navigability and community access should be studied. Pursuing alternatives for community access, fuel, and freight delivery is recommended. *Points of Contact: NWAB, DCCED, NANA.*

Critical infrastructure is vulnerable to subsidence and erosion. Noatak's location on the west-facing bank of the Noatak River increases vulnerability to permafrost thaw, subsidence and erosion. There is only one permafrost monitoring point in Noatak, installed by UAF in 2006. Increased permafrost surveillance is recommended, especially in the vicinity of critical infrastructure and homes. Careful evaluation of ground conditions and best practices during construction are recommended to minimize disturbance to vegetation and underlying soil. Foundations can be monitored for damage and leveled as needed. *Points of contact: ANTHC, UAF.*

The water treatment plant foundation is unstable due to permafrost thaw. Beneath the water treatment plant the soil has thawed resulting in settling of the slab foundation by at least four inches. The primary cause of foundation failure appears to be the waste heat supply and return lines. Other contributing factors may include thawing caused by rainwater runoff, warming by the sun, and retarded freezing of the soil caused by snow drifts. Corrective action is needed to prevent further damage to the water system. *Points of contact: ANTHC, Maniilaq.*

The water distribution system is being damaged due to permafrost thaw. Within the last decade, more than a dozen water main breaks and leaks were observed and repaired. These have been attributed to ground movement due to thawing of the permafrost surrounding the pipeline. Similar problems have occurred with the waste water system. More frequent monitoring of pipelines will be necessary to prevent line breaks in the future, and to repair them before they can develop into a community water shortage or other problems. *Points of contact: Maniilaq, ANTHC.*

Seasonal change in water quality is an emerging water treatment problem. Erosion during the warm seasons and heavy rain storms can affect turbidity. The water system relies on bag and cartridge filters to remove solids, and chlorine to disinfect the water. High turbidity is clogging filters, decreasing effectiveness of chlorine, increasing maintenance and operational cost. Recommendations include monitoring of source water conditions, an in-depth analysis of treatment system performance, and evaluation of alternative water treatment processes. *Points of contact: ANTHC, Maniilaq, ADEC.*

This report is about the effects of climate change—both good and bad—on people's lives as described by Noatak's residents and interpreted through the lens of public health.

Bank erosion is depositing waste from the old dump site into the river. The abandoned dump site in Noatak is gradually being exposed because of erosion. Permafrost thaw is a contributing factor destabilizing the bank during summer months. The waste from the dump is falling into the Noatak River, downstream of the community. Relocating the old dump would prevent further river pollution. An engineering feasibility study is recommended for dump relocation. Funding can be pursed through an EPA Tribal Solid Waste Management Assistance Grant. *Points of contact: EPA, ADEC, NANA.*

Disappearing river.
Ryan Brubaker, June 2010.

Coastal subsistence camps are at increased risk from flooding. Seventy-five percent of the recorded major storm events have occurred during the past eight years. Permafrost thaw and delayed freeze-up makes these storms more damaging to fragile coastlines. Precautions to prepare for flooding and to prevent injury and property loss are recommended. *Points of contact: NWAB, USACE.*

Warming climate impacts air quality and the risk of respiratory ailments. Noatak has experienced increasing number of wildfires related to hot summer temperatures, increased lightening strikes, and dry forest and tundra conditions. Wildfire smoke and dust from wind and summer road and airfield traffic can increase the risk of respiratory ailments, as can allergens like tree pollen that is projected to increase in the region. Air quality monitoring, advisories, and dust control measures are recommended. *Points of contact: ADEC, ANTHC, DOT.*

"We were stranded for five days down river, because the water was so low."

Leslie Burns

High summer temperatures increase risk of heat stress. Summer temperatures have exceeded 90 °F in Noatak and are projected to continue increasing. Noatak clinic has recently seen cases of mild heat stress. It is recommended that the adequacy of building designs for hot summer conditions be assessed. *Points of contact: NWAB, NWIHA, RurAl Cap.*

Food security is a concern for many households. About 39% of households in Noatak reported low to marginal food security in 2007. The high cost of living is one important factor and the availability of adequate subsistence resources is another. Funding for regular harvest assessments by the Alaska Department of Fish and Game is recommended to monitor harvest levels and food security. *Points of contact: ADF&G, Maniilaq.*

Butchering caribou.
Courtesy Wanda Sue Page.

At first we thought the caribou, our lifeblood, our subsistence staple, was just very, very late. But they just never showed up. The majority of Noatak did not get their catch."

Carol Wesley

Poor sea ice conditions are increasing the risk for injury. Hunters last spring reported growing difficulty in navigating to spring harvest areas because of thin and slush ice conditions. Hunters can expect increasing hazards with sea travel. Personal locator beacons can be used to increase speed of rescues, and float coats to reduce risk of drowning. *Points of contact: NWAB, Maniilaq.*

Low water level is an obstacle to navigation in Kotzebue Sound. Water level has been low in recent years, groundings boats traveling to and from subsistence camps. Hunters are concerned that climate may be a contributing factors reducing stream flow and increasing sediment discharge into the Sound. Factors contributing to change in Kotzebue Sound could be studied and appropriate navigational aides installed. *Points of contact: NWAB, NOAA.*

Traditional food and water safety monitoring. Water from traditional sources can carry pathogens such as giardia lamblia, and traditional foods can carry infectious diseases. Surveillance of subsistence foods and traditional water sources is recommended. Appropriate guidance measures can be provided as needed. *Points of contact: Maniilaq, ANTHC.*

Changing environment presents increased risk for some food borne and water borne diseases. Emerging wildlife can introduce new infectious disease. Some pathogens can be passed on to people through uncooked food, untreated water, or by hand to mouth contact. Noatak residents are advised to take appropriate health precautions such as treating water from traditional sources. *Points of contact: Maniilaq, ANTHC, ADF&G.*

Climate change is affecting subsistence harvest and may affect diet - Regular surveys by ADF&G will help monitor subsistence harvest at the community level. Integrating survey methods that will monitor time of harvest season and change in harvest season is recommended. Periodic dietary surveys would compliment harvest data. *Point of contact: ADF&G, ANTHC.*

Adaptation capacity would be improved by establishing local environmental observers. This would involve individuals who would monitor environmental change related to climate including precipitation, coastal conditions, soil temperature, erosion, wildlife change, pollution events, and emerging health concerns. *Points of contact: ANTHC, UAA, NWS, UAF, NOAA, USACE.*

"The kids notice what is going on, but we just go with it. More swimming time I guess."

Nicki Foster

Summers are increasingly hot and dry; Children playing in the Noatak River.
Ryan Brubaker, 2010.

INTRODUCTION

Noatak is an Inupiat community of about 500 residents located on the west bank of the Noatak River. Over 90% of the residents are Alaska Native or part Native. Life in Noatak revolves around subsistence activities as people engage year-round in hunting, fishing, and gathering wild foods and materials they need from the land and sea. They base these activities from two distinct areas: up-river at Noatak and on the coast at the seasonal subsistence camps of Nuvguruk and Sisualik. The most important subsistence species by harvest weight are caribou, Dolly Varden trout, chum salmon, bearded seal, and white fish. Over 40 other varieties of plants and wildlife are also harvested (Magdanz, et al., 2010).

Climate change refers to change over time due to natural variability or as a result of human activity (IPCC, 2008). In Noatak, the rate of climate change is not just measured in decades, but rather in years, months, or even hours. Residents traveling the river encounter sections of collapsed riverbank that were intact only hours before. In Noatak, the spring ice break-up was once a community event with people lining the riverbank to watch the ice crack, boom, and flow downstream towards Kotzebue Sound. Today, such breakup events are mostly a memory. As one resident stated, "the ice now is humble and leaves quietly."

In every season of the year, the air temperature is warmer than it was in the past. Land is thawing and then washing away into the rivers. Sea and river ice is diminishing, making travel and hunting more dangerous. New species of plants, insects, fish, birds, and other wildlife are observed, while harvest of traditional species, such as caribou is more time consuming, hazardous, and difficult. These changes are influencing food and water security and increasing the potential for disease and injury. These changes also raise new concerns about the mental health of Arctic people, as concern about on-going change and uncertainty about the future weighs heavily on the Inupiat.

Low water on the river bank.
Ryan Brubaker, 2010.

"When I was growing up, we had big boats, 26' long. We can't use boats like that anymore."

Amil Burns

In January, March and July of 2010, and April and May of 2011, sites visits were performed by ANTHC's Center for Climate and Health. 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 Noatak 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, a shorter flu season, longer boating season, less ice jam flooding, and warm summer days for playing in the river.

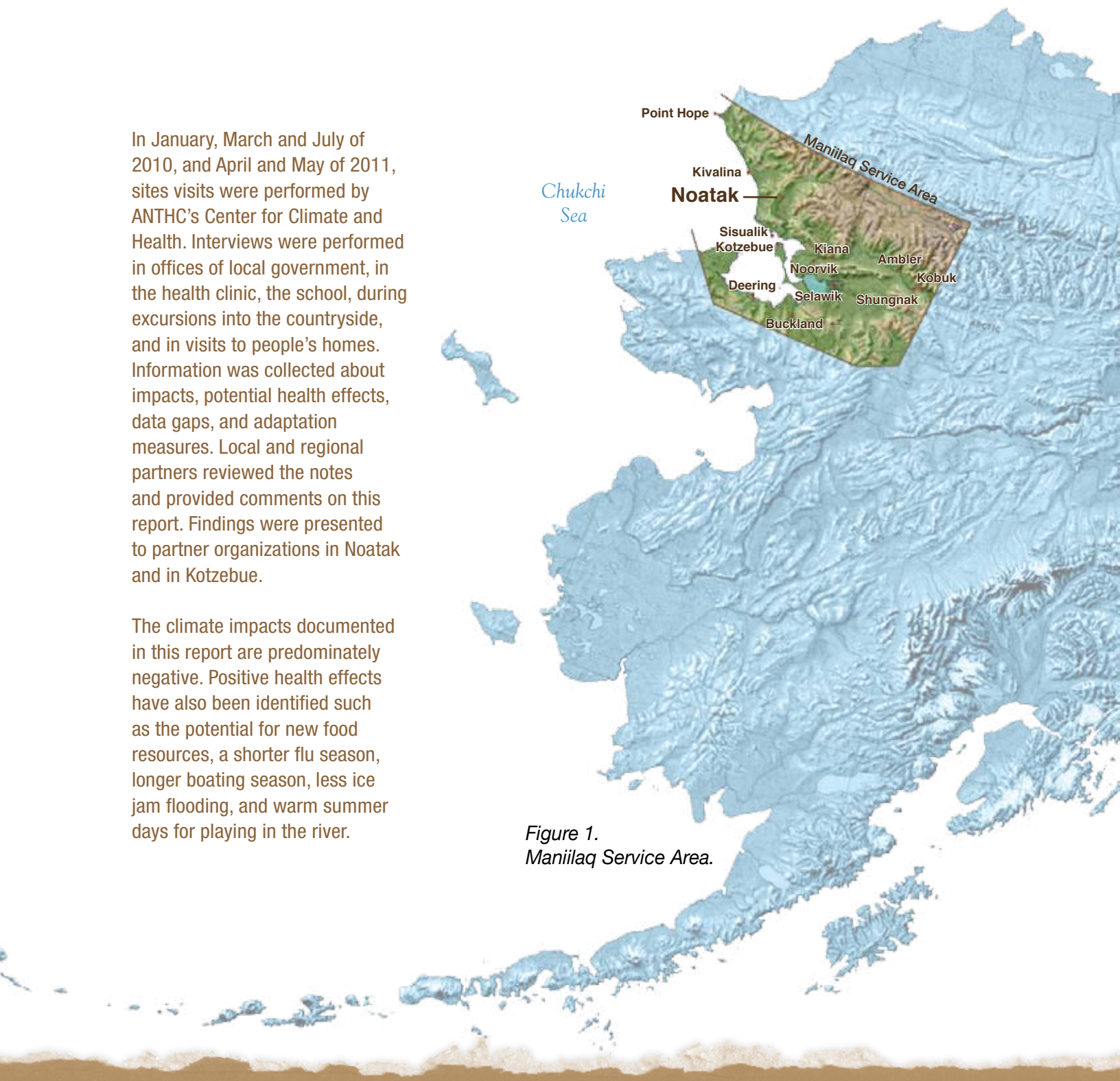


Figure 1.
Maniilaq Service Area.

"Where is the water going? It is worrisome!"

Robyn Howarth

COMMUNITY

The Noatak area has been used by the Inupiat for over 1,000 years.
The descendants of people from 32 settlements once spread across the upper and lower Noatak River now inhabit the modern community of Noatak (Burch, Jr. 1998). The Community is located on the west bank of the Noatak River, 55 miles north of Kotzebue and 70 miles north of the Arctic Circle. It is the only community on the river that runs for over 100 miles from the Delong Mountains to its outlet in Kotzebue Sound. The 1880 census listed the site as Noatagamut, which means "inland river people." The modern community was founded in 1908 when a mission and school were constructed (Burch Jr., 1998). The Native Village of Noatak was established under the Indian Reorganization Act of 1939 and a post office was established in 1940.

No roads lead to Noatak and the community relies on the river for transportation all year round. Noatak has been without barge service for years, due to low water conditions in the river. Transport by aircraft is expensive but it is the only way to bring bulk loads of fuel into the village. In winter, the river provides an ice road inland to the mountains for hunting and downriver for travel by snowmachine to Kotzebue. In spring the river floods, filling the drainage with melting ice and water right up to the banks of the village. In summer, a sandy beach exposed by the receding water provides an area to pull up small boats, for catching fish, for picnics and cook outs and for children to play in the shallow water of the river. As the water level drops, dry beds provide avenues up and down the river for ATVs to recreate and to travel to subsistence harvest areas.

Subsistence is perhaps the most important activity in Noatak, but residents are employed in construction, mining, fishing, guiding, health care, education, traditional crafts, and the government services required to keep a rural Alaska community running. In many ways, Noatak looks like other Arctic villages: there are rows of HUD houses, a few churches, the tribal administrative offices, a health clinic, water plant, school, Native store, and a bulk fuel storage facility. Snowmachines, sleds, boats and ATVs are parked outside houses. In summer, there is a landing for small boats down river. It is also a "dry" community, where the sale, importation or possession of alcohol is banned.

The village is separated into two areas; the old town site along the river, and the new housing development, clinic, and school located a short distance inland. Most of the homes were constructed by the Northwest Inupiat Housing Authority. The homes are heated by small fuel oil stoves, some homes also burn wood. The tribal government manages local utilities including water, sewer, and operation of the dumpsite. Electricity is provided by diesel generators operated

"The river gets lower every year. We have not been able to get a barge since the early 90s. We have to fly everything in. The prices at the store are very high."

Lucy Hall

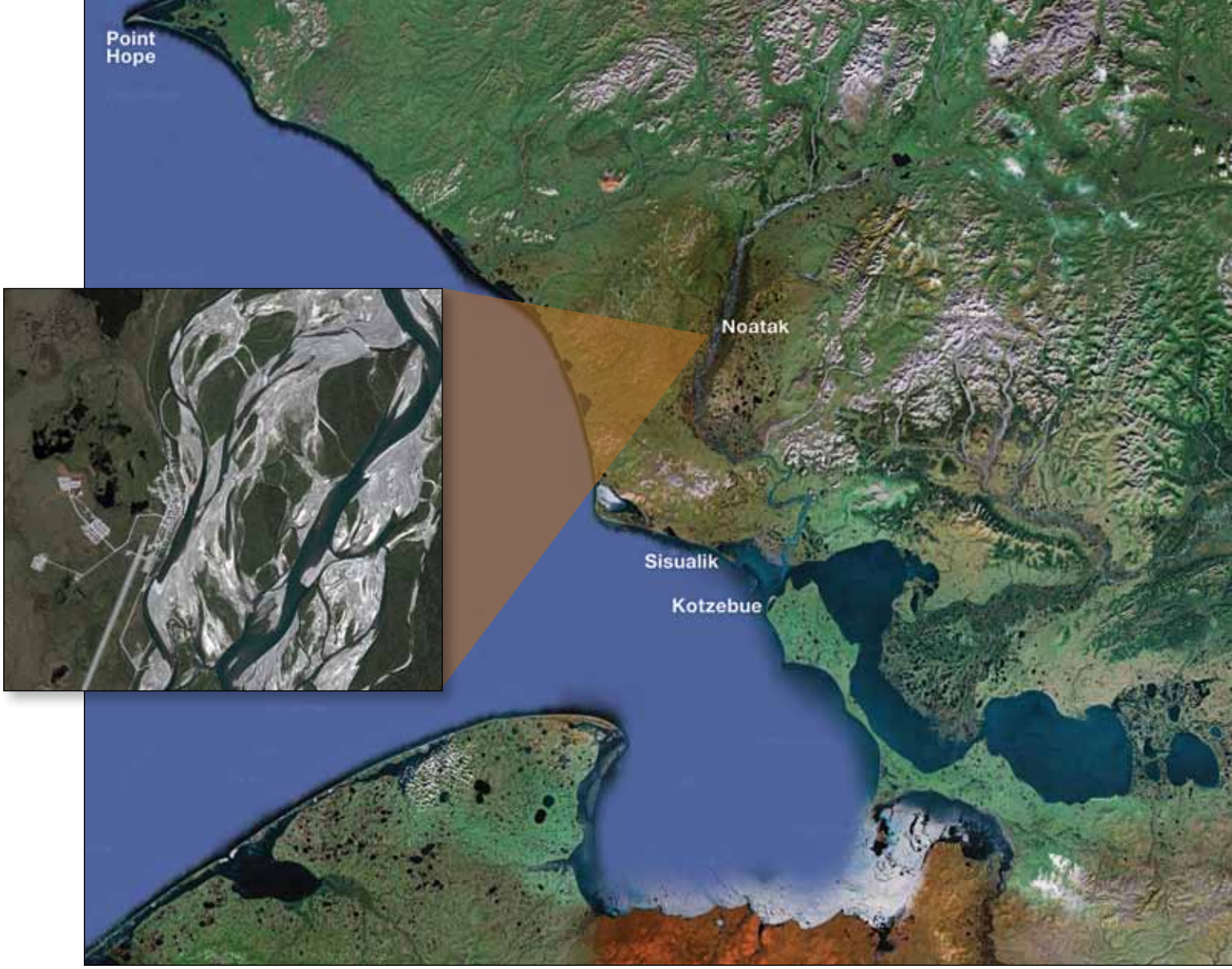


Figure 2. Google view of Noatak and regions.

by the Alaska Village Energy Cooperative. Heating oil and gasoline is sold from a pump located outside the Native store. Fuel prices in Noatak are among the highest in the region. In 2010 the per-gallon price for fuel oil was as high as $10.99 and $11.99 for gasoline. In times of fuel shortage the prices can be as high as $15.00 per gallon.

"The river is more important for supplies than by air. We bring a lot more in by boat or by snowmachine."

Nora Booth

The Napaaqtugmiut School is administered by the Northwest Arctic Borough School District and provides K-12 education for about 156 students. The Esther Barger Memorial Health Clinic is operated by Maniilaq Association and is staffed by two 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. Community water is derived from three shallow wells in the Noatak River. The water is treated using filtration and chlorination. A piped, recirculation water and sewer distribution system serves approximately 77 of the 100 homes in the community, plus the school, clinic, and businesses (LCG, 2009). Approximately 23 homes cannot use the service due to lack of plumbing. These residents haul water and use honey buckets (DCCED 2011). The community does not have a washeteria.

Potlatch on the banks of the wide Noatak River.
Brenda Brandon, June 2003.

Seven years later.
Mike Brubaker, June 2010.

Seasonal Camps

Many residents travel each spring down the Noatak River to seasonal subsistence camps located on the coast. Sisualik and Nuvgurak, are located 60 miles from Noatak. These camps provide excellent access for fishing, sealing, whaling, berrypicking and bird hunting. Sisualik, recorded as "Sesualik" by Captain Frederick William Beechey in 1831, was once an Inupiat village. In the 1880 census, Sisualik was listed as "Sheshalegamute" with a population of 100. Today, during the sealing and fishing seasons, Sisualik is still like a small village, with family owned camps stretching for miles along the coast of Kotzebue Sound. There are no local services in Sisualik, nor is there much in the way of infrastructure. Electricity is provided by small diesel generators or solar panels. Water is hauled from Kotzebue, Noatak, or collected from tundra streams in the vicinity. Honey bucket waste is disposed of at nearby ponds and solid waste is hauled out or burned.

"Our river used to be plenty wide. Now we don't hardly have a river."

Don Booth

Cutting seal at Nuvguraq.
Mike Brubaker, 2010.

"We don't have break up anymore. We used to sit on the bank and watch the ice pop and break up. Now it just melts."

Tanya Kirk

CLIMATE

Observed change: *warmer temperatures in every season; more precipitation except in summer.*
Health concerns: *extreme weather injury and illness.*
Potential adaptation: *improve local weather observations.*

Weather is temperature, precipitation, humidity, wind, and other conditions that we experience on a daily basis. "Climate," on the other hand, is based on long-term weather trends. Over the past 50 years, Alaska has experienced temperature change and warming at more than twice the rate of the rest of the country.

Noatak is located in the Arctic Maritime climate region of Alaska. Average temperatures range from 5°F to -15°F in winter to between 45°F and 60°F in mid-summer. Temperature extremes have been recorded from below -50°F to over 90°F. Annual snowfall averages 48 inches, with 10 to 13 inches of total precipitation. The highest temperatures occur between July and August, and the lowest temperatures in January. For precipitation, the wettest month is September, and the driest is June. Subsistence camps on the coast benefit from the cool maritime weather that provides good conditions for drying fish, seal, and caribou meat. There is also more precipitation and wind on the coast, while inland the summers tend to be hot, dry and less windy. Residents report summers that are increasingly hot and dry even on the coast, and winters that are more variable with sudden and dramatic temperature swings. The annual average temperature in Alaska has increased 3.4°F, with winters warming by 6.3°F (Fitzpatrick et al., 2008).

Noatak Ice Road.
Mike Brubaker, 2010.

"There was hardly any snow this winter. We had to travel on the river, because it was too rough on the tundra."

Robbie Kirk

Average annual temperatures are projected to rise another 3.5°F to 7°F by the middle of this century (U.S. Global Change Research Program, 2009).

Community Charts developed by the Scenario Network for Alaska Planning (SNAP) at the University of Alaska Fairbanks (UAF) provide down-scaled temperature and precipitation data as well as projections for the future. For air temperature, snapshots of two previous time periods are available: 1961 to 1990, and 2001 to 2010 (see Figure 3). During these periods, the average monthly temperature in Noatak increased in every month of the year. The biggest temperature increases occurred in winter; January temperatures increased by about 4°F. Smaller increases occurred in other seasons with the least, 1°F, occurring in June.

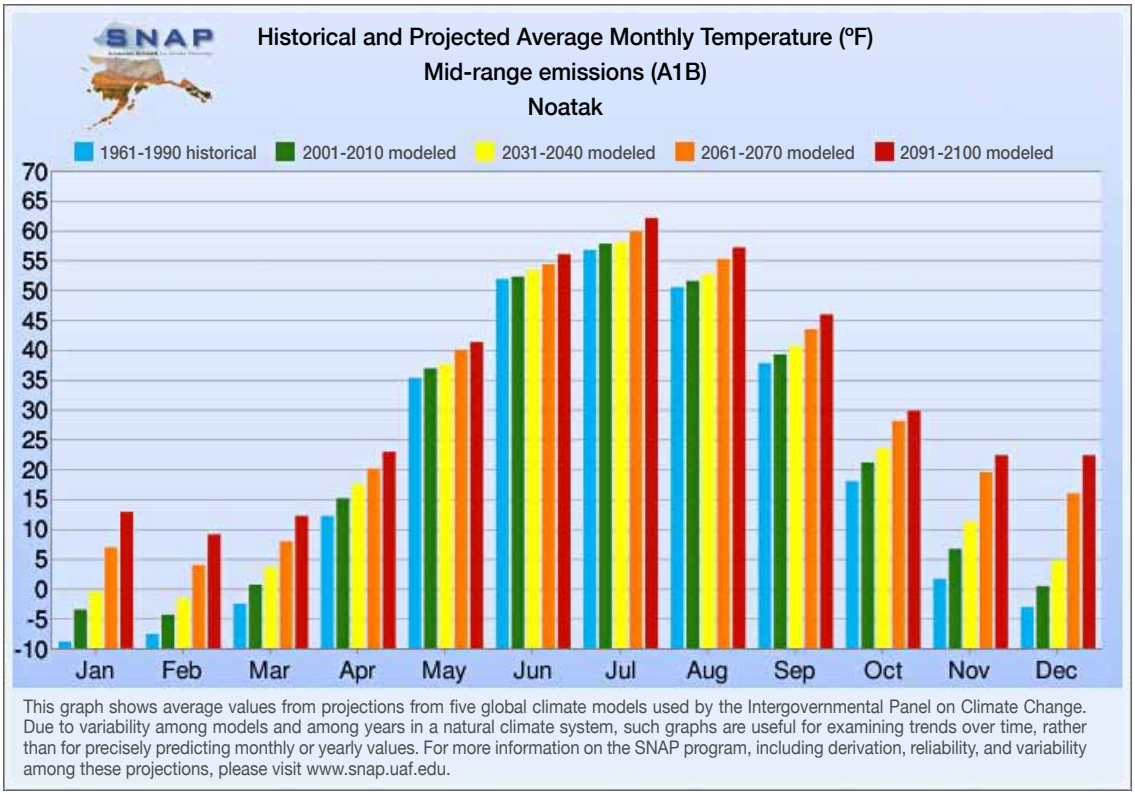


Figure 3. Historic & Projected Temperature, Noatak, Alaska.
UAF, Scenario Network for Alaska Planning 2010.

"When the temperature gets into the 80s the clinic puts out an alert on the VHF for elders to stay inside and drink lots of water. We don't want them to get heat stroke."

Tanya Kirk

The precipitation record for Noatak is not as complete so there is only one period available, from 2001 to 2010 (see Figure 4). Assessing precipitation trends for Noatak will have to wait for more data, but Kotzebue has good precipitation records and we know that there has been a gradual increase in annual average precipitation since about 1950 (Alaska Climate Research Center).

SNAP Community Charts also provide future "projections" based on five global models used by the United Nations Intergovernmental Panel on Climate Change (IPCC). There are three scenarios, based on high, low, or medium projected global CO2 levels. The graphs included in this report are for the medium CO2 level projections (SNAP 2010). In all

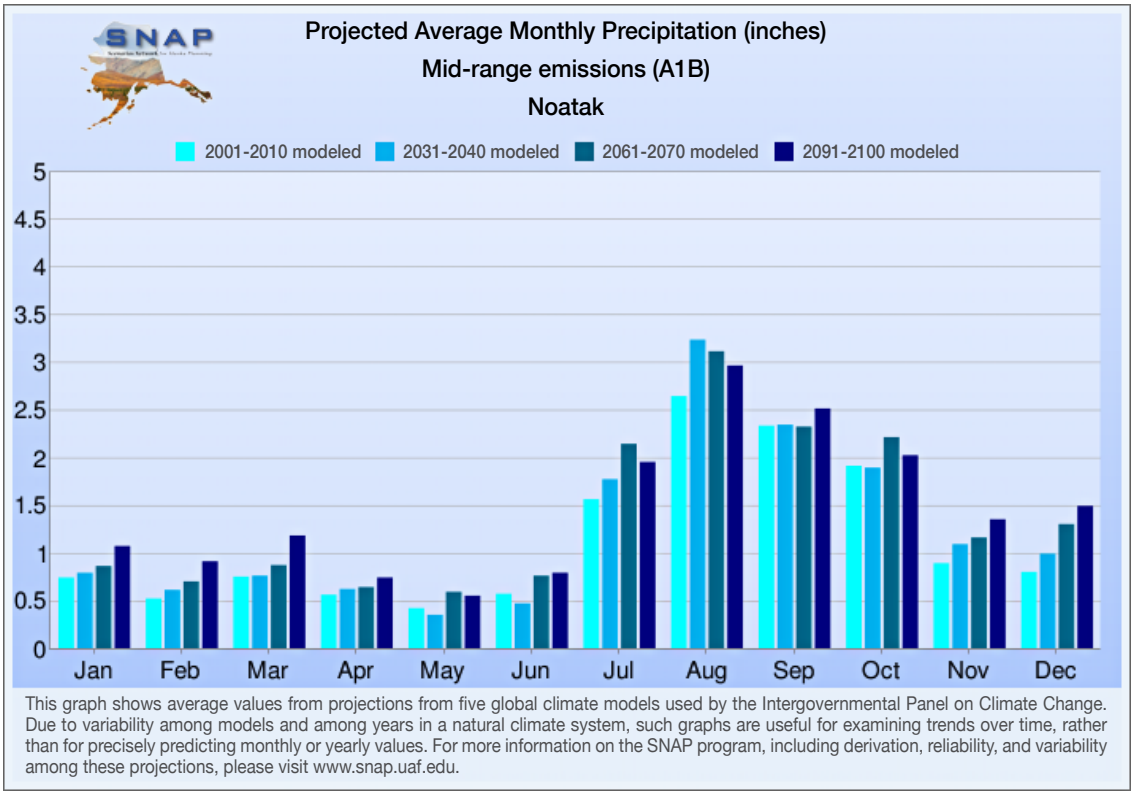


Figure 4. Projected Average Monthly Precipitation, Noatak, Alaska.
UAF, Scenario Network for Alaska Planning 2010.

"We had fires from lightening near the school and the graveyard. The fire actually burned the crosses. We had to clean them up before Memorial Day."

Robyn Howarth

scenarios, the monthly warming trends are expected to continue with the biggest increases occurring in the winter. Despite higher annual precipitation, a generally drier summer is expected resulting from increased temperature, evaporation and transpiration and decreased precipitation.

One persistent question not directly addressed by climate models is whether the future will bring more snow or less. Adequate snow is important for many reasons including winter travel by snow machine. Too much snow and all travel comes to a standstill; too little and travel becomes limited to ice on the rivers. Snow is one of the precipitation measures that have not been collected in Noatak because of the lack of local weather observation personnel.

Recommendation: Residents rely upon local and traditional knowledge to make decisions about where and when to hunt and travel. They also rely upon weather data from the automated weather station at the Noatak airstrip, and observations from the National Weather Service. Two staff members from Noatak IRA Council were trained by the National Weather Service in 2010 to collect daily precipitation data. This is a promising new capacity and should be encouraged. Having daily precipitation measures would improve weather forecasting and climate change monitoring, and development of appropriate adaptation responses.

Noatak health clinic.
Mike Brubaker, 2010.

"We went up river with some friends. Inside the boat it got very hot. The driver got heat sick. He spent the night in the clinic."

Tanya Kirk

SEASONS

Observed change: *later freeze up; early thaw; change in time of harvest.*
Health concerns: *travel hazards; food insecurity; chronic disease.*
Potential adaptation: *monitor seasonal change, adjust harvest period.*

Seasons for the Inupiat are different than in western traditions

and are closely tied to the Arctic climate, subsistence, and important cultural activities. Understanding seasons as described and measured by residents of Noatak is important for recording local observations and measuring change. How seasons have changed, and may still in the future is an important public health question. Table 5 provides an overview of traditional subsistence seasons in Noatak based on important subsistence resources.

Recommendation: The biggest seasonal concern is the decreasing harvest of some land and sea mammals. Active monitoring of seasonal change related to weather, environmental conditions, and subsistence harvest are important for developing effective adaptation strategies. A community-based monitoring program can help document seasonal change. Resources could include the National Phenology Network through the United States Geologic Survey. The Alaska Native Tribal Health Consortium and the University of Alaska, Anchorage, Institute for Circumpolar Health are providing assistance in developing methods for monitoring seasonal change using local environmental observers (LEOs). Another model is the SIWO or Sea Ice for Walrus Outlook program, that teams scientists, satellite technology, and local observers to monitor sea ice conditions and improve safety for Eskimo hunters.

Noatak snowgo ride.
Mike Brubaker, 2010.

"I used to be riding my snowgo on my birthday, October 28. Now the seasons are all tangled. It is really weird."

Nicki Foster

Figure 5. Traditional Subsistence Seasons.

Name	Inupiat	Traditional Season	2010-2011 Season	Comments
Bearded seal	Ugruk	June	Sea ice conditions are changing	Greater dependence on seal because of high cost of living.
Beluga whale	Sisuak	April	Same	We wait till word from the coast, Kivalina and surrounding, then head out from Noatak
Blueberries	Asiavik	End of July	Same	It was a good berry season.
Caribou	Tuttu	August-Winter	No Caribou season (missing)	Frustration - there was potential for boating all the way into October but no Caribou.
Chum Salmon	Qalugrauq	July-Sept	Same	Drying salmon has been difficult. Temperature is often too warm.
Dolly Varden trout	Aqalukpiq	Year round	Same	People did not catch many trout this year.
Moose	Tiniikaq	September - October	Same	Harvested as you come upon them, not necessarily heavily sought after, 3 moose were harvested by community members this year
Salmonberry	Aqpik	End of July-August	Same	
Whitefish	Sii, Qaalgig	Sept-Oct, May-June	No change	Some big whitefish caught recently by some proud community harvesters.

ANTHC, 2010.

"We are boating till November. Then it rains in January. The kids go swimming in June instead of July."

Enoch Mitchell

AIR

Observed change: *hot and dry summers; increased wildfires; changing plant species.*
Health concerns: *respiratory ailments from smoke, dust, and pollen and other allergens.*
Potential adaptation: *fire and road dust management and air quality advisories.*

Climate change can impact air quality in the Northwest Arctic

by affecting three kinds of outdoor air pollutants: dust, smoke, and allergens such as pollen. These air pollutants can increase risk of respiratory ailments, incite asthma and acute bronchitis, and compromise people with respiratory disease and other ailments.

Historically, wildfires have been rare in the Northwest Arctic, but today wildfires are more frequent. Between 1950 and 2007, the number of wildfires increased significantly (Joly et al., 2009), the result of warmer and drier summer conditions, more frequent lightening strikes, an increase in woody plants, and tinder dry conditions on the tundra and in the taiga (Duffy et al. 2005). Big fires typically occur every 10 years, but recently the period has been about every five. In the Northwest Arctic, more then 10.5 million acres burned between 1950 and 2007, including 24.1% of boreal forest and 9.2% of the tundra (Joly et al., 2009).

Dust is an on-going problem in Noatak and many other rural Alaska communities, aggravated in recent years by the increasing use of vehicles. The streets in Noatak are sand and gravel. When conditions are dry, clouds of dust can be kicked up by wind, the movement of heavy equipment, planes at the airstrip, or passing vehicles can inundate the village. Dust generally contains coarse dirt particles that can, when inhaled, aggravate heart or lung-related conditions such as asthma and it sometimes contains man-made and naturally-occurring pollutants. Sensitive individuals or people with respiratory conditions can reduce their health risks by

Wildfire is a growing threat along the Noatak.
ANTHC archives.

"When it gets hot we get a lot of fires and it is hard for elders and babies. The smoke inhalation effects people's asthma."

Robyn Howarth

staying indoors during dusty conditions. Foods such as berries and fish and meat that are affected by dust should be rinsed before eating and water storage containers should be covered.

How climate change may affect dust levels in Noatak is uncertain. Increased precipitation could result in fewer dusty days, while drier summer conditions could increase dust conditions. In 2001, the State of Alaska Department of Environmental Conservation tested the air quality in Noatak and five other Northwest Arctic communities: Ambler, Buckland, Kiana, Kotzebue and Noorvik. All six communities had summer dust levels that exceeded the EPA national standard for particulates. Noatak has some of the worst summer dust conditions anywhere in the country. The Alaska Department of Transportation is testing road dust control methods in Noatak this summer. Based on the outcomes of these tests, a community plan is recommended to consider appropriate dust suppression strategies.

Dust kicked up by ATVs.
Courtesy Wanda Sue Page.

Dust cloud whipped up by takeoff envelopes Noatak.
Mike Brubaker, 2011.

Allergens produced by tree pollen may also be an emerging air pollutant in the region. Typically, the Arctic has had low incidence of hay fever, as tundra does not produce as much pollen as do grass and forest lands. But as new vegetation including deciduous trees have become established, allergies have increased in some parts of the state (personal communication Dr. Jeffery Demain). No reports of air quality problems were noted for the subsistence camps of Nuvgurak or Sisualik.

Recommendation: Clinical staff provide air quality advisories by VHF radio, when smoke or dust levels are high. Local monitoring of dust levels and tracking of the number of poor air quality days is recommended.

"There are quite a few people who have seasonal allergies. This is worse in the summer when it is hot and dusty."

Lucy Hall

SEA

Observed change: *poor ice condition; increased waves; low water in Kotzebue Sound.*
Health concern: *injury; exposure; drowning; mental stress, food insecurity.*
Potential adaptation: *apply condition appropriate equipment and methods for sea travel.*

Changes in sea ice conditions are one of the most pronounced climate impacts in the Northwest Arctic. The Chukchi Sea was typically ice-free from late June until mid-September, when slush ice would form along the shoreline. In recent years however, ice-free conditions have been occurring as late as December and January. This means a shorter season for over-ice travel and ice-based hunting. The decrease in summer sea ice has become very pronounced (Comiso, 2002; Shimada et al. 2006). Over large areas of the Western Arctic the ice depth has decreased by one to three feet (Shirasawai et al., 2009). Continued sea ice retreat is projected.

From the seasonal hunting camps at Nuvgurak and Sisualik, Noatak hunters travel in small boats out to the ice floes to hunt for seal, bearded seal, beluga whale and walrus. In 2010, hunters described spring ice conditions that made boating hazardous. The ice flows were light and easily pushed by the wind, which resulted in boats becoming trapped between drifting ice. They also described sea ice that was too thin to walk on, making retrieval of seal difficult and more hazardous. Decreasing ice cover has also increased the distance that the wind travels over open water, making waves larger.

Kotzebue Sound is very shallow with depths averaging nine to fifteen feet. Travel by boat across the Sound can be dangerous when water levels are low. Boats can easily become grounded in the soft shallow bottom, delaying travel and increasing risk of injury. The shallow conditions are due to the output of three rivers -- the Noatak, the Kobuk and the Selawik -- which discharge large amounts of sediment and create sand bars. Seasonal residents expressed concern over possible

Shallow water – Dr. Tim Thomas pushing stuck boat.
Mike Brubaker, 2010.

"The water in the Sound is really low this year."
Mike Adams

Robbie Kirk heads out to hunt ice seal.
Mike Brubaker, 2010.

climate impacts to water level, such as reduced snow pack in the mountains and increasing sediments from riverbank erosion. Sea level rise could provide some benefit improving navigability of the Sound. For the time being, residents have observed that the Sound is freezing up later in the fall then in the past. This extends the boating season, but can significantly delay the ice travel season by snowmachine.

Recommendations: Poor ice conditions can increase the risk of injury and reduce harvest of sea mammals. An analysis of frequency and seasonality of ice related hazards is recommended. Technology like personal locator beacons being distributed by the Northwest Arctic Borough are recommended to reduce the response time for people who have been stranded or are otherwise in peril. Monitoring of sea ice conditions through the Sea Ice for Walrus Outlook program (SIWO) can also help increase safety. Low water is an obstacle to navigation in Kotzebue Sound. It is recommended that changes in Kotzebue Sound be studied and appropriate navigational aides installed as needed.

"There is really young and thin ice. You have to be really careful. The wind will blow it into you and trap your boat."

Morris Wilson, Sr.

COAST

Observed change: *delayed fall freeze-up; increased storm intensity.*
Health concerns: *storm-related injury; damage to infrastructure.*
Potential adaptation: *flood damage assessment; flood and storm preparedness.*

Although Noatak is an upriver community, residents travel down to the coast in the spring, to subsistence camps located on the south side of Kotzebue Sound. So, the residents of Noatak are also coastal people with hunting practices, traditional use areas, resources and property that are vulnerable to coastal ice conditions, storms, erosion and flooding.

Since the early 1980s, the time between spring breakup and autumn freeze-up along Arctic shorelines has increased from three months to five. In 2009, the freeze-up occurred 30 days later then average (Harry Lind, NWS personal communication). This means longer periods when the coastline is ice-free and highly vulnerable to erosion.

This seasonal camp is vulnerable to flooding.
Mike Brubaker, 2010.

Seasonal camps located in low lying coastal areas like Sisualik and Nuvgurak are increasing at risk of damage from storm surge and flooding.

Nuvgurak and Sisualik are located on a sand and marsh peninsula that extends into the northern half of Kotzebue Sound. The average elevation range from approximately three to nine feet (Google 2011). Since 1970, 75% of the major storm events on this coast have occurred during the past eight years (Gray, 2009). No flood risk information was available for Nugvurak or Sisualik. In the neighboring community of Kivalina, 67 miles north, the U.S. Army Corps of Engineers has established a 50-year estimated flood risk of 13.7 feet (USACE, 2006).

Traveling up the Noatak River.
Mike Brubaker, 2010.

Both camps are mostly seasonal use and in the case of a major storm threat, evacuation may be possible by air from a small gravel strip. Inland channels provide protected boat passage for some camps, to the Noatak River. Flooding would threaten the air strip and private cabins. No accurate measures for mean sea level are available nor have future sea level rise estimates been made for Sisualik. The United Nations has estimated sea level rise of one-to-two feet over the next 100 years (IPCC, 2007), however these estimate are seen by many as overly conservative, and estimates of up to three feet are now common.

Recommendation: Seasonal camps located in low lying coastal areas like Sisualik and Nuvgurak are at increased risk of storm surge and flooding. Sea level rise is expected to increase risk in the near future. It is recommended that seasonal residents be prepared for a decreasing beach area and increased risk of storm damage to property.

"The ice is different at camp. They are just melting. Can't boat around. It is hard to get to the seals, because of rotten ice."

Noah Downey

LAND

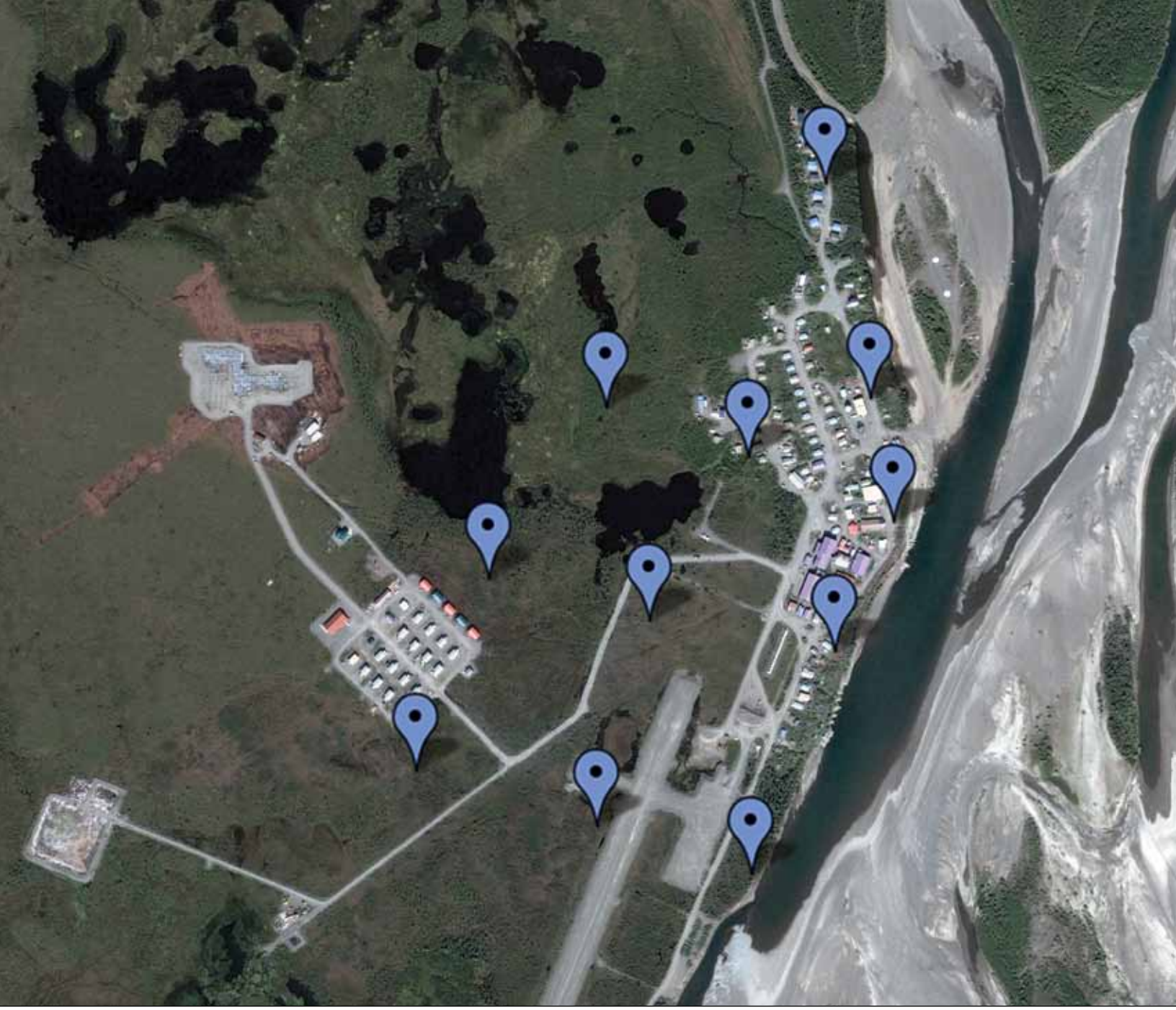
Observed change: *rapid permafrost thaw; erosion; subsidence.*
Health concerns: *hazardous travel; damaged infrastructure.*
Potential adaptation: *travel advisories, erosion prevention; ground temperature monitoring.*

Warming in the Northwest Arctic is causing the thaw of ice-rich permafrost, erosion, and subsidence. One of the most dramatic land changes in recent years has been the appearance of hundreds of thermokarsts, areas where warming permafrost results in erosion. Large slumps have been documented along the Kugururok River, a tributary of the Noatak and in the Makakrak section of the Noatak (Enoch Mitchell, personal

Mike Sherman shows former ground level at the old school.
Ryan Brubaker, 2010.

"When I was a kid we used to crawl under the school skirting. It was really tight. Now the ground has settled at least a foot."

Mike Sherman



Map of proposed permafrost monitor sites.
Prepared by ANTHC.

"An expanded monitoring system would show trends and identify thaw vulnerable areas."

Vladimir Romanovsky, UAF

communication). Aerial photo analysis found an increase of 136 thermokarst features since 1980 including new slides, slumps and gullies (Balser, 2009). In the near term, thermokarsts conditions are expected to continue, resulting in erosion and changes to hydrology, vegetation, and wildlife (Martin et al., 2008).

Structures in Noatak are vulnerable to permafrost thaw. Thawing is contributing to sinking of the land, and a gradual movement of buildings towards the river. Some homes are regularly in need of leveling, utility poles are leaning, and the foundation at the water plant has fractured due to subsidence. Lakes in the community of Noatak are showing signs of rapid change including drying. Warming of the east-facing riverbank and related permafrost thaw are also thought to be mechanisms for bank erosion. The old dump site continues to erode depositing waste into the Noatak River. Erosion is also threatening the airstrip and the road that connects the village with the boat landing.

There is one soil temperature gauge in Noatak installed by Dr. Kenji Yoshikawa of UAF. For the period of June 1, 2008 to May 31, 2009, the mean annual ground temperature at a depth of -5.5 meters was 30.182°F. Soil temperatures are projected to increase over the next 30 years but longer term monitoring will be necessary to determine specific temperature conditions and trends for Noatak.

Recommendation: It is recommended that permafrost conditions be monitored, especially in the vicinity of critical infrastructure including the water plant, distribution lines, sewage lagoon, fuel tank farms, and homes. New infrastructure should be sited in stable land areas, minimize permafrost disturbance and designed to accommodate projected conditions.

"We used to go up to a lake in Sisualik on Blueberry Hill. In the last five years, the lake has been dry."

Paul Norton

Second Noatak Lake, June 2006.
Google.

Second Noatak Lake showing signs of drying, July 2007.
Google.

RIVERS

Observed change: *less dynamic breakup; decreased water level; bank erosion; decreased navigability.*
Health concerns: *injury from travel accidents; food insecurity.*
Potential adaptation: *river observation system; river gauges; alternative transportation options.*

Climate change is impacting hydrology, including precipitation

and the amount of water moving through the land and rivers. Changes in winter snowpack, spring thaw, summer precipitation and temperatures all affect the amount and movement of water into the area and through the Noatak River watershed.

The Noatak is a braided river with a fairly heavy bed of medium-sized gravel. The west bank is composed of ice-rich silt that can be easily eroded and transported downstream by the current

Undercut banks near Noatak.
Ryan Brubaker, 2010.

"We used to see cut river banks. Now we see undercut banks."
Robbie Kirk

Breakup on the Noatak river.
Aqvaluq Photography.

(USACE 2007). The river is typically navigable by shallow-draft boats from early June to as late as November. Residents travel by boat in the ice-free months and by snowmachine after freeze-up. They are adapting to changing river conditions by increasing travel on dry river beds by ATVs.

The river level has continued to drop in recent years, making boat navigation more hazardous and costly as measured in broken outboards and bent props. Low snowfall, rapid melt of snowfields in the spring, and the proliferation of beaver lodges throughout the watershed may be contributing to the changing seasonal water conditions. Another possible factor is thawing permafrost, and increasing number of thermokarsts in the Noatak Basin that is contributing to the sediment load in the river (Bowden et al., 2008).

"Everyone used to go to the river bank in the spring, to watch the ice break up. It was really loud. Now the ice is humble and leaves quietly."

Carol Wesley

Efforts have been made to prevent erosion of the riverbank in Noatak caused by the natural river flow, fall flooding, spring breakup, land vehicles and boat traffic. A 3.4 million dollar Armorform revetment wall was installed in 1981. Part of this system has since collapsed. A treated wood retraining wall constructed in the 1990s was destroyed by spring breakup, the following year. The 1993 spring breakup caused 30 feet of erosion adjacent to the cemetery. The community has relocated 200 graves to protect them from erosion. In 2007 the tribal administrator reported that the main factor causing erosion was melting permafrost. Bank loss was reported at a rate of approximately 10 feet per year. Vulnerable infrastructure in Noatak includes homes and facilities, the airstrip, and the road leading to the boat landing. Prior to construction of the new landfill in 1995, the community used an unregulated dumpsite for the disposal of waste. Today the remains of the dump are being exposed by erosion, dumping debris into the Noatak River. The trash fromm the old dump creates a navigation hazard for boats. Permafrost thaw is also likely a factor in the erosion of the old dump site.

Warming temperature is also associated with poor ice conditions, affecting the time of river ice breakup and freeze-up. Past breakup events were typically dynamic, with ice breaking into large chunks. In recent years, however there has been more thermal breakup, as the ice becomes soft, and dissipates quietly and slowly. The breakup date of the ice on the Noatak is occurring roughly four days earlier then when records began in 1918 (NOAA River Forecast Center). One possible benefit of thermal breakup is lower risk of ice jams that can cause flooding.

Residents report that hazards of river travel are increasing. Low water is limiting boat travel, a problem for shipping supplies and for access to subsistence use areas. The last barge delivery to Noatak was in 1992, and today only small boats can navigate the river. Even in small boats much of the river is now inaccessible. It was once possible to go as far as 30 miles up river from the village, but now the water in many areas is too low.

Recommendation: Observations of ice thickness, including when the ice is no longer safe for travel, may help to reduce injury. The impacts of erosion on the riverbank should be monitored, measured, and reported annually to the Army Corp of Engineers, to adequately document the need for erosion prevention measures. Funding could be pursued to move and clean up the abandoned dump site. Developing cost effective methods to transport fuel and supplies to Noatak is critical for reducing the cost of living, providing affordable local services, and the long term survival of the community.

"We are losing the river bank from thaw and erosion. The garbage falls right into the river."

Wanda Sue Page

Erosion exposes old dump site on the Noatak River.
Ryan Brubaker, 2010.

BIOTA

Observed change: *invasive species; rapid plant growth and change; changing wildlife behavior.*
Health concerns: *risk of wildlife attacks; food insecurity.*
Potential adaptation: *wildlife and plant surveillance.*

Biota refers to the plants and animals that occupy the lands and waters of the region. Some plant and wildlife species benefit from climate changes; others adapt, migrate, or perish as conditions change. Residents expressed concerns about the appearance of hungry polar bears, miles from their normal coastal range, and the implications for public safety. Increasing numbers of beaver, martin, and river otter have been observed in recent years and residents wonder about the impact on trout (Carothers, 2010), an important subsistence food that accounts for about 18% of the wild food harvest in Noatak. The biggest concerns were about changes in Noatak's most important food resource, caribou harvested from the Western Arctic herd. Caribou makes up about 32% by weight of the food harvested in Noatak (Magdanz, 2010). In 2010 the fall caribou harvest was a failure, as the herd did not arrive in the normal hunting grounds for Noatak and several other communities in the region. Climate change is a potential contributing factor to changes in caribou migration patterns and even in declines due to stress-induced disease, or loss of forage to wildfire, ice storms, or vegetation change.

Porcupine benefit from an increase in woody plants.
Ryan Brubaker, 2010.

"We have noticed more willows, birch and alders along the river."

Carol Wesley

Fires consume fruticose lichen the primary winter forage food for caribou, which takes decades to recover (Jandt et al. 2008). Some climate projection models suggest that suitable habitat for caribou is retreating (Murphy et al. 2009), moving northward and eastward. The Western Arctic Caribou Herd has moved from the Buckland Valley and Selawik Refuge to the Nulato Hills and Seward Peninsula (Joly et al. 2010). The population of the Western Arctic Caribou Herd is about 348,000, down from a record high of about 490,000 in 2003. Cause for the decline is uncertain, but it may be a gradual return to normal levels after a population peak.

Polar bears have been sighted near Noatak and other inland communities.
Wayward bear near Noorvik courtesy Wanda Sue Page.

Climate change can affect natural cycles by altering seasonal weather patterns. By changing timing for migration, calving, mating and other behavior, animals can become more susceptible to diseases they were once able to avoid or resist. Stress related to changes in habitat, forage conditions, weather, or water availability can also make animals more vulnerable. Extreme heat in the Interior may be affecting caribou, musk ox, moose (Lenarz and others, 2009), and other large land mammals (Murray, 2009).

Recommendations: Understanding how climate change is affecting plant and animals is important for human health because of their role in the coastal arctic ecosystem, their value as subsistence and cultural resources. Continued structured surveillance of biota is recommended.

"I shot a polar bear in Noatak last January. It was starving. The last time we saw a polar bear in Noatak was in the 1950s."

Robbie Kirk

WATER

Observed change: *low river level, ground subsidence; decreasing water quality.*
Health concerns: *water availability; system damage and interruption; decreased water safety.*
Potential adaptation: *repair water plant; improve treatment.*

Noatak has three wells that provide community water year round.

The two wells used for drinking water are located in the river basin and together produce about 40 gallons per minute. The third well is located up on the bluff and is used for other purposes. All three wells are shallow at a depth of 40 to 50 feet below surface grade. Because they are influenced by the river, the water must be filtered and chlorinated. A 2010 climate change vulnerability analysis, found that the wells were vulnerable to erosion (Tetratech, 2010). Climate change may also be changing the quality and quantity of the community water supply.

The average air temperatures have been increasing in every month of the year since at least 1961 (SNAP, 2011). Also periods of extreme summer heat have occurred, resulting in a deeper ground thaw. In 2007 the average monthly temperature soared to 74°F, 20 degrees above average monthly temperatures since 1995 (Weather Underground, 2011). Warming and rapid seasonal thaw are increasing the frequency of thermokarsts, bank erosion and turbidity (Balser et al. 2009). Warming is also increasing levels of organics in surface water as thawed soil releases stored carbon and nutrients as well as sediments (Bowden et al. 2008). The treatment system is not designed to remove dissolved organics and thus allows them to pass through the filters. When chlorine is added to the water, the organics react and form byproducts. As the level of these organics increase in the water source, so does the difficulty in producing water that will meet health and regulatory guidelines.

Water Supply

From the wells, water is pumped up hill through a network of water lines to the water treatment plant. The water treatment plant was built in 1995, and has a reinforced concrete slab foundation on an insulated gravel pad. Ten thermosyphons inhibit thawing of the underlying permafrost, helping to remove heat from the ground. Despite these features the permafrost has been thawed to a depth of five to ten feet, resulting in the ground subsiding under the concrete foundation. The cause of the settling is attributed to a combination of

"They had to move the well because the river was too shallow."

Lucy Hall

natural and engineered factors including the effect of warm pipelines, drifting snow, rain water runoff and radiant heat from the sun (LCG, 2009).

Since 2003, the floor in the northeast corner of the water plant has settled by approximately 4-inches and the water supply/return manifolds have settled between four and six inches. The primary cause of foundation failure appears to be caused by the waste heat supply and return lines. Unless the factors causing the thawing are addressed, settlement of the water plant foundation could ultimately result in failure of the building structure. ANTHC is currently developing measures that will help prevent thawing and will restore the structural integrity of the building.

Noatak well site.
Ryan Brubaker, 2010.

Erosion is increasing the organics in the river water, and creating a water treatment problem.

Water Treatment

Water treatment includes three stages of filtration: roughing bag filters, intermediate cartridge filters and ADEC approved giardia/cryptosporidium bag filters. Chlorination is then provided for disinfection. Currently, during normal operating conditions, the roughing bag filters are replaced weekly and the cartridge filters are replaced every two weeks. But the giardia / cryptosporidium filters have been problematic. They can become clogged in as little as 24 hours and are expensive costing hundreds of dollars per change out, which can be daily in poor water conditions. Turbidity is thought to be increasing in the river as warming causes permafrost thaw and accelerated erosion.

As of March 2011, the giardia/cryptosporidium filters were not being used at the Noatak water plant. A review of water sample test results back to 1999 found no record of biological contamination of water indicating a good water disinfection record. However, the water treatment system is operating out of compliance with regulatory requirements, and without the giardia / cryptosporidium filters, residents may be vulnerable to waterborne illness. A treatment pilot study and an engineering design have been completed for a new water treatment system that will be less expensive to operate than the existing system and could provide safe aesthetically pleasing water regardless of changing source water quality. In order to acquire funding for a new water treatment system, Noatak will need to acquire documentation from ADEC that the current water system is not operating properly.

Water Storage

The treated water is stored in a 97,000-gallon insulated, bolted steel tank, located adjacent to the treatment plant. The tank is also built on an insulated gravel pad and is equipped with three thermosyphons. Both the inlet and outlet lines are above ground and the tank is equipped with a pressure transducer to relay water level information to the water plant's control panel, and is used to control pumping of raw water from the wells. The tank provides about three days of water storage based on an estimated population of 486 (the current population is over 500) and an average demand of 35,000 gallons per day. This however, is significantly below the recommended 10 days storage capacity for rural Alaska. Water main breaks and overall system leakage combined with minimal storage could compound to create operational difficulties for the community. Operators will need to remain vigilant in monitoring and repairing leaks immediately.

A reoccurring problem with clogged sewer lines has been attributed to thawing permafrost.

Once the water is treated, it is pressurized, heated and circulated through four distribution loops. The majority of water distribution lines are buried underground and provide water to approximately 88 services, including homes, the clinic, school, store, IRA office, and post office. Within the last decade, more than a dozen water main breaks or leaks were observed and repaired along west and south water main loops (Paul Walton, personnel communication). Breaks in the water main have been attributed to ground movement due to thawing of the permafrost surrounding the pipeline. The frequency of water main breaks has increased over the last decade and appears to coincide with increasing air temperatures.

The Wastewater System

The wastewater collection system was largely constructed in 1992, and includes approximately 7,500 lineal feet of sewer main, a number of concrete manholes, and several arctic pipe cleanouts. Wastewater from 88 sewer services flows into the sewer main, is collected into three lift stations, and is then discharged into two, 10,000 gallon septic tanks. The septic tanks provide primary treatment by removing most of the solids. The effluent is discharged into a 50,000 gallon lagoon and then flows down hill into a three-acre tundra pond for secondary treatment. The utility uses a 500 gallon trailer mounted vacuum pumper to collect and dispose of sludge from the septic tanks into the landfill. Over the last few years,

Jeffery Luther shows foundation crack in water plant.
Ryan Brubaker, 2010.

Unless the factors causing the thawing are addressed, settlement of the water plant foundation could ultimately result in failure of the building structure.

one manhole located in the Beverly Hill part of town has required flushing in the spring to remove accumulated waste because the manhole has settled. Clogging of the sewer lines connecting to the manhole has also been a problem because of sagging sewer mains. The cause of the sagging sewer mains has been attributed to subsidence of the pipelines caused by melting permafrost.

Traditional Water Sources

The Noatak River is used as a traditional source of drinking water. The collection and drinking of water untreated is a common practice in subsistence fishing and hunting camps located up and down river. At Sisualik and other coastal seasonal camps, some people collect water from tundra streams. These traditional sources have been used for thousands of years without concern for water safety. However, in recent years Noatak residents have reported increases in the population of beaver in the many small tributaries that feed the Noatak River. Rivers further north including the Wulik and the Kukpuk are seeing beavers for the first time. This may be related to changes in climate including more trees along Arctic rivers.

Beaver are among the species known to carry giardia lamblia, a microscopic protozoa that enters the water in the feces. Other species know to carry giardia include muskrats, foxes, muskoxen and people. If ingested, giardia can cause an unpleasant and sometimes serious infection in the small intestines. Proper chlorination and filtration at the water treatment plant will prevent exposure to giardia through the public water system. For residents who are drinking untreated water, giardiasis may be a growing health risk.

Recommendations: River change caused by warming and permafrost thaw raises concerns about water quality and availability. It is recommended that the water level in wells be monitored and alternative treatment options explored that will address the ongoing deficiencies in the Noatak water system. Permafrost thaw has resulted in damage to the treatment plant and breaks in the distribution system. Sewer lines are increasingly clogged because of ground settling. It is recommended that monitoring of ground temperature and source water conditions be expanded and drinking water from all sources be treated adequately to prevent water borne illness.

"Every tributary on the Noatak has a beaver dam, except above the canyon."

Elmer Howarth

A traditional water source used for Sisusalik.
Mike Brubaker, 2010.

FOOD

Observed change: *decreased harvest, increased cost of subsistence and market foods.*
Health concerns: *increased risk of foodborne illness; food insecurity.*
Potential adaptation: *regular harvest surveys; improve access to food; expand local gardening.*

The day-to-day life of Noatak residents revolves around subsistence, the tradition practice of gathering resources from the land and sea. People are tied to seasonal migration patterns of wildlife and are engaged year-round in preparations or in the hunting, fishing and gathering. Critical for wellness, the traditional lifestyle has many cultural, social, economic and health benefits. Although subsistence activities can involve considerable risk for injury, they also provide significant mental health benefits and are an important source of physical exercise. The traditional diet is extremely healthy, providing protection against cardiovascular disease, hypertension, type 2 diabetes, stroke, obesity, osteoporosis, and some cancers. It also provides a wide range of essential micronutrients including iron and vitamins A, D, and E (Bersamin et al., 2007).

Salmonberries.
Mike Brubaker, 2010.

Vegetables started in the greenhouse.
Mike Brubaker, 2011.

Food safety refers to the practice of harvesting, preparing, and storing foods in ways that prevent foodborne illness. Food security means having nutritious foods and not having to live in hunger. The types of food consumed in Noatak can be divided into three categories: food gathered from the sea and coast; food collected upriver or inland; and food purchased in a store. All are affected by climate change. An emerging fourth category is locally grown food through the community greenhouse. Physical changes to weather, river, land and ice

"I don't think we will get very good berries this year. Not enough snow."

Dolly Booth

Drying salmon at a Noatak Fish Camp.
Mike Brubaker, 2010.

is making harvest more difficult and unpredictable; and increasingly, extreme weather and low water conditions on the river are making transport of food to Noatak more difficult and more costly. This increases the cost of food in the market, and the cost of acquiring wild foods through subsistence. A longer growing season, however, is improving conditions for growing vegetables.

Climate change is expected to significantly alter the subsistence harvest in the Arctic coastal plain and the coastal marine environment (Martin et al., 2008). In the spring of 2010, fishermen reported that rapid thaw of spring ice shortened the season for ice fishing on the Noatak River. Sea mammal hunters at Sisualik observed that poor ice conditions were interfering with seal harvest. Warming observed in the summer and fall made drying of chum salmon on food racks more difficult (Carothers, 2010). The fall 2010 caribou season was a failure when the herd failed to arrive in traditional hunting areas. These observations raise concerns about food safety and security.

"People rarely hang fish anymore because it is too hot. So people freeze it or use it for dog food."

Robyn Howarth

In 2007, Noatak residents reported using a harvest area of 12,596 square miles, including the northern half of Kotzebue Sound, inland as far north as the Kivalina River, and the entire Noatak River from the delta to the mouth of Anisak Creek (Magdanz 2010). The average annual household harvest was 1601 pounds of wild food including mostly fish and caribou but also significant amounts of sea mammal, moose, and berries. Approximately 40 different species were harvested for use as food. The top five by estimated edible weight were caribou, trout, salmon, seal and whitefish.

Sixty percent of households were considered to have high food security, 22% had marginal food security, 14% had low food security, and 3% had very low food security. This was mostly related to the high cost and limits of the local market. Currently transportation (by air or small boat) and fuel cost are the primary factors affecting price of market foods. With river travel becoming more difficult, there is concern that costs could continue to increase if navigability or distance to a suitable boat landing were to increase. Eleven percent of households reported food insecurity related to subsistence foods and 42% reported not getting enough land mammals, in particular caribou. The most common reasons stated by residents includes distance from the community, scarcity, and changing migration routes. The highest time for food insecurity was during the migration of the Western Arctic Caribou Herd.

As temperatures rise, food safety may be affected. Animals may become stressed and more vulnerable to diseases, including some that can be passed on to people. Additionally, methods for traditional food preparation and storage may be less likely to prevent the growth or introduction of pathogens that cause illness. Pregnant women, infants, the elderly, and those with weakened immune systems are at higher risk for infections that result from eating diseased wildlife, or contaminated food.

Recommendation: Noatak residents exercise care in the preparation and storage of wild foods, especially fermented foods, as there is a clear relationship between temperature and pathogens such as botulism. Foodborne diseases can be prevented by taking precautions such as wearing gloves when harvesting game, thoroughly cleaning cooking surfaces, and by cooking meat adequately prior to consumption. Improved surveillance is recommended to determine levels of disease in subsistence resources. Regular surveys would be beneficial to help monitor harvest conditions and food security. Noatak would benefit from strategies that lower the cost of food and increase food security.

"There used to be so many big herds of caribou that crossed near us, and they were easy to get. Now we have to go way up river and the last few years we hardly get any."

Robyn Howarth

Caribou Camp.
Courtesy Wanda Sue Page.

CONCLUSION

Public health considers climate change based on effects to mental health, injury, disease, and food and water safety and security. In Noatak, climate change is increasing the risk in all of these areas. Climate change is altering the Arctic environment at a rate never before recorded in human history. Noatak is experiencing rapid change and negative outcomes related to injury, food and water security, and health infrastructure. Only through equally rapid adaptation efforts can health consequences be prevented.

This report raises awareness about current, emerging, and potential future climate change. It is hoped that this will help Noatak make informed planning decisions, find community appropriate development strategies, and pursue a safe, healthy, and sustainable future. The qualities that have served the Inupiat for over 4,000 years will serve them well again now, as changing climate mandates a new chapter of resilience and adaptation.

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

Eroding river bank at a fish camp.
Mike Brubaker, 2010.

"Viola's camp was here in the river ten years ago. It was eroded away."

Nora Booth

Figure 6. Climate Change Health Assessment Findings, Noatak, 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 "break up." Dry summer conditions.	Spring – ice related injury Summer - heat injury. Fall – ice related injury Winter – cold injury	Travel advisories. Locator beacon loaner program for travelers. Assess buildings for heat hazards.
Seasons	Early spring thaw and later winter freeze up.	Changes in travel and harvest. Decreased mobility.	Injury and food insecurity. Reduced physical activity and subsistence food content in diet.	Shift in timing and methods for subsistence activities.
Air	Hot summer temperatures and low precipitation.	Dry vegetation, increased lightning strikes, wildfire, and dust.	Increase respiratory problems due to smoke, dust and allergens.	Dust suppression on streets and airstrip. Air quality monitoring. Evacuation of sensitive individuals as needed.
Sea	Poor ice conditions. Low water in Kotzebue Sound.	Poor conditions for seal/ sea ice hunting.	Increased risk of injury. Decreased harvest.	Condition appropriate equipment. Locator beacons. Participation in SIWO program.
Coast	Increased storm activity. Sea level rise	Increasing risk of flooding at seasonal camp (Sisualik).	Injury during storm events. Mental stress. Damage to property.	Plan for periodic storm events and associated property damage.
Land	Erosion and subsidence related to permafrost thaw. Drying lakes.	Loss of stable land. Exposure of old landfill.	Damage to infrastructure. Interruption of services. Exposure to contaminants.	Perform permafrost thaw / ground stability assessment. Monitor erosion rate. Move old dump.
River	Decreased water level. Increased water temperature.	Decreased navigability. Increased erosion. Poor ice conditions.	Increased risk of injury. Increased cost of living. Mental stress.	Travel advisories. Improve community access and decrease costs. Study factors contributing to river change.
Biota	Warmer air and river temperature. Dry summer conditions.	More trees and wildfire. More beaver. Increased algae growth in lakes. Invasive species.	Increased disease. Stress for some endemic species.	Engage in surveillance of area biology.
Water	Lower river level and higher turbidity. Increase in disease vectors. Permafrost thaw, erosion, subsidence.	Lower water level in wells. Lower water quality. Interruption of water services.	Exposure to waterborne diseases and increased risk of infections related to service interruption. Water insecurity	Monitor community wells. Baseline testing of traditional water source. Feasibility study for new water treatment system at Noatak. Improved water treatment.
Food	Changing climate, seasonality, and environment.	Change in subsistence timing, quality and availability.	Decreased food security and safety. Increased risk of acute and chronic disease.	Regular harvest surveys. Surveillance of wildlife for disease. Improve food delivery system. Dietary surveys.

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.

	Topic Reference	Position	Name	Association	Date
1	Education	Clerk	Tina Mills	NWASD	03-04-10
2	Education	Teacher	Velma Jones	NWASD	03-04-10
3	Education	Maintenance	Mike Adams	NWASD	06-26-10
4	Elder	Elder	James Adams	Resident	06-24-10
5	Elder	Elder	Betsy Bailey	Seasonal Sisualik	06-22-10
6	Elder	Elder	Dolly Booth	Resident	06-21-10
7	Resident	Resident	Chester Burns Jr.	Resident	06-21-10
8	Resident	Resident	Elmer Howarth	Resident	06-23-10
9	Resident	Resident	Kathy Howarth	Resident	06-23-10
10	Elder	Elder	Virgin Naylor Sr.	Resident	06-24-10
11	Elder	Elder	Gussie Norton	Resident	06-25-10
12	Elder	Elder	Paul Norton	Resident	06-25-10
13	Elder	Elder	Morris Wilson Sr.	Kotzebue/Sisualaq	06-24-10
14	Environmental	Coordinator	Wanda Sue Page	Noatak IRA	06-21-10
15	Environmental	Assistance Coordinator	Carol Wesley	Noatak IRA	06-21-10
16	Environmental Health	Water Operator	Jeffrey Luther	Noatak IRA	06-22-10
17	Environmental Health	Primary Water Operator	Paul Walton	Noatak IRA	04-08-11
18	Environmental Health	Utility Manager	Emma Ahvakana	Noatak IRA	03-04-10
19	Environmental Health	Remote Maintenance Work.	John Monville	Maniilaq	04-06-11
20	Environmental Health	Regional Director	Paul Eaton	Maniilaq	04-06-11
21	Governance	Former Tribal Council Member	Enoch Mitchell	Noatak IRA	06-22-10
22	Resident	Former Tribal Administrator	Vicki Mitchell	Noatak IRA	03-05-10
23	Governance	Tribal Administrator	Mary Lou Sours	Noatak IRA	06-23-10
24	Governance	Tribal Council	Leslie Burns	Noatak IRA	03-05-10
25	Governance	Tribal Council President	Mike Sherman	Noatak IRA	06-23-10
26	Governance	Tribal Council	Fred Luther Sr.	Noatak IRA	06-08-11
27	Resident	Resident	Harry Penn	Resident	06-23-10
28	Resident	Resident	Carl Wilson	Resident	06-22-10
29	Resident	Resident	Noah Downey	Resident	06-22-10
30	Resident	Resident	Pauline Vestal	Resident	06-22-10
31	Resident	Resident	Joann Ashby	Resident	06-22-10
32	Resident	Resident	Frank Onalik Sr.	Resident	06-22-10
33	Resident	Resident	Helen Ashby	Resident	06-22-10
34	Health	Health Aide / CHAP	Lucy Hall	Maniilaq	06-21-10
35	Health	Health Aide / CHAP	Robyn Howarth	Maniilaq	06-21-10
36	Health	Adminstrative Assistant	Janice Mills	Maniilaq	06-21-10
37	Health	Custodian	Ida Ashby	Maniilaq	06-21-10
38	Health	IT Technician	Robbie Kirk	Maniilaq	06-21-10
39	Health	Health Staff	Della Booth	Maniilaq	06-22-10
40	Public Safety	VPSO	Amil Burns	Maniilaq	06-23-10
41	Subsistence	Land (plants/berries)	Ida Ashby	Resident	06-24-10
42	Resources	Gardening	Amber Howarth	Maniilaq	06-23-10
43	Resources	River	Don Booth	NANA	06-22-10
44	Social Services	Occupational Development	Alice Adams	NANA	03-05-10
45	Social Services	Occupational Development	Robert Sheldon	NANA	06-22-10
46	Social Services	Social Services	Tanya Kirk	Maniilaq	06-21-10
47	Youth	Senior Noatak School	Nicki Foster	Resident	06-23-10
48	Youth	Student	Michela Sherman	Attended meeting	06-22-10

APPENDIX B

Noatak Climate and Health Web Resources

Topic	Resource	Location
Noatak Profile	State of Alaska Community Database	http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm
Noatak Erosion Data	USACE Community Erosion Report, 2009	www.poa.usace.army.mil/AKE/Home.html
Noatak Permafrost	UAF Permafrost Laboratory	www.gi.alaska.edu/snowice/Permafrost-lab/
Noatak Flood Data	USACE Flood Hazard Database	http://www.poa.usace.army.mil/en/cw/fld_haz/Noatak.htm
Temp & Precipitation	SNAP at UAF	www.uaf.edu/accap/
Noatak Climate Reports	ANTHC, Center for Climate and Health	www.anthc.org/chs/ces/climate/links.cfm
Local Weather Observations	NWS Extreme Weather Spotter Program	http://www.weather.gov/skywarn/ Contact: Harry Lind, NWS in Kotzebue.
Local Weather Observations	Community Collaborative Snow Rain and Hail Program	http://www.cocorahs.org/ Contact: Harry Lind, NWS in Kotzebue.
Regional Climate Data	Kotzebue 1930s to present - UAF	climate.gi.alaska.edu/
Regional Climate Data	Center for Global Change (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	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
Erosion Data	US. Army Corp of Engineers, Alaska Baseline Erosion Assessment	http://www.climatechange.alaska.gov/docs/iaw_USACE_erosion_rpt.pdf
Local Water Vulnerability	Alaska Department of Environmental Conservation, Tetra Tech, 2010	http://www.climatechange.alaska.gov/docs/iaw_tt_imperiled_h2o_30jun10.pdf
Climate Mitigation	DCRA Coastal Impact Assistance Program	http://www.commerce.state.ak.us/dca/planning/cciap/pub/CCIAP_Public_Solicitation_Application_Guide.pdf
Regional Health Data	Maniilaq Association, Kotzebue	www.maniilaq.org/
Regional Health Profile	Alaska Native Tribal Health Consortium	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 Based Monitoring – Seasonality	U.S. Geological Survey-National Phenology Network	www.usanpn.org/
Community Based Monitoring – Wildlife	National Oceanographic and Atmospheric Administration – Marine Stranding	www.fakr.noaa.gov/protectedresources/strandings.htm

APPENDIX C

Recommendations for Climate Adaptation Planning

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

1. Protection of human life and health is the top priority.
2. Traditional values should guide local and regional decision making.
3. Development should follow the principles of sustainability "meeting 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 local resources, such as subsistence areas, cultural sites, critical water sources, and develop plans to protect them.
5. Critical ecological systems, wetlands, and subsistence resource areas should be protected where possible.
6. Considerations for climate impacts on erosion, flooding, subsistence, water availability, and transportation should be incorporated into planning, and new infrastructure siting and design.
7. Cost-benefit analyses should be applied to evaluate the social and environmental costs of building and maintaining coastal protection structures.
8. Phased abandonment of at-risk areas should be considered.
9. Coastal emergencies are inevitable and disaster response and recovery capacity, including evacuation routes, emergency response plans, drills, and shelters, should be reviewed.
10. Building capacity to participate in monitoring, research, and advocacy is critical to facilitate development of effective adaptation strategies.

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For more information please contact:
Center for Climate and Health
Alaska Native Tribal Health Consortium
(907) 729-2464

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http://www.anthc.org/chs/ces/climate/index.cfm

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