Jude Stamp
Fredrick Brower

NORTH SLOPE BOROUGH
RESOLUTION SERIAL NO. 51-2016

A RESOLUTION ADOPTING THE NORTH SLOPE BOROUGH LOCAL ALL-HAZARD MITIGATION PLAN

WHEREAS, the North Slope Borough, a Home Rule Borough duly organized under the laws of the State of Alaska, is vulnerable to damages from natural hazard events, which pose a threat to public health and safety and could result in property loss and economic hardship; and

WHEREAS, the "North Slope Borough Local All-Hazard Mitigation Plan" (the Plan) was developed through the efforts of the North Slope Borough's Planning Team, including members from each of the affected Borough communities, and in coordination with the State of Alaska Department of Homeland Security & Emergency Management; and

WHEREAS, the Plan recommends hazard mitigation actions to protect people and property affected by natural hazards, and to reduce costs of disaster response and recovery; and

WHEREAS, the Disaster Mitigation Act of 2000 (P.L. 106-390) (DMA 2000) and associated Federal regulations published under 44 CFR Part 201 require the North Slope Borough Assembly to formally adopt the Plan for eligibility into the Federal Emergency Management Agency's Hazard Mitigation Assistance Program; and

WHEREAS, the North Slope Borough Planning Team held public meetings in each affected Borough community to receive Plan comments as required by DMA 2000.

NOW, THEREFORE, BE IT RESOLVED THAT:

The North Slope Borough Assembly hereby adopts the North Slope Borough Local All Hazard Mitigation Plan 2015 Update as this Borough's Hazard Mitigation Plan, and resolves to execute the actions in the Plan.

INTRODUCED: 08/02/2016
ADOPTED: 08/02/2016

[signature]
John Hopson, Jr., President
Date: 8/2/16

ATTEST:
Sheila H. Burke
Sheila Burke, Borough Clerk
Date: 8-3-2016

passed by Assembly 2 August 2016

Harry Brower Jr.

Harry K. Brower, Jr., Mayor

Date: 8/3/2016

North Slope Borough
Local All-Hazard Mitigation Plan

2015 Update
The North Slope Borough

Acknowledgements

North Slope Borough

Charlotte Brower, Mayor
Jacob Adams Sr., Chief Administrative Officer
Rhoda Ahmaogak, Planning Director
Jeannie Brower, Borough Clerk
Reed O'Hair, Administration & Finance Director
Rob Elkins, Administration Deputy Director
William Tracy, Fire Chief
Leon Boyea, Police Chief
Charles Sakeagak, Public Works Director
Frederick Brower, Risk Manager
Hina Kilioni, Disaster Coordinator
Taylor Elbert, Assistant Disaster Coordinator

City of Anaktuvuk Pass

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Justus Mekiana, Vice Mayor
Cathy Lynn Wagner, City Clerk
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Esther Hugo
Lawrence Burns
Della Tagarook

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Office Manager
IRA Council:
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Marie Tracey, Vice President
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Allison Segevan, Bookkeeper
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Sandra L. Peetook
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Enoch Oktolik

<u>Technical Assistance</u>
Ann Gravier, Alaska State DHS&EM
Scott Nelsen, Alaska State DHS&EM

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List of Acronyms and Abbreviations

°F	degrees Fahrenheit
AFG	Assistance to Firefighters Grant
AS	Alaska Statute
AVCP	Association of Village Council Presidents
CD	compact disc
CDBG	Community Development Block Grant
CHEMS	Community Health and Emergency Medical Services
DEC	Department of Environmental Conservation
DHS&EM	State of Alaska, Department of Homeland Security and Emergency Management
DHSS	Department of Health and Social Services
DHS	Department of Homeland Security
DMA2000	Disaster Mitigation Act of 2000
DNR	Department of Natural Resources
DOF	Department of Forestry
DOT&PF	Department of Transportation and Public Facilities
FMA	Flood Mitigation Assistance
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
HAZUS-MH	Hazards U.S. – Multi-Hazard
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
KTC	Emmonak Traditional Council
LYSD	Lower Yukon School District
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PDM	Pre-Disaster Mitigation
STAPLE+E	Social, Technical, Administrative, Political, Legal, Economic and Environmental
URS	URS Corporation
U.S.	Unites States
USGS	U.S. Geological Survey

1. Hazard Mitigation Planning

Hazard mitigation is the process of profiling hazards, analyzing risk, and designing preventative actions to reduce or eliminate risk.

1.1 Purpose

The purpose of the North Slope Borough Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) is to identify and coordinate risk mitigation efforts with State, Federal, and local partners and to fulfill the requirements set forth by the Code of Federal Regulations, Title 44 "Emergency Management and Assistance", Part 201 "Mitigation Planning", subsections 6 and 7 (44 CFR §201.6, §201.7):

> Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. This definition distinguishes actions that have a long-term impact from those that are more closely associated with immediate preparedness, response, and recovery activities. Hazard mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage reconstruction, and repeated damage. As such, States, Territories, Indian Tribal governments, and communities are encouraged to take advantage of funding provided by HMA programs in both the pre- and post-disaster timeframes.

Current Federal regulations 44 CFR §201.6 and §201.7 require local communities and tribes, except under Regional Administrator approved "extraordinary circumstances" (§201.6(a)(3), to have a FEMA approved hazard mitigation plan for most of FEMA's grant programs (all but PA Category A, B, and IA). Currently, Federal regulations require local plans to be formally updated and approved by FEMA every five years.

Hazard Mitigation Assistance grant program eligible activities by program:

Specific FEMA programs, such as Public Assistance categories C through G, Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), and the Hazard Mitigation Grant Program (HMGP) are detailed in Chapter 6, "Resources."

1.2 Authority

On October 30, 2000, Congress passed the Disaster Mitigation Act of 2000 (DMA 2000) (P.L. 106-390) which amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) (Title 42 of the United States Code [USC] 5121 et seq.) by repealing the act's previous mitigation planning section (409) and replacing it with a new mitigation planning section (322). This new section emphasized the need for State, Tribal, and local entities to closely coordinate mitigation planning and implementation efforts. In addition, it provided the legal basis for the Federal Emergency Management Agency's (FEMA) mitigation plan requirements for mitigation grant assistance.

For implementation guidance, FEMA published the Final Rule in the Federal Register on September 16, 2009 [Docket ID FEMA-2006-0010], 44 CFR Part 201 with subsequent updates. The planning requirements for local entities are described in detail in Section 2 and are identified in their appropriate sections throughout this HMP.

Alaskan Native Tribes with an approved Tribal Mitigation Plan in accordance with 44 CFR 201.7 may apply for assistance from FEMA as a grantee. If the Tribe coordinates with the State of Alaska for development and review of their Tribal Mitigation Plan, then the Tribe also has the option to apply through the State as a subgrantee. A grantee is an entity such as a State, territory, or Tribal government to which a grant is awarded and is accountable for use of the funds. A subgrantee is an entity, such as a community, local, or Tribal government; State-recognized tribe; or a private nonprofit (PNP) organization to which a subgrant is awarded and is accountable to the grantee for use of the funds.

1.3 Plan Layout

This plan focuses upon mitigation as part of the North Slope Borough's emergency management efforts. The plan contains seven sections:

1. Introduction
2. Planning Process
3. Hazard Profiles
4. Risk Analysis
5. Mitigation Strategy and Goals
6. Resources (includes links and references to information, graphics and documentation)

Appendices (cited throughout the text)

1.4 North Slope Borough Profile

Location

Encompassing 89,000 square miles and just over 15% of the state's total land area, the North Slope Borough is the largest borough in Alaska. It consists primarily of the north and northeastern coast of Alaska, including the Brooks Range and most American land north of the Arctic Circle (Figure 1-1).

Climate

The borough's climate is arctic. Temperatures range from -56 to 78 °F. Precipitation is light, with an average of 5 inches a year and snowfall averaging 20 inches a year.

Government

Incorporated in 1972, the North Slope Borough is a Non-Unified Home Rule Borough. Table 1-1 lists the eight participating communities and their demographic data. Figure 1-2 shows the State Demographer NSB historical population estimates.

Table 1-1 Community Demographics

Community	2013 Population Estimate	Classification
*Anatuvuk Pass	358	2nd Class City
*Atqasuk	248	2nd Class City
Barrow	4,717	1st Class City
*Kaktovik	262	2nd Class City
*Nuiqsut	452	2nd Class City
*Point Hope	683	2nd Class City

Point Lay	215	Unincorporated
*Wainwright	543	2nd Class City

Sources: Alaska State HMP 2013 and Alaska State Department of Labor
** Small and Impoverished Community from Appendix 10 Alaska State HMP 2013*

Figure 1-1 North Slope Borough

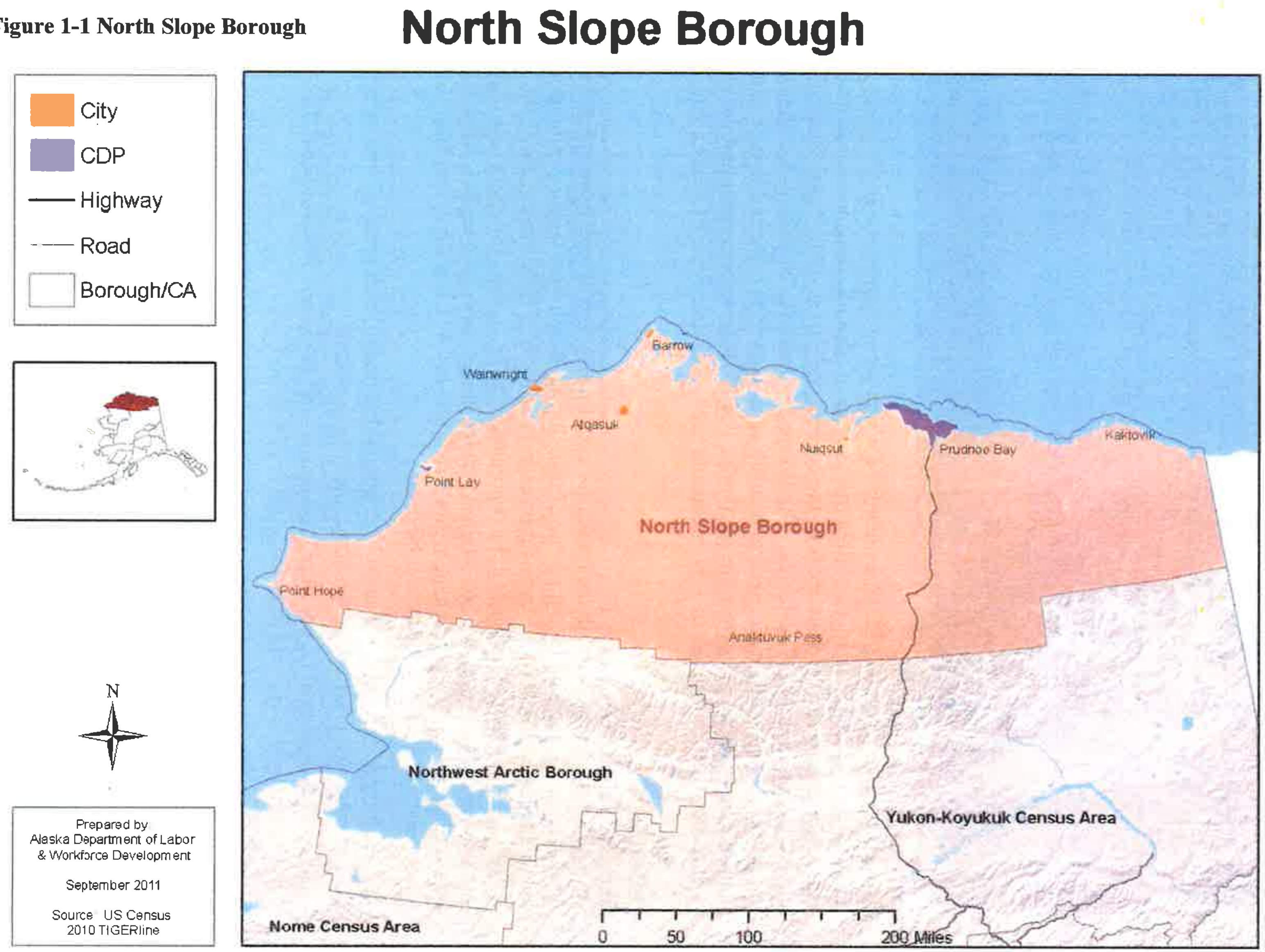
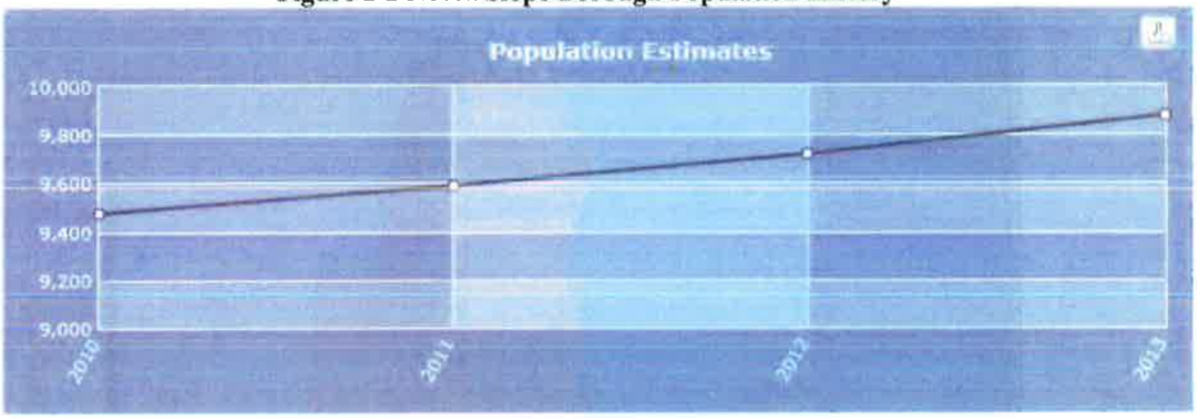


Figure 1-2 North Slope Borough Population History



The 2000 census recorded 7,208 residents, of which the median age was 24, while the 2010 Census recorded 9,430 residents with a median age of 35, indicating an overall maturing population. According to State records, the current population of the North Slope Borough has increased slightly to 9,727 residents. The Borough's majority inhabitants are Inupiat Eskimos and 54 percent of residents recognize themselves as such. The male and female composition is approximately 63 and 37 percent respectively. The 2010 census revealed that there are 1,966 households with an average of 3.34 occupants each. *(Source: State of Alaska, Department of Labor).*

History and Culture

Inupiat Eskimos have lived in the region for centuries, active in trading between Alaskan and Canadian bands. Atqasuk was a source of coal during World War II. Oil exploration in the 1960s led to the development of the huge reserves in Prudhoe Bay and, subsequently, the Trans-Alaska Pipeline in the 1970s. The borough incorporated in 1972. Today, oil operations support between 4,000 and 5,000 oil company and support service employees in the region. After the passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971, families from Barrow re-settled the abandoned villages of Atqasuk and Nuiqsut.

The majority of permanent residents are Inupiat Eskimos. Traditional marine mammal hunts and other subsistence practices are an active part of the culture.

Source: Department of Community, Commerce, and Economic Development [DCCED], Division of Community and Regional Affairs [DCRA] 2012.

Economy

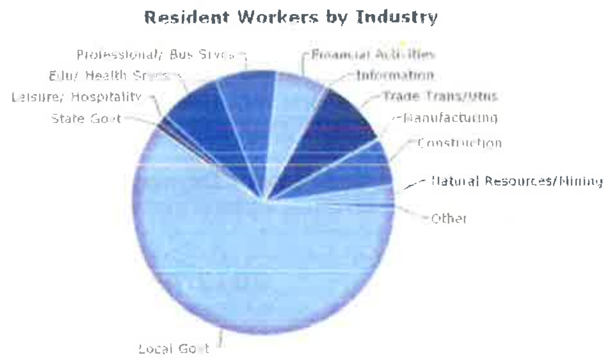
The North Slope Borough, the North Slope Borough School District and local native corporations are the largest employers of local residents. Subsistence is still a large part of the local economy in the North Slope Borough, especially in the outlying villages. Barrow, the northernmost city in North America, is the economic, service, and administrative center of the region. Many local businesses provide support services to oil field operations. It is also the area's transportation hub, with jet service connecting to Anchorage. The North Slope Borough is home to Alaska's major oil production facilities at Prudhoe Bay with over 5000 non-resident workers currently employed there.

According to the 2010 census, the median household income in North Slope Borough was $76,667. Approximately 946 individuals (10.56 percent) were estimated to be living below the poverty level. The potential work force (those aged 16 years or older) in the NSB was estimated to be 4,600, of which 3,343 were actively employed. About 623 individuals were seeking work and were not part of the active labor force. In 2012 the unemployment rate was 5.3 percent. State of Alaska, Department of Labor Employment Estimates for 2012 are displayed in Figures 1-3 and 1-4, and tables 1-2 and 1-3.

Figure 1-3 Employment Demographics 2012

Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section, updated August 30, 2013.

Figure 1-4 2012 Resident Workers by Industry



Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section, updated August 30, 2013.

Table 1-2 2012 Labor Industry Classification

Industry	Number of workers	Percent of total employed	Female	Male	Age 45 and over	Age 50 and over
Natural Resources & Mining	82	2.4	16	66	18	12
Construction	217	6.4	79	138	78	50
Manufacturing	5	0.1	2	3	1	1
Trade, Transportation and Utilities	291	8.6	110	181	73	46
Information	18	0.5	8	10	6	5
Financial Activities	182	5.4	109	73	64	49
Business Services	261	7.7	93	168	90	56
Educational and Health Services	236	7.0	174	62	75	60
Leisure and Hospitality	52	1.5	38	14	18	14
State Government	25	0.7	16	9	9	7
Local Government	1,944	57.4	985	959	792	576
Other	69	2.0	35	34	22	14

Table 1-2 Source: State of Alaska Department of Labor and Workforce Development, 2013

Table 1-3 identifies the Top 2012 Occupations for the North Slope Borough.

Table 1-3 2012 Top Occupations, Gender, and Age Group

2012 Top Occupations	Number of workers	Female	Male	Age 45 and over	Age 50 and over
Janitors and Cleaners, Except Maids and Housekeeping Cleaners	176	52	124	57	40
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	123	113	10	33	22
Maintenance and Repair Workers, General TOP JOB	120	21	99	63	46
Office Clerks, General	104	77	27	17	12
Construction Laborers TOP JOB	98	16	82	18	8
Teacher Assistants	77	62	15	38	31
Office and Administrative Support Workers, All Other	70	51	19	25	19
Bookkeeping, Accounting, and Auditing Clerks	69	63	6	22	14
General and Operations Managers TOP JOB	60	22	38	41	34
Laborers and Freight, Stock, and Material Movers, Hand	94	15	79	16	9
Water and Wastewater Treatment Plant and System Operators TOP JOB	77	7	70	19	9
Power Plant Operators	53	2	51	24	14
Recreation Workers	62	27	35	12	10
Executive Secretaries and Executive Administrative Assistants TOP JOB	70	61	9	26	18
Cashiers	50	43	7	7	4
Heavy and Tractor-Trailer Truck Drivers TOP JOB	52	3	49	29	17
First-Line Supervisors of Office and Administrative Support Workers TOP JOB	54	46	8	24	16
Carpenters TOP JOB	50	2	48	20	12
Retail Salespersons	53	25	28	7	5
Managers, All Other	40	27	13	22	18
Information and Record Clerks, All Other	42	33	9	22	14

Operating Engineers and Other Construction Equipment Operators TOP JOB	44	1	43	23	17
Personal Care Aides	52	47	5	21	14
Cooks, Institution and Cafeteria	39	24	15	15	11
Elementary School Teachers, Except Special Education TOP JOB	37	31	6	23	19
Roustabouts, Oil and Gas	40	5	35	2	2
Registered Nurses TOP JOB	49	39	10	9	7
Chief Executives TOP JOB	39	14	25	22	17

Table 1-3 Source: State of Alaska Department of Labor and Workforce Development, 2013

means the occupation has been identified as an important occupation involved in the oil and gas industry

means the occupation has been identified as an important occupation involved in the maritime industry.

means the occupation has been identified as green.

TOP JOB means the occupation is projected to have a high growth rate and numerous openings, and has an above average wage.

Air travel provides the only year-round access, while land transportation provides seasonal access. The Dalton Highway provides road access to Deadhorse at Prudhoe Bay, though it is restricted during winter months. "Cat-trains" are sometimes used to transport freight over land from Barrow during the winter.

2. Planning Process

This section explains the planning process and summarizes the review and incorporation of relevant plans, studies, and reports used to develop this HMP. Public outreach and meeting documentation form Appendices F and G.

2.1 Overview

The North Slope Borough (NSB) developed the plan update with assistance from the State of Alaska, Division of Homeland Security and Emergency Management (DHS&EM). Updates to this plan include:

1 Community demographic, land use, and economic information
2 A review of the local hazards facing the community.
3 A hazard vulnerability assessment.
4 A hazard mitigation strategy with attainable goals and actions.
5 A list of incorporated planning documents.

The planning team reviewed their roles in the planning process and identified applicable NSB resources. They also reviewed their prior HMP and familiarized themselves with the natural hazards affecting the communities such as erosion, flooding, and ground failure.

The planning team asked the public to review their community's hazards, reassess risks to residential and critical facilities, and assist the team with reviewing and prioritizing mitigation actions for potential future funding.

The following five-step process took place from May 2012 through May 2015:

1. Organize resources: Members of the planning team identified information resources, such as local experts and various organizations, capable of providing the technical expertise and historical information.
2. Assess risks: The planning team reviewed their hazards and risk assessments.
3. Assess capabilities: The planning team assessed their community's current administrative, technical, regulatory, and fiscal capabilities.
4. Develop the mitigation strategy: The planning team identified and prioritized their mitigation goals and actions.
5. Monitor, evaluate, and update the plan: The planning team evaluated their goals and actions for compatibility with community priorities.

2.2 Hazard Mitigation Planning Team

Table 2-1 identifies the local planning team members from each participating community:

Table 2-1 Hazard Mitigation Planning Teams

Name	Title	Organization	Key Input
Charlotte Brower	Mayor	North Slope Borough	Planning Team Member, data input and HMP review.
Rhoda Ahmaogak	Planning Director	North Slope Borough	Planning Team Lead, HMP review.
Jacob Adams, Sr.	Borough Administrator	North Slope Borough	Planning Team Member, data input and HMP review.
Jeannie Brower	Clerk	North Slope Borough	Planning Team Member, data input and HMP review.
Reed O'Hair	Finance Director	North Slope Borough	Planning Team Member, data input and HMP review.
William Tracy, Sr.	Fire Chief	North Slope Borough	Planning Team Member, data input and HMP review
Leon Boyea	Police Chief	North Slope Borough	Planning Team Member, data input and HMP review
Charles Sakeagak	Public Works	North Slope Borough	Planning Team Member, data input and HMP review
Scott Nelsen	Mitigation Planner	State of Alaska	HMP development, lead writer, planning coordinator
Thomas Rulland	Mayor	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Justus Mekiana, Jr.	Vice Mayor	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Cathy Lynn Wagner	City Clerk	City of Anaktuvuk Pass	Planning Team Lead, HMP review.
James Nageak	City Council Secretary	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Lela Ahgook	City Council Treasurer	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Esther Hugo	City Council Member	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Lawrence Burris	City Council Member	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Della Tagarook	City Council Member	City of Anaktuvuk Pass	Planning Team Member, data input and HMP review
Douglas Whiteman	Mayor	City of Atqasuk	Planning Team Member, data input and HMP review
Charlene Brower	Clerk	City of Atqasuk	Planning Team Lead, HMP review.
David Ivanoff	Fire Chief	City of Atqasuk	Planning Team Member, data input and HMP review

Name	Title	Organization	Key Input
Ethel Burke	City Council Secretary	City of Atqasuk	Planning Team Member, data input and HMP review
Della Shugluk	City Council Member	City of Atqasuk	Planning Team Member, data input and HMP review
Fritz Kagak	City Council Member	City of Atqasuk	Planning Team Member, data input and HMP review
Jimmy Nayukok	City Council Member	City of Atqasuk	Planning Team Member, data input and HMP review
Bert Shugluk	City Council Member	City of Atqasuk	Planning Team Member, data input and HMP review
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Kimberly M. Kaleak	Clerk	City of Kaktovik	Planning Team Member, data input and HMP review
Crystal Kaleak	Public Works Director	City of Kaktovik	Planning Team Member, data input and HMP review

Name	Title	Organization	Key Input
Ben Hunsaker	Village Public Safety Officer (VPSO)	City of Kaktovik	Planning Team Member, data input and HMP review
Margaret Kayotuk	City Council Member	City of Kaktovik	Planning Team Member, data input and HMP review
Fenton Rexford	City Council Member	City of Kaktovik	Planning Team Member, data input and HMP review
Joe Kaleak	City Council Member	City of Kaktovik	Planning Team Member, data input and HMP review
Matthew Rexford	City Council Member	City of Kaktovik	Planning Team Member, data input and HMP review
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Cornelia Sovalik	Bookkeeper	City of Nuiqsut	Planning Team Member, data input and HMP review
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Jimmy Oygak	City Council Member	City of Nuiqsut	Planning Team Member, data input and HMP review
Samuel Kunaknana	City Council Member	City of Nuiqsut	Planning Team Member, data input and HMP review
Carl Brower	City Council Member	City of Nuiqsut	Planning Team Member, data input and HMP review
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Masuk Lane	Administrator	City of Point Hope	Planning Team Lead, HMP review.
Molly Omnik	Clerk	City of Point Hope	Planning Team Member, data input and HMP review
Rayme Grubbs-Lynch	Police Chier	City of Point Hope	Planning Team Member, data input and HMP review
John Long, Jr.	Public Works Director	City of Point Hope	Planning Team Member, data input and HMP review

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Masuk Cassados Lane	Bookkeeper	City of Point Hope	Planning Team Member, data input and HMP review
Daisy Sage	City Council Secretary	City of Point Hope	Planning Team Member, data input and HMP review
Jeffery Kowunna	City Council Treasurer	City of Point Hope	Planning Team Member, data input and HMP review
David U. Stone, Sr.	City Council Member	City of Point Hope	Planning Team Member, data input and HMP review
Caroline P. Cannon	City Council Member	City of Point Hope	Planning Team Member, data input and HMP review
Jack W, Schaefer	City Council Member	City of Point Hope	Planning Team Member, data input and HMP review
JoAnne Neakok	Village Liaison & Office Manager	Native Village of Point Lay	Planning Team Lead, HMP review.
Willard P. Neakok	President	Native Village of Point Lay	Planning Team Member, data input and HMP review
Marie Tracey	Vice President	Native Village of Point Lay	Planning Team Lead, HMP review.
Gwendolyn Pikok	Treasurer	Native Village of Point Lay	Planning Team Member, data input and HMP review
Lily Anniskett	Secretary	Native Village of Point Lay	Planning Team Lead, HMP review.
Bertha Tazruk	Council Member	Native Village of Point Lay	Planning Team Member, data input and HMP review
Bill Tracey, Jr.	Council Member	Native Village of Point Lay	Planning Team Lead, HMP review.
Marjorie Long	Council Member	Native Village of Point Lay	Planning Team Member, data input and HMP review
John Hopson, Jr.	Mayor	City of Wainwright	Planning Team Lead, HMP review.
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Allison Segevan	Bookkeeper	City of Wainwright	Planning Team Member, data input and HMP review

Name	Title	Organization	Key Input
Oliver Peetook	City Council Member	City of Wainwright	Planning Team Lead, HMP review.
Linda Agnasagga	City Council Member	City of Wainwright	Planning Team Member, data input and HMP review
Sandra L. Peetook	City Council Member	City of Wainwright	Planning Team Lead, HMP review.
Raymond Aguvluk	City Council Member	City of Wainwright	Planning Team Member, data input and HMP review
Enoch Oktollik	City Council Member	City of Wainwright	Planning Team Lead, HMP review.

2.3 Public Involvement

Initial Public Meeting: During the month of February, 2015, The NSB planning teams held a public meeting in their respective cities announcing the hazard mitigation plan update project. A project newsletter describing the plan update process was posted at each City Office, the NSB website and on the State of Alaska Department of Homeland Security and Emergency Management (DHS&EM) website, http://ready.alaska.gov/plans/localhazmitplans, seeking public comment (Appendix G). DHS&EM sent an e-mail to the State Hazard Mitigation Advisory Committee (SHMAC) seeking expert comment. SHMAC members are documented in the State of Alaska Hazard Mitigation Plan. During the meetings, the public and the planning teams reviewed the seven hazards documented in their 2006 HMP:

1. Earthquake
2. Erosion
3. Flood / Coastal Storm Surge
4. Ground Failure
5. Severe Weather
6. Ivu / Coastal Ice Override
7. Wildland/Urban Interface Fire

Assisted by elder community members, the planning teams conducted a vulnerability assessment of their assets. They exposed buildings and infrastructure to the most severe scenarios. The results revealed the damage extents for each hazard.

2.4 Incorporation of Existing Plans

During the planning process, the planning team reviewed and incorporated information from existing plans into the HMP. The following were referenced during the risk assessment of the HMP for the North Slope Borough (Table 2-2).

Table 2-2 Incorporated Planning Documents

Existing Plans, Studies, Reports & Ordinances	Contents Summary
North Slope Borough Strategic Economic Plan, March 1, 2004	Defined the Borough's future economic goals.
City of Barrow Comprehensive Plan 2014-2035	Addresses the City's land & resource development, culture trends, goals, and subsistence initiatives.
North Slope Borough Comprehensive Plan (in development)	Documents community economic goals, area hazards, land use, and facilities profiles for Anaktuvuk Pass, Atqasuk, Barrow, Kaktovik, Nuiqsut, Point Hope, Point Lay, and Wainwright
North Slope Borough Oil Discharge Prevention and Contingency Plan 2011 & 2012	Produced by Great Bear Petroleum LLC covering oil leases on the North Slope.
North Slope Borough Comprehensive Emergency Management Plan, 2004	NSB Emergency response plan
North Slope Utility Master Plan and Emergency Utility Plan, June 2008	Sanitation, emergency operations, electrical production & distribution, and water supply
North Slope Borough Comprehensive Transportation Plan 2005	Documents Transportation needs and land use for Anaktuvuk Pass, Atqasuk, Barrow, Kaktovik, Nuiqsut, Point Hope, Point Lay, Wainwright
State of Alaska, Department of Commerce Community and Economic Development Profile	Provided historical and demographic information
State of Alaska Hazard Mitigation Plan (SHMP), 2013	Defined statewide hazards and potential risks.

Existing Plans, Studies, Reports & Ordinances	Contents Summary
City of Barrow Comprehensive Economic Development Strategy, 2011	Economic Development Plan
City of Atqasuk Local Government Operations and Youth Program, 2007	Addressed the needs for upgraded facilities and community programs for a growing population
City of Kaktovik Comprehensive Plan 2014	Provides guidance for future land use and natural resource management
City of Kaktovik Local All Hazard Mitigation Plan, 2005	Evaluated risks to local hazards in Kaktovik
City of Anaktuvuk Pass Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Anaktuvuk Pass
City of Atqasuk Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Atqasuk
City of Barrow Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Barrow
City of Nuiqsut Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Nuiqsut
City of Point Hope Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Point Hope
City of Point Lay Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Point Lay

Existing Plans, Studies, Reports & Ordinances	Contents Summary
City of Wainwright Local All Hazard Mitigation Plan 2005	Evaluated risks to local hazards in Wainwright
North Slope Borough Local All Hazard Mitigation Plan 2006	Profiled natural hazards in Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright

2.5 Plan Maintenance

The North Slope Borough Hazard Mitigation Plan will be maintained using the following three step process:

1. Incorporation into existing planning mechanisms
2. Continued public involvement
3. Monitoring, reviewing, evaluating, and updating the HMP

2.5.1 Existing Planning Mechanisms

The planning teams will incorporate planning mechanisms into their Hazard Mitigation Plan through the following activities:

- ☐ Research community-specific regulatory tools to facilitate mitigation strategy implementation as defined in the capability assessment section.
- ☐ Involve community departments and tribal organizations when researching existing information for inclusion into the HMP.
- ☐ Update or amend existing planning mechanisms as necessary.

2.5.2 Continued Public Involvement

The North Slope Borough is dedicated to involving the public in the continual reshaping and updating of the HMP. A paper copy of the HMP and any proposed changes will be available at all participating community offices. The planning team's contact information to which people can direct their comments or concerns are included in the acknowledgement section of this plan. Additionally, a copy of the plan will be posted on both the Borough and the State of Alaska Division of Community and Regional Affairs (DCRA) websites.

http://www.north-slope.org/

http://commerce.alaska.gov/dnn/dcra/PlanningLandManagement/CommunityPlansAndInfrastructure.aspx

Through community outreach activities, the planning team will continue to raise awareness about their Borough HMP. Outreach activities could include attendance and provision of materials at community-sponsored events, outreach programs, and public distributions. Any public comments received regarding the HMP will be collected by the planning team leaders, included in the annual report, and considered during future HMP updates.

2.5.3 Continued HMP Activities

Monitoring the HMP

The HMP was prepared as a collaborative effort. Building upon that effort, the planning teams will continue their involvement in monitoring, evaluating, and updating the HMP. Each authority identified in Table 2-1 will be responsible for implementing the mitigation action plan. The hazard mitigation planning team leader or designee will serve as the primary point of contact and will coordinate local efforts to monitor, evaluate, and revise the HMP.

Reviewing the HMP

The North Slope Borough will review their goals and actions for progress during the annual review. For convenience sake, the HMP annual review will coincide with the Comprehensive Plan review. During the annual review, each agency or authority administering a mitigation project will submit a progress report (Appendix C) to the planning team. The report will include the current status of the mitigation project and a comparison of the project to the corresponding goal identified in the plan.

Evaluating the HMP

The planning team leaders will initiate the annual review two months prior to the planning meeting date. The findings from the review will be presented at the planning team meeting. Each review, as shown on the annual review worksheet, will include an evaluation of the following:

- ☐ Involvement of community authorities, outside agencies, stakeholders, and residents
- ☐ Changes in risk for each natural or human- caused hazard
- ☐ Impact upon land development activities and related programs
- ☐ Mitigation Action Plan implementation progress, with problems and solutions
- ☐ HMP local resource implementation for HMP identified activities

Updating the HMP

The North Slope Borough will review their HMP annually and update it every five years, or when changes to hazards, actions, or priorities are made. The NSB planning team will solicit community involvement through participating community planning teams and the distribution of annual review questionnaires. The Annual Review Questionnaire (Appendix E) documents the Community's assessment of the Mitigation Action Plan and identifies potential changes to hazards, actions, and resource allocations.

No later than the beginning of the fourth year following HMP adoption, the NSB planning team will undertake the following activities:

- ☐ Request assistance from DHS&EM to update the HMP.
- ☐ Require each authority administering a mitigation project to submit a comprehensive progress report to the planning team.
- ☐ Identify the HMP sections needing improvement.

- Determine the current status of the mitigation actions in progress.
- Identify completed, deleted, or delayed projects. For statuses other than "completed", include a reason for the designation.
- Document changes in priorities.
- Assess the impact of completed projects.
- Identify any barriers preventing the implementation of mitigation projects such as financial, legal, or political restrictions and develop solutions.
- Thoroughly analyze and update their risks to natural hazards.
- Update the Mitigation Action Plan.

☐ Prepare a draft of the updated HMP.

☐ Submit the updated draft HMP to the DHS&EM and FEMA for review and approval.

2.5.4 State and FEMA Review and Technical Assistance

Draft local hazard mitigation plans are submitted to the State Hazard Mitigation Officer (SHMO) for review. The SHMO reviews the plan for consistency with the State HMP and the Disaster Mitigation Act of 2000 (DMA 2000) regulations. The primary guidance is the FEMA Local Mitigation Plan Review Guide and Tool, October 2011, and the FEMA Local Mitigation Planning Hand Book, March 2013. The State assists the community with any necessary revisions and then forwards the plan to FEMA Region 10 for final review. If no further revisions are necessary, FEMA issues an "approval pending adoption" (APA) letter to the community council. The local community council will formally adopt the plan by a resolution. If the community is unorganized, the State will act as the promulgate authority for plan adoption. Once the plan is adopted, the SHMO forwards a copy of the adoption resolution to FEMA Region 10 for final approval. FEMA sends the final approval letter to the community and the State for their records. Finally, the SHMO places copy of the FEMA approved Local HMP in DHS&EM files and on the State web site for reference.

3. Hazard Profiles

Profiling hazards is the act of researching their nature, history, magnitude, frequency, location, extent, and probability. Communities identify hazards through historical and anecdotal information, and reviews of pertinent plans and studies. Mapping the hazards determines their geographic extent and proximity to populated areas. All natural phenomenon are considered, and those found to have minimal impact or an unlikely occurrence are eliminated (Table 3-1).

Table 3-1 Hazard Identification and Screening

Natural Phenomenon	Should It Be Profiled?	Explanation
Earthquake	Yes	Periodic, unpredictable occurrences. NSB experienced no damage from the 11/2003 Denali EQ, and experienced less than 10% damage throughout the Borough from the 1964 Good Friday Earthquake.
Erosion	Yes	Sleetmute experiences riverine erosion along the area's river, streams, and creek embankments from high water flow, riverine ice flows, wind, surface runoff, and boat traffic wakes.
Flood Coastal Storm Surge	Yes	NSB communities experience snowmelt and rainfall flooding during spring thaw and the fall rainy season. Coastal communities experience sea water flooding and storm surge.
Ground Failure	Yes	Frost heaving and permafrost subsidence have damaged buildings and infrastructure in North Slope Borough communities.
Tsunami & Seiche	No	This hazard does not exist for this Borough
Volcano	No	This hazard does not exist for this Borough.
Weather, Severe	Yes	Annual weather patterns, severe cold, heavy rain, freezing rain, snow accumulations, and wind, are the predominate threats. Complex weather systems are the most severe bringing severe cold, wind, freezing rain, storm surge, and flooding.
Ivu Coastal Ice Override	Yes	Although rare, ice override events have been documented within the North Slope Borough.
Wildland/Urban Interface Fire	Yes	Small wildland fires have been documented within the boundaries of the Borough. However, none of the communities have ever been threatened.

During May and June of 2015, the planning team reviewed the natural hazards: earthquake, erosion, flood, ground failure, severe weather, Ivu, and wildland fire. These hazards were considered even if any particular one had not occurred within the past five years. The planning team reviewed their local hazards using the following criteria:

- ☐ Nature
- ☐ History
- ☐ Location
- ☐ Extent

☐ Impact ☐ Probability of future events

NFIP insured Repetitive Loss Structures (RLS) are addressed in Section 4.0, Vulnerability Analysis.

Each hazard receives a rating based on the following criteria for probability (Table 3-2) and magnitude/severity (Table 3-3).

Table 3-2 Hazard Probability Criteria

Probability	Criteria
4 - High	☐ Event is probable within the calendar year. ☐ Event has up to 1 in 1 year chance of occurring (1/1=100 percent). ☐ Probability is greater than 33 percent per year. ☐ Event is Highly Likely.
3 - Likely	☐ Event is probable within the next three years. ☐ Event has up to 1 in 3 years chance of occurring (1/3=33 percent). ☐ Probability is greater than 20per cent but less than or equal to 33 percent per year. ☐ Event is Likely.
2 - Credible	☐ Event is probable within the next five years. ☐ Event has up to 1 in 5 years chance of occurring (1/5=20 percent). ☐ Probability is greater than 10 percent but less than or equal to 20 percent per year. ☐ Event is Credible.
1 - Remote	☐ Event is possible within the next ten years. ☐ Event has up to 1 in 10 years chance of occurring (1/10=10 percent). ☐ History of events is less than or equal to 10 percent likely per year. ☐ Event is Remote.

Table 3-3 Hazard Magnitude/Severity Criteria

Magnitude / Severity	Criteria
4 - Catastrophic	☐ Multiple deaths. ☐ Complete shutdown of facilities for 30 or more days. ☐ More than 50 percent of property is severely damaged.
3 - Critical	☐ Injuries and/or illnesses result in permanent disability. ☐ Complete shutdown of critical facilities for at least two weeks. ☐ More than 25 percent of property is severely damaged.
2 - Limited	☐ Injuries and/or illnesses do not result in permanent disability. ☐ Complete shutdown of critical facilities for more than one week. ☐ More than 10 percent of property is severely damaged.
1 - Negligible	☐ Injuries and/or illnesses are treatable with first aid. ☐ Minor quality of life lost. ☐ Shutdown of critical facilities and services for 24 hours or less. ☐ Less than 10 percent of property is severely damaged.

Table 3-4 indicates numerical values representing the factors of the Risk Priority Index. The planning team rated each factor using data from prior disasters, and used the results to assign relative importance to each hazard.

Table 3-4 Risk Priority Index

Risk Priority Index			
.45 Probability	.30 Magnitude / Severity	.15 Warning Time	.10 Duration
4 - High	4 - Catastrophic	4 - Less Than 6 Hours	4 - More than 1 Week
3 - Likely	3 - Critical	3 - 6-12 Hours	3 - Less than 1 Week
2 - Credible	2 - Limited	2 - 12-24 Hours	2 - Less than 1 Day
1 - Remote	1 - Negligible	1 - 24+ Hours	1 - Less than 6 Hours

Example: Probability = 4-High, Magnitude=3-Critical, Warning Time=2-12-24 Hours, Duration=4-More than 1 Week.

(4x0.45) + (3x0.30) + (2x0.15) + (4x0.10) = 1.8+.9+.3 = 3.0

Table 3-5 reveals the Calculated Priority Risk Index for each hazard facing each community:

Table 3-5 Calculated Priority Risk Index by Hazard

North Slope Borough					
Hazard	Probability	Magnitude / Severity	Warning Time	Duration	Priority Risk Index
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion	4 High	3 Critical	1 24 + Hours	4 > One Week	3.25
Riverine Erosion	4 High	2 Limited	1 24+ Hours	4 > One Week	2.95
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	3 Likely	2 Limited	2 - 12-24 Hrs	4 > One Week -	2.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5
City of Anaktuvuk Pass					
Hazard	Probability	Magnitude / Severity	Warning Time	Duration	Priority Risk Index
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion (N/A)	0	0	0	0	0
Riverine Erosion	4 High	3 Critical	1 24+ Hours	4 > One Week	3.25
Flooding	2 Credible	3 Critical	2 12-24 Hours	3 < One Week	2.4
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	3 Likely	2 Limited	2 - 12-24 Hrs	4 > One Week -	2.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5
City of Atqasuk					
Hazard	Probability	Magnitude / Severity	Warning Time	Duration	Priority Risk Index
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion (N/A)	0	0	0	0	0
Riverine Erosion	2 Credible	2 Limited	1 24+ Hours	4 > One Week	2.05
Flooding	2 Credible	3 Critical	2 12-24 Hours	3 < One Week	2.4
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2

Wildfires	3 Likely	2 Limited	2 - 12-24 Hrs	4 > One Week -	2.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5
City of Barrow					
Hazard	**Probability**	**Magnitude / Severity**	**Warning Time**	**Duration**	**Priority Risk Index**
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion	4 High	3 Critical	1 24+ Hours	4 > One Week	3.25
Riverine Erosion (N/A)	0	0	0	0	0
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	2 Credible	2 Limited	2 - 12-24 Hrs	3 < One Week -	2.1
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5
City of Kaktovik					
Hazard	**Probability**	**Magnitude / Severity**	**Warning Time**	**Duration**	**Priority Risk Index**
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion	4 High	3 Critical	1 24+ Hours	4 > One Week	3.25
Riverine Erosion (N/A)	0	0	0	0	0
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	3 Likely	2 Limited	2 - 12-24 Hrs	4 > One Week -	2.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5
City of Nuiqsut					
Hazard	**Probability**	**Magnitude / Severity**	**Warning Time**	**Duration**	**Priority Risk Index**
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion (N/A)	0	0	0	0	0
Riverine Erosion	4 High	2 Limited	1 24+ Hours	4 > One Week	2.95
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	3 Likely	2 Limited	2 - 12-24 Hrs	4 > One Week -	2.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5

City of Point Hope					
Hazard	**Probability**	**Magnitude / Severity**	**Warning Time**	**Duration**	**Priority Risk Index**
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion	4 High	3 Critical	1 24+ Hours	4 > One Week	3.1
Riverine Erosion (N/A)	0	0	0	0	0
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.1
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.6
Wildfires	1 Remote	2 Limited	2 - 12-24 Hrs	3 < One Week -	1.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5

Native Village of Point Lay					
Hazard	**Probability**	**Magnitude / Severity**	**Warning Time**	**Duration**	**Priority Risk Index**
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 hrs	1.45
Coastal Erosion	4 High	3 Critical	1 24+ Hours	4 > One Week	3.25
Riverine Erosion (N/A)	0	0	0	0	0
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	1 Remote	2 Limited	2 - 12-24 Hrs	3 < One Week -	1.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5

City of Wainwright					
Hazard	**Probability**	**Magnitude / Severity**	**Warning Time**	**Duration**	**Priority Risk Index**
Earthquake	1 Remote	1 Negligible	4 under 6 Hrs	1 under 6 Hrs	1.45
Coastal Erosion	4 High	3 Critical	1 24+ Hours	4 > One Week	3.25
Riverine Erosion (N/A)	0	0	0	0	0
Flooding	4 High	3 Critical	2 12-24 Hours	3 < One Week	3.3
Severe Winter Storm	4 High	3 Critical	1 24+ Hours	3 < One Week	3.15
Ivu (Ice Override)	2 Credible	2 Limited	4 < 6 Hours	1 < 6 Hours	2.2
Wildfires	1 Remote	2 Limited	2 - 12-24 Hrs	3 < One Week -	1.65
Ground Failure	3 Likely	2 Limited	1 24+ Hours	4 > One Week	2.5

Table 3-6 documents the event history and damage extents for the North Slope Borough.

Table 3-6 Hazard History and Extent

Hazard History and Extent – North Slope Borough						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
17 - L	34 - L	4 - L	10 - T	10 - L	8 - L	3 - L
Hazard History and Extent – City of Anaktuvuk Pass						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
1 - L	0 - L	4 - L	0 - T	0 - L	2 - L	N/A
Hazard History and Extent – City of Atqasuk						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
1 - L	0 - L	4 - L	0 - T	0 - L	1 - L	N/A
Hazard History and Extent – City of Barrow						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
4 - L	0 - L	4 - L	0 - T	5 - L	0 - L	3 - L
Hazard History and Extent – City of Kaktovik						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
4 - L	0 - L	4 - L	1 - T	2 - L	1 - L	0
Hazard History and Extent – City of Nuiksut						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
1 - L	0 - L	4 - L	0 - T	0 - L	1 - L	N/A
Hazard History and Extent – City of Point Hope						
Flood	Wildland Fire	Earthquake	Severe Weather	Erosion	Subsidence	Ivu
2 - L	1 - L	4 - L	0 - T	2 - L	1 - L	0

Hazard History and Extent – Native Village of Point Lay						
Flood	**Wildland Fire**	**Earthquake**	**Severe Weather**	**Erosion**	**Subsidence**	**Ivu**
2 - L	0 - L	4 - L	0 - T	1 - L	1 - L	0
Hazard History and Extent – City of Wainwright						
Flood	**Wildland Fire**	**Earthquake**	**Severe Weather**	**Erosion**	**Subsidence**	**Ivu**
2 - L	1 - L	4 - L	0 - T	1 - L	1 - L	0

Extent
L - Limited – Minimal through maximum impact to part of community
Falls short of the definition for total extent
T - Total – Impact encompasses the entire community
Number: Number of occurrences
(Source: Alaska State All-Hazards Plan, Bethel Census Area)

The hazards profiled for the Borough are presented throughout the remainder of Chapter 3. The order does not signify their importance or risk level.

3.1 Earthquake

Nature

An earthquake is a sudden motion or trembling caused by a release of strain accumulated within or along the edge of tectonic plates. Earthquakes usually occur without warning and after only a few seconds, ground motion at the surface may cause extensive damage and many casualties.

Ground motion increases with the amount of energy released and decreases as seismic waves travel through and along the earth's surface, away from the fault or epicenter. There are two basic types of seismic waves, body waves and surface waves. The first jolt felt during an earthquake is the push-pull body wave, or P (primary) wave. P waves are compression waves moving through the earth. The second wave felt is another type of body wave, called an S (secondary) wave. S waves, also known as shear waves, are slower than P waves and behave like sound waves. The rolling motion felt along the surface is an R (Raleigh) wave. R waves move continuously forward, although the individual particles move in an elliptical path, similar to water waves. L (Love) waves, like Raleigh waves, are continuously forward travelling surface waves, but the individual particles move side to side, perpendicular to the direction of travel. Surface waves are responsible for much of the ground motion experienced during an earthquake.

Secondary natural hazards associated with earthquakes are:

- ☐ **Surface Faulting** is the differential ground movement of a fault at the earth's surface. Displacement along faults varies but may be significant (e.g., over 20 feet), as may the length of the surface rupture (e.g., over 200 miles). Surface faulting may severely damage linear structures, including railways, highways, pipelines, and tunnels.

- **Liquefaction** refers to a loss of soil structure as seismic waves pass through saturated granular soil. The higher pore water pressure suspends the soil grains and moves to areas of low pressure, moving the soil with it. The soil will behave as a liquid. There are three telltale signs indicating liquefaction has taken place:
    1. Lateral spread, horizontal movements commonly ten to fifteen feet, possibly reaching over one hundred feet in length.
    2. Debris flows, massive flows of soil, typically hundreds of feet, possibly reaching over twelve miles in length.
    3. Loss of bearing strength, soil deformations causing structures to settle or tip.

- **Landslides** occur as a result of horizontal seismic inertia forces induced by ground shaking. The most common earthquake-induced landslides are rock falls, rockslides, and soil slides.

The severity of an earthquake is expressed in terms of intensity and magnitude. Intensity is determined from the effects on people and their environment. It varies depending upon the location with respect to the earthquake epicenter, which is the point on the earth's surface that is directly above the origin (Focus). The intensity generally increases with the amount of energy released and decreases with distance from the epicenter. The scale most often used in the U.S. to measure intensity is the Modified Mercalli Intensity (MMI) Scale. As shown in Table 3-7, the MMI Scale consists of 12 increasing levels of intensity that range from imperceptible to catastrophic destruction. Peak ground acceleration (PGA) is also used to measure earthquake intensity by quantifying how hard the earth shakes in a given location. PGA can be measured as acceleration due to gravity (g) (MMI 2012).

Magnitude (M) is the measure of the earthquake strength related to the amount of seismic energy released at the earthquake's actual position of origin, known as the hypocenter (Table 3-7).

Table 3-7 Magnitude/Intensity/Ground-Shaking Comparisons

Magnitude	Intensity	PGA (% g)	Perceived Shaking
0 – 4.3	I	<0.17	Not Felt
	II-III	0.17 – 1.4	Weak
4.3 – 4.8	IV	1.4 – 3.9	Light
	V	3.9 – 9.2	Moderate
4.8 – 6.2	VI	9.2 – 18	Strong
	VII	18 – 34	Very Strong
6.2 – 7.3	VIII	34 – 65	Severe
	IX	65 – 124	Violent
	X	124 +	Extreme
7.3 – 8.9	XI		
	XII		

Source: (MMI 2012)

History

On Good Friday, March 27, 1964, North America's strongest recorded earthquake, with a moment magnitude of 9.2, rocked central Alaska. Globally, three of the ten strongest earthquakes ever recorded were in Alaska. Table 3-8 lists the largest earthquakes to occur within the North Slope Borough.

Table 3-8 Largest Earthquakes in North Slope Borough

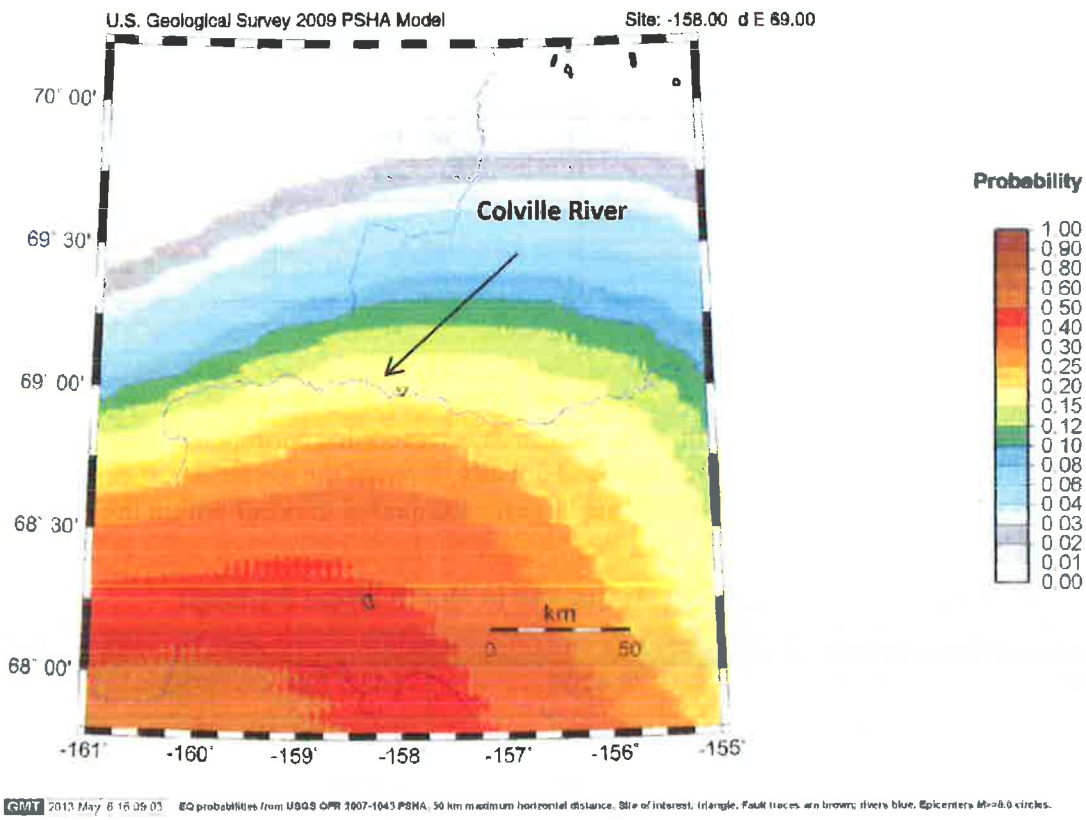
Date	Time	Latitude	Longitude	Magnitude
1/22/68	23:44	70.4100	-143.7700	5.3
7/19/69	1:48	68.8000	-155.7000	5.1
12/04/93	14:11	69.6908	-146.9037	5.2
8/31/95	8:20	69.3603	-147.1513	5.0

Location

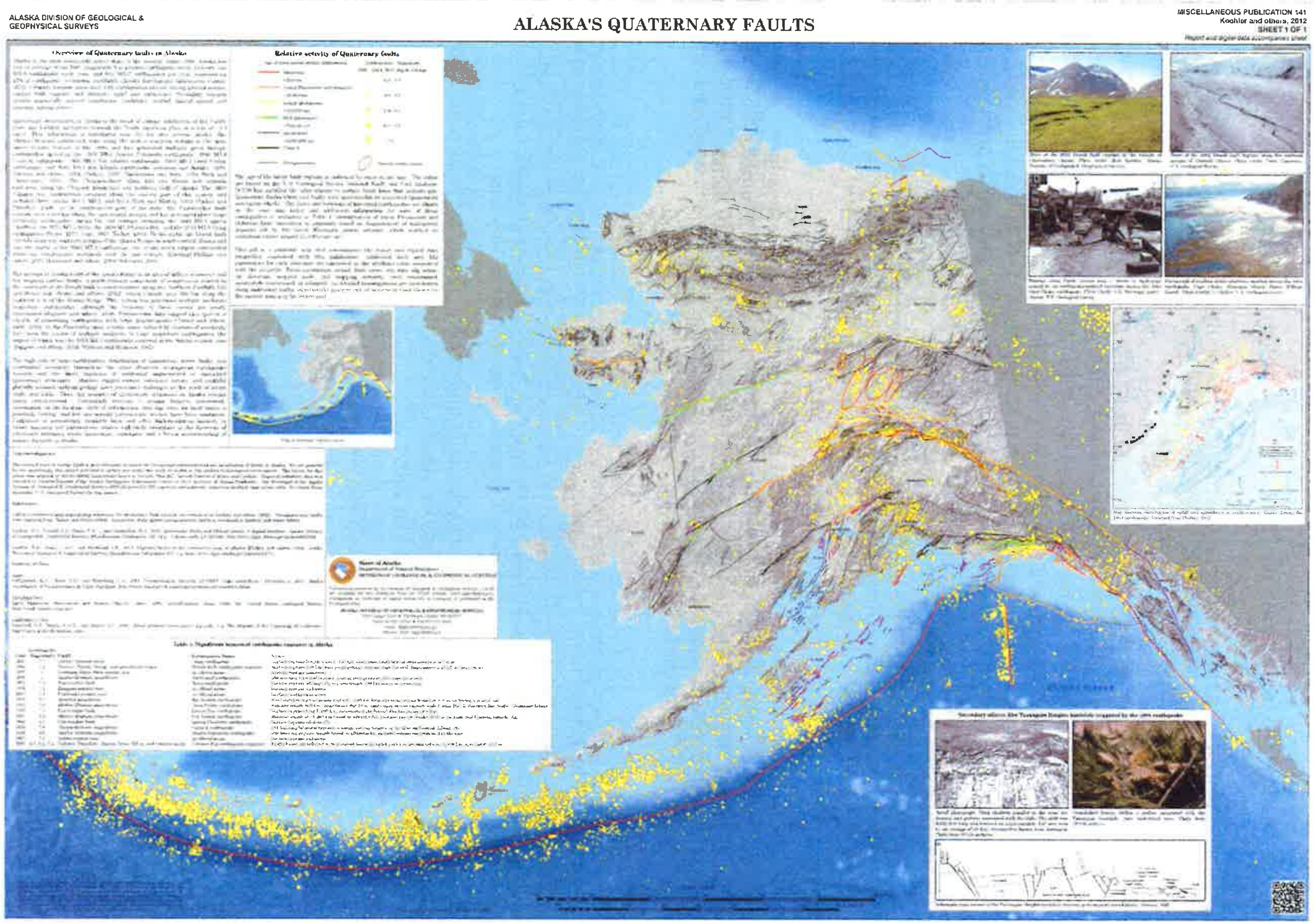
The entire geographic area of Alaska is prone to the effects of an earthquake. Figure 3-1 was generated using the U.S. Geologic Survey (USGS) Earthquake Mapping model and indicates a three percent probability of a 5.0 magnitude or greater earthquake occurring within ten years in the North Slope Borough.

Figure 3-1 Borough Earthquake Probability

Probability of earthquake with M > 5.0 within 50 years & 50 km



The Department of Geological and Geophysical Survey (DGGS) Map of Alaska's Quaternary Faults depicts Alaska's known earthquake fault locations (Figure 3-2).


ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
ALASKA'S QUATERNARY FAULTS
MISCELLANEOUS PUBLICATION 141
Koehler and others, 2012
SHEET 1 OF 1
Overview of Quaternary faults in Alaska
Relative activity of Quaternary faults

Extent

Alaskans experience approximately 5,000 earthquakes annually, including 1,000 measuring above 3.5 on the Richter scale. Alaska is vulnerable to three types of earthquakes:

1. **Subduction zone earthquakes** begin with one crustal plate moving beneath another plate. This is the case in Southcentral Alaska and along the Aleutian Islands, where the Pacific Plate dives beneath the North American Plate. The Good Friday Earthquake in Alaska resulted from movement along the Aleutian Megathrust subduction zone.
2. **Transform fault earthquakes** originate from crustal plates sliding by each other. A popular example is the San Andreas Fault in California. A transform fault exists just offshore of southeastern Alaska, where the North American Plate and the Pacific Plate slide past each other on the Fairweather - Queen Charlotte Fault.
3. **Intraplate earthquakes** occur within a tectonic plate, occasionally at great distance from the plate boundaries. These types of earthquakes may have magnitudes of 7.0 and greater. Shallow earthquakes in the Fairbanks area are an example of intraplate earthquakes.

Impact

Although the North Slope Borough is located in a less seismically active area than others in the state, communities may feel earthquakes centered elsewhere. The magnitude of impacts would be considered negligible with minor injuries, less than 10 percent of property damaged, and little to no permanent damage to transportation, infrastructure, or the economy.

Probability

Considering the location, Figure 3-1 and Table 3-2, it is unlikely an earthquake would originate anywhere within the North Slope Borough (remote). Figure 3-1 was generated using the USGS Earthquake probability mapping model, also known as a Shake Map, and indicates a 3 percent probability of a 5.0 magnitude or greater earthquake occurring within 10 years.

This 2009 Shake Map incorporates current seismicity in its development and is the most current map available for this area. Peter Haeussler, USGS, Alaska Region, explained factors influencing probability in earthquake hazard mapping in 2009:

> The occurrence of various small earthquakes does not change earthquake probabilities. In fact, in the most dramatic case, the probability of an earthquake on the Denali fault was/is the same the day before the 2002 earthquake as the day afterward. Those are time-independent probabilities. The things that change the hazard maps is changing the number of active faults or changing their slip rate.

3.2 Erosion

Nature

Erosion is the wearing and transportation of land. In developed regions, Erosion undermines buildings and infrastructure. The North Slope Borough experiences:

- Coastal erosion

- Riverine erosion
- Wind erosion

Coastal Erosion

Coastal erosion is a common term used to describe the retreat of the shoreline along the ocean. It is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. Coastal erosion forces are waves, currents, and wind. Surface and ground water flow, and freeze-thaw cycles may also play a role. Not all of these forces may be present at any particular location. Erosion rates are not uniform, and are accelerated by intense natural and human activities.

Factors Influencing Coastal Erosion

Natural events such as storm forces, wind, and coastal flooding or human activities like boat wakes and dredging accelerate coastal erosion. Other human factors are construction along the shoreline and contributions to a warming climate. Climatic factors such as sea-level rise, increased storm activity, and land subsidence exacerbate coastal erosion in Alaska. According to the National Oceanic and Atmospheric Administration (NOAA), global average sea levels rose a total of 7.7 inches between 1870 and 2004.

Attempts to control erosion using shoreline protective measures such as groins, jetties, seawalls, or revetments could lead to increased erosion elsewhere. However the Borough Council interprets inaction as leading to increased damages.

Below is a summary of natural and human-induced factors influencing coastal erosion in the North Slope Borough:

- Shoreline composition
- Shoreline orientation
- Prevailing winds
- Wave action
- Geomorphology
- Human activity along the shoreline
- Density of development
- Erosion controlling structures
- Coastal topography
- Coastal dune and bluff elevations
- Shoreline exposure to wind and waves

History

Coastal Erosion in the North Slope Borough

The prevailing coastline composition is loose sandy soil and underlying permafrost. Coastal storms erode the sandy soils and expose the permafrost, which thaws and washes out to sea.

- **Barrow**

The issue of coastal erosion has been the issue of many scientific studies over the years, so a variety of data exists for the community of Barrow. As stated in the previous section, coastal erosion in Barrow is limited to the 3-4 months of ice-free water. Although this is a relatively brief period of time, a study published in 2003 (Brown, J.; M.T. Jorgenson; O.P. Smith & W. Lee 2003 Long-term rates of coastal erosion and carbon input, Elson Lagoon, Barrow, Alaska. *In* Proceedings of the Eighth International Conference on Permafrost, v.1. M. Phillips, S.M. Springman and L.U. Arenson (eds.). Zurich.) observed extreme rates of 10 meters per year have been documented along many Arctic coastlines, and average coastal erosion rates of 2 to 6 meters per year are common. Coastal erosion rates are an average of annual erosion events.

The previously mentioned study centers on the area around the Elson Lagoon in Barrow. Data gathered for the study spans the years of 1948 through 2000, providing a long term study of coastal erosion rates, as well as depicting current patterns in erosion rates. The study discovered the area near Point Barrow lost an average of .48 meters of coastline due to erosion annually during the period spanning from 1948-1979, but the average rate increased to .86 meters per year during the period spanning 1979-2000. The comparison illustrates a 47% increase in annual coastal erosion rates from the period spanning 1948-1979 to the period spanning 1979-2000.

Storms occurring in 1954, 1963, and again in 1986 are notable in the amount of coastal erosion they caused. A fall storm in 1954 (Schalk, 1957) created a storm surge of 9 to 10 feet in height, and substantially eroded the beaches and bluffs surrounding the community.

According to a published report from Hume and Schalk, 1967, "The most devastating single episode of bluff erosion occurred during the storm of October 3, 1963, described as the worst storm in the memory of the Eskimo people." A 350-mile fetch, coupled with storm surges of 12 feet caused the entire Barrow spit to be submerged. According to Hume and Schalk, more sediment was moved from the beaches and bluffs during this storm than would normally be transported over a 10 year period.

The September 1986 storm caused significant erosion damage, leading the State of Alaska to declare an emergency for all the coastal villages in the North Slope Borough. As a result, the Borough hired the California firm of Tekmarine to inspect the storm damage and evaluate various protection measures. A subsequent report, titled, "Bluff and Shoreline Protection Study for Barrow, Alaska", includes a statement reflecting the conditions at the time, which has only grown more relevant today:

> The coastal erosion at Barrow has been recorded in scientific literature for at least the past 30 years, but the erosion has become a serious problem recently as it began to threaten the local community. In particular, the receding bluff line has encroached upon the housing and streets of Barrow, and it is feared that the spit separating the sewage and fresh water lagoons may be breached if the shoreline erosion is allowed to continue.

Although natural forces are responsible for much of the erosion within the Borough, human activity has exacerbated the problem. When the Navy built the Naval Arctic Research Lab nearing Barrow in the 1940's, gravel was removed from nearby beaches to build roads and pads. Similarly, gravel from local beaches was used for the construction of Barrow's first airport. This activity has concerned federal agencies for some time. In a memo from the Chief of Division of Lands and Minerals, dated June 28, 1968, great concern was expressed over the rapid reduction in coastal beaches during the previous 30 years. Sources quoted in the memo remembered the beaches near Barrow extending over 100 yards wide in 1937, and stated the beach width had been reduced to less than 15 yards by 1968. The memorandum attributes much of the erosion of beach sands to the mining of gravel from beaches and offshore. The ocean eroded the beach sands and deposited them in the hollows formed from gravel mining.

- **Kaktovik**

Some preliminary erosion studies have been conducted in Kaktovik. In a December 1998 US Army Corps of Engineers (USACOE) report entitled, "Design Analysis for Landfill Protection, Long Range Radar Site (LRRS) Barter Island, Alaska", bluffs along the northerly limit of the radar site receded between 25 to 30 feet from 1991 to 1995. The U. S. Army Corps of Engineers estimated the bluffs were receding at the rate of 5 to 8 feet annually.

The USACOE became concerned when erosion encroached upon a decommissioned site named the DEW line landfill. As part of the decommissioning, the DEW line landfill was closed by encapsulation. However, erosion had exposed it by the year 2000. According to the USACOE, "Miscellaneous debris from the landfill including barrels, scrap metal, and other unknown materials have washed out into the Beaufort Sea," as a result of the continued erosion in the area.

Erosion has also threatened other infrastructure in the community of Kaktovik. In the early 1980's, the North Slope Borough built a seawall along the lagoon to prevent newly built roadways from erosion damage.

Coastal storms continue to encroach upon the Barter Island Airport and storm surges routinely inundate and erode portions of the runway. Although the North Slope Borough has attempted to protect the airport, erosion slowly progresses. In September of 1986, a large fall storm completely submerged the runway and swept a substantial portion of adjacent land out to sea. The runway has since flooded on an average of every two years.

- **Point Hope**

Coastal erosion is a great concern for the community of Point Hope. Over the last 2,500 years, various processes of erosion have forced the community to relocate several times. The point itself was at one time several miles longer, curving far around to the north, but it gradually wore away. As flooding and erosion battered the village, archeological records were buried and lost. Known settlements are Old and New Tikigak Village, Ipiutak, Quzmiarzuq (Jabbertown), and the present community, Point Hope. The most recent move was in the early 1970s when erosion and periodic storm-surge flooding forced the village to move to a site just east of the Old Village. Houses were moved on runners to the new site and the North Slope Borough constructed some new housing. Continuing erosion may necessitate yet another move in the future.

In 1972, the Army Corps of Engineers (USACE) completed the study "Point Hope Beach Erosion, Point Hope, Alaska" that centered on the old town site. In this study, they estimated the average annual erosion rate at 8.8 feet per year, or a total loss of one acre per year. Recent observations by experienced community members feel the erosion rate is accelerating. At the time of the report, the USACE estimated erosion would directly impact the old town site by 2005; a prediction since proven true. Even more troubling is their projected annual erosion rate of 8.8 meters for the end of the point, where the airport and the ancient site of Old Tigara are located.

During a storm in October 2004, the community experienced south winds gusting over 60 mph and waves in excess of 12 feet in height. The ensuing storm surge eroded 45 feet of coastline on the south side of the community, and another 25 feet of coastline on the north side of the spit. Additionally, the storm eroded a substantial amount of the bluff upon which the runway and the old village of Point Hope sit. Erosion is now a serious threat for the north and south ends of the runway, as well as old middens, sod houses, and ice cellars located in the area.

A 2003 North Slope Borough Project Analysis Report for the construction of an Emergency Evacuation Road in Point Hope echoed much of the concern of the 1971 Army Corps of Engineers report. In commenting on the PAR, the Tikigaq Corporation strongly emphasized the need for an evacuation road, as well as relocation of the airport.

- **Point Lay**

Coastal erosion is a concern for the community of Point Lay. Local residents report moderate erosion on the coastline bordering the Kasegaluk lagoon, which separates the community of Point Lay from the sea. Some concern has been expressed that continued erosion would eventually breach this thin strip of land, allowing the sea to reclaim the lagoon.

- **Wainwright**

In the community of Wainwright, two homes are threatened by erosion of the bluffs upon which they are built. Milikruak Road, which borders the coastline, is also at risk of erosion, as is the utility infrastructure along the roadway.

- **Atqasuk, Nuiqsut, Anaktuvuk Pass**

Due to their inland locations, coastal erosion is not problematic for the communities of Atqasuk, Nuiqsut or Anaktuvuk Pass.

The North Slope Borough has made several attempts to stem the risk of erosion. Public works crews work annually to construct sand berms, or place sand bags upon the coastline surrounding Barrow, Wainwright, Kaktovik and Point Hope. Although such efforts appear to reduce the risk of flooding, there is little impact on reducing erosion.

During the 1999 and 2000, the North Slope Borough attempted an annual beach nourishment project, deploying a barge to dredge sand and gravel from the ocean floor, and redeposit it upon the beach. This program proved extremely costly, with negligible results in stemming beach erosion. The program was discontinued when the barge was grounded during a large coastal storm in the year 2000.

In the summer of 2004, the North Slope Borough began its latest effort to control coastal erosion in Barrow and Wainwright. The North Slope Borough Public Works Department acquired a product called "concentainers", which are similar in design and purpose to gabions. The containers are filled with local sand and gravel, and then stacked in interlocking fashion along critical areas. The North Slope Borough Public Works Department chose two areas as beta sites in each community for the product, creating retaining walls during the summer of 2004. The North Slope Borough Public Works Department continues to monitor and evaluate the effectiveness of this technology.

Riverine Erosion

Riverine erosion is the wearing of riverbanks and riverbeds over time. In Alaska, high breakup rates and heavy rainfall accelerate this process. High volume and velocity run-off concentrates in the lower drainages and scours the riverbanks. The water continues to increase its sediment load while flowing downstream and eventually deposits it in slower moving sections such as dams or reservoirs. The river may eventually change course and threaten developments. Riverine erosion threatens many Alaskan villages and they need extensive mitigation measures to prevent further bank loss.

- **Anaktuvuk Pass**

Riverine erosion was a yearly occurrence in Anaktuvuk Pass prior to 1981. At that point, the North Slope Borough deepened and widened the channel of the Contact Creek and lined the riverbanks with riprap to reduce the effects of erosion. The North Slope Borough continues to monitor the channel of the river, and makes repairs to area impacted by erosion on an annual basis.

- **Atqasuk**

As the Meade River runs adjacent to the community of Atqasuk, but not through a developed area, riverine erosion does not currently threaten the infrastructure of the City of Atqasuk. Local residents do report that the Northside Cemetery in Atqasuk could be threatened by erosion of the banks of the Meade River in the future.

- **Nuiqsut**

In Nuiqsut, the Nechelik Channel of the Colville River causes annual erosion to the gravel source road, and is currently eroding the bank on the north edge of the community. The erosion on the north edge of the community is threatening the current location of the sewage outflow lines, as well as the location of historic snow machine trails used by the community.

- **Barrow, Kaktovik, Point Hope, Point Lay, Wainwright**

As the communities of Barrow, Kaktovik, Point Hope, Point Lay and Wainwright have no large streams or rivers running through their boundaries, they are not susceptible to riverine erosion.

Based upon the information contained above, a limited risk of riverine erosion does exist in Anaktuvuk Pass, Atqasuk, and Nuiqsut.

Wind Erosion

Wind erosion is very selective, carrying the finest particles, particularly organic matter, clay and loam (top soil) long distances. Wind erosion reduces the capacity of the soil to store nutrients and water, thus making the environment drier. However, deposits of this alluvial formed the fertile loess soils covering large areas of Europe and North America, where highly productive farming has developed. The wind moves soil particles 0.1-0.5 mm in size in a hopping or bouncing fashion (known as saltation) and those greater than 0.5 mm by rolling (known as soil creep). The finest particles (less than 0.1 mm) are suspended in the air. Wind erosion will increase during periods of drought.

Wind erosion removes topsoil, which may hinder agricultural production. Although this problem does not exist on the North Slope, the dust may reduce visibility causing automobile accidents, hinder machinery, and have a negative effect on air and water quality creating animal and human health concerns. Wind erosion may damage public utilities and infrastructure. Although wind erosion occurs in all the communities of the North Slope Borough, the greatest risk presented is the reduction in air quality, and the tainting of subsistence foods being dried in the traditional manner.

Location

- Coastal: Barrow, Kaktovik, Point Hope, Point Lay, Wainwright
- Riverine: Anaktuvuk Pass, Atqasuk, Nuiqsut
- Wind: All North Slope Borough communities

Extent

Erosion rarely causes death or injury. However, erosion does destroy property, development, and infrastructure. In Alaska, coastal erosion is the most destructive, riverine erosion a close second, and wind erosion a distant third.

Impact

The primary impact from erosion is the loss of land and anything on it. Erosion may increase sedimentation of river deltas and hinder channel navigation. Other impacts include reduction in water quality due to high sediment loads, loss of native aquatic habitats, damage to public utilities (fuel headers and electric and water/wastewater utilities), and economic impacts associated with the costs of trying to prevent or control erosion sites. Referring to Table 3-3, possible impacts to Borough communities are limited.

Probability

Given the event history, it is highly likely the North Slope Borough will experience further erosion of its land. Additional events are likely every calendar year with a 1 in 1 year chance of occurring (1/1=100 percent) and the event history is greater than 33 percent likely per year.

3.3 Flood

Nature

Flooding is the accumulation of water where usually none occurs or the overflow of excess water from a stream, river, lake, reservoir, glacier, or coastal body of water onto adjacent floodplains. Floodplains are lowlands adjacent to water bodies that are subject to recurring floods. Floods are natural events and only considered hazards when they inundate developed areas.

Six primary types of flooding occur in the Borough: rainfall-runoff, snowmelt, coastal storm surge, alluvial fan floods, flash floods, and ice jam floods.

Rainfall-Runoff Flooding occurs in late summer and early fall. The rainfall intensity, duration, distribution, and geomorphic characteristics of the watershed all play a role in determining the magnitude of the flood. Rainfall runoff flooding is the most common type of flood.

Snowmelt Floods typically occur from April through June. Snowpack depths, spring weather patterns, and geomorphic characteristics of the watershed determine the magnitude of flooding.

Coastal Storm Surge or coastal floods, occur when the sea is driven inland above the high-tide level onto land that is normally dry. Often, heavy surf conditions driven by high winds accompany a storm surge.

Alluvial Fan Floods are areas of eroded rock and soil deposited by watersheds. When debris fills the river channels on the alluvial fan, the water overflows its banks and creates a new channel. Fast, debris filled water can flow over large areas.

Ice jam floods occur after an ice jam develops on a river or stream and blocks the path of flowing water. This type of flood may occur any time when ice is present. Ice jams form during the following three situations:

- Fall freeze up
- Midwinter when stream channels freeze forming anchor ice.
- Spring breakup, when the existing ice cover breaks apart, flows downstream, and jams together at narrow sections of the stream channel.

Ice jams commonly develop in areas where the channel slope decreases, becomes shallow, or at constricted areas such as at bridges, bends in the river, headwaters, and reservoirs. Ice jams frequently impede water along rivers during spring breakup.

The water level rises upstream behind the ice jam and floods low lying areas. As the ice jam is breached, there is usually rapid draining of the excess flood water. The water level downstream will rise quickly and behave much like a flash flood, carrying large chunks of ice, trees, bank vegetation, and other debris in it's current. Notable large floods in recent years on the Kenai, Susitna, Kuskokwim, and Yukon rivers were all caused by ice jams in conjunction with water from melting snow.

Flash floods are characterized by a rapid rise in water. They often result from heavy rain, ice jam formations, or by dam failure. They are usually swift moving and debris filled, causing them to be very powerful and destructive. Steep coastal areas typically experience flash floods.

Events related to riverine flooding are sediment deposition and stream bank erosion. Deposition is the accumulation of soil, silt, and other particles on a river bottom or delta. Deposition leads to the destruction of fish habitat and presents a challenge to river navigation. Deposition also decreases channel capacity and increases risk to flooding and bank erosion.

Seasonal Occurrences

In the North Slope Borough, the highest risk to ice jams and snow melt flooding occurs in early summer, also referred to as breakup season. The highest risk to excessive rainfall and storms occur during late summer and early fall seasons. Most of the annual precipitation occurs April through October with August typically being the wettest month. The risk to rainfall generated floods corresponds to this cycle.

History

The following summarizes flood events in the North Slope Borough:

➢ **Rainfall-Runoff Floods**

- Nuiqsut experiences relatively low precipitation levels, however rainfall collecting in the Brooks Range has caused some flooding in the Nechelik Channel of the Colville River. In one instance in 1973, floodwaters created from this phenomenon buried the tundra east of town under water, including both the gravel source and the boat dock. There is no recorded history of a flood substantial enough to reach the community.
- In Point Hope, the Marrayatt Inlet, which neighbors the community on the north side, frequently rises with increased runoff from the rivers to the north. Although the community itself has experienced no flooding from this action, travel becomes problematic when the ice

and water clog the natural drainage waterways from the lagoon to the sea.

- **Snowmelt Floods**

- In Atqasuk, the level of the Meade River does rise when the snow melts, however the river lies at a substantially lower elevation than the community.
- In Anaktuvuk Pass the water level of the Contact Creek rises in the same manner, however the creek has not crested its banks since it was channelized in the 1980's. Little Contact Creek, which runs north of the community, floods every spring. Although no damage to homes or property has occurred as yet, a year of exceptionally heavy snowfall in the surrounding Brooks Range could impact the community.
- Although no river or major stream runs through the community of Kaktovik, snowmelt flooding poses some threat. In the spring, melting snow and ice causes large amounts of water to accumulate in the east end of the community. Homes on Pipsuk Road, Barter, Kaktovik, Hula Hula and First Streets are surrounded by water. During June 2004 the water level rose within four inches of flooding at least one home. Community residents advise that additional, and larger drainage culverts need to be installed in this area.
- In Point Hope, the Marrayatt Inlet, which neighbors the community on the north side, frequently swells with snowmelt runoff. Although the community itself hasn't experienced any flooding, the freshwater lagoon does flood and mixes with the sea.
- In Point Lay, melting snow runs over the community landfill, then pools near their water source, a fresh water lagoon. The lagoon lies lower than the landfill. Presented with this situation, residents are concerned about the contaminated snowmelt mixing with their drinking water. They report the contaminated snowmelt approached within 100 feet of the freshwater lake during the early summer of 2004.

- **Coastal Storm Surge**

- Storm surge is the leading natural hazard in Barrow, threatens homes and infrastructure in Wainwright and Point Hope, and floods the runway in Kaktovik.
- A fall storm occurring in 1954, accompanied by 9 to 10 foot storm surges, caused substantial flooding throughout the Borough coast. According to all accounts, this event was the greatest storm remembered in the community up to that point.
- **Barrow:** The greatest storm in the recorded history of the North Slope Borough occurred on October 3, 1963, and centered on the community of Barrow. A deepening low-pressure system moved eastward across the Arctic Ocean and Beaufort Sea, and a storm surge developed traveling west by northwest. Cyclone level winds pushed coastal storm surges to levels of 11 to 12 feet near Barrow, causing millions of dollars of damage to the community. The Tundra Drums Newspaper reported that 15 homes, 15 other buildings and four aircraft were lost as a result of the storm. In addition, substantial damage was inflicted to the area's electrical generation plant, and the lagoon from which the community drew its drinking water was ruined after being flooded with seawater.
  - In September 1986 two fall storms struck the community of Barrow. Each storm was accompanied by 4 to 6 foot surges resulting in the State of Alaska declaring an emergency for Barrow. Substantial damages were inflicted upon Stevenson Street and other roadways in the community, with damages valued in the hundreds of thousands of dollars.

- **Wainwright:** The same 1963 storm created a surge of 11-12 feet near the community of Wainwright, which damaged several homes, buildings, with approximately 50% of the community of Wainwright left flooded by this event.
- **Kaktovik** has endured intermittent flood activity over the years, mostly caused by coastal storm surges. During a major storm in September 1957, waves estimated at 6 to 12 feet caused substantial road damage on Barter Island, and caused 4,400 barrels of fuel to be swept away.
    - During another substantial storm in August 1972, coastal storm surges in Kaktovik inundated the runway of the Barter Island airport in four inches of water, temporarily closing the runway.
    - The September 1986 storm created surges of sufficient height to completely submerge the Barter Island Airport in Kaktovik. The runway at the airport now experiences annual flooding as a result of summer and fall storms.
    - A storm occurring in August 2000 caused water levels to rise 3.76 feet above the mean sea level, causing at least half of the Barter Island Airport runway to be submerged. This storm caused the airport to be closed for approximately three days, inhibiting transport of persons and supplies to and from the community. Minor flooding of the runway occurred again during falls storms in 2002, 2003 and 2004.
- **Nuiqsut:** During a community meeting held in Nuiqsut on November 1, 2004 local residents advised that the greatest risk posed by coastal storm surge is that oil from the Alpine and Prudhoe Bay developments is pushed west and collects along the shore in some of the historic fishing areas used by the community.
- **Point Hope:** In Point Hope, village elders recount a story told to them by their elders of storm that occurred approximately 70 – 85 years ago (1919-1934). According to the story, the storm was of sufficient strength and duration to submerge the entire spit.
    - In August of 1962 a large storm hit the community of Point Hope. This storm caused substantial flooding, filling natural gullies in the community, and cutting the community into three areas separated by bodies of water. Village elders report this storm led to relocation of the town to its present location.
    - In the fall of 1997 the community of Point Hope experienced a large storm event generating multiple storm surges accompanied by near hurricane force winds. Although water levels were sufficient to completely flood the community, multiple levees protected Point Hope. The levees were constructed by the North Slope Borough Department of Municipal Services.
    - In October 2004 the community of Point Hope was subjected to a large-scale storm, with south winds gusting to over 70 miles per hour. Although no buildings were damaged, wind driven waves pushed debris over 120 feet onto the shoreline, and caused the water level of three small lakes to rise substantially, merging the three bodies of water into one. As a result of the storm, approximately 40 foot of shoreline was lost on the south side of the spit and additional 25 foot of shoreline was lost on the north side of the spit.
- **Point Lay:** The community of Point Lay experiences large coastal storms, just as the other North Slope Borough coastal villages, however village residents report that no damage has been experienced during such an event. Village residents report that the community enjoys some protection due to the location of the Kasegaluk lagoon between it and the community.

- **Flash Floods**

- Although this phenomenon is a rare event in the North Slope Borough, residents of Anaktuvuk Pass report the occurrence of a flash flood on the Little Contact Creek in the summer of 1999. Residents describe seeing a "wall of water" wash down Little Contact Creek, but report that the event did not cause damages to either homes or businesses.
- One such instance is recorded as occurring near the community of Nuiqsut, on the Nechelik Channel of the Colville River in August of 2004. During a community meeting on November 1, 2004, Nuiqsut residents reported that although the water level did not threaten the community itself, the community gravel source, its access road and surrounding lowlands were submerged by the flood.

- **Alluvial Fan Floods**

- Prior to 1981 in Anaktuvuk Pass, localized flooding attributable to the rainfall run-off, snowmelt and alluvial fan floods on the Contact Creek was an annual event. Although the community suffered little structural damage, the North Slope Borough recognized the risk and performed a mitigation project on Contact Creek by deepening the channel, and lining the banks with riprap. The project appears to have been successful, as the creek has not breached its banks since that time. Alluvial Fan flooding is an annual event on the Little Contact Creek, which runs north of the community. Water from the Little Contact Creek washes over the banks, and runs onto the tundra near Poker Hill Road. Although no damage has occurred as a result of this annual event, the floodwaters submerge Main Street, until they eventually drain through culverts under the road.
- In Nuiqsut, this form of flooding is an annual event on the Nechelik Channel of the Colville River, although it currently does not pose a risk to the community.
- Alluvial fan flooding is not a risk for the communities of Atqasuk, Barrow, Kaktovik, Point Hope, Point Lay or Wainwright. Based upon the low level of documented occurrences, as well as the absence of topography attributable to alluvial fan flooding, this hazard is a very low risk for these communities.

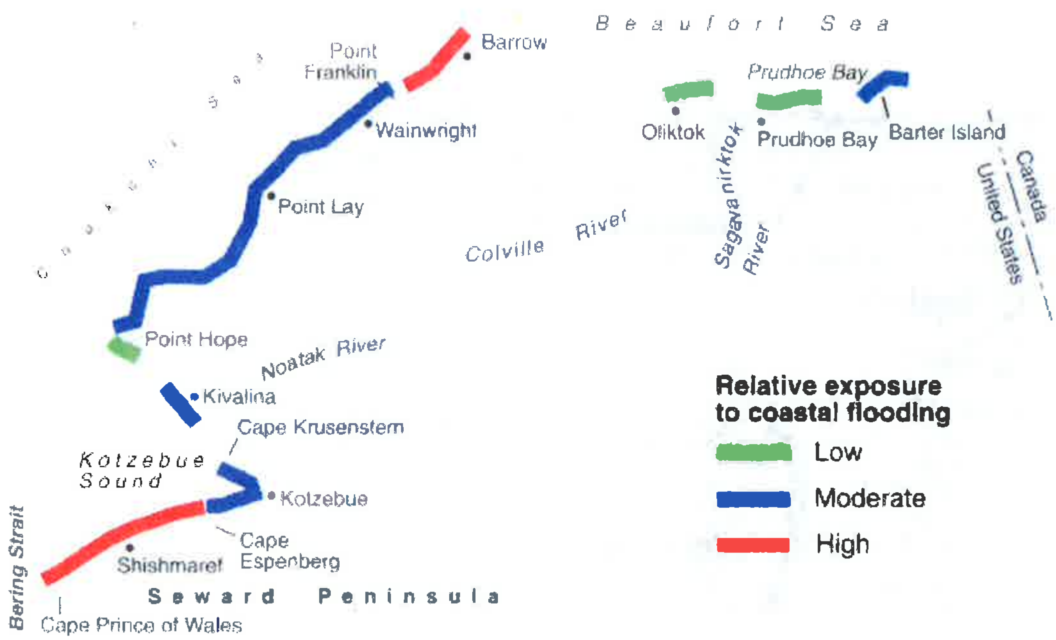
Location

- Rainfall Runnoff and Snowmelt Floods: Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Hope, Point Lay
- Coastal Storm Surge: Barrow, Kaktovik, Point Hope, Point Lay, Wainwright
- Flash Floods: Anaktuvuk Pass, Nuiqsut
- Alluvial Fan Floods: Anaktuvuk Pass, Nuiqsut

Extent

The entire North Slope Borough is vulnerable to one or more types of flooding. The majority of the infrastructure is located along the coast and is subject to coastal surge, snow melt, and rainfall-runoff flooding. Figure 3-3 depicts relative coastal flooding rates.

Figure 3-3, Relative Exposure to Coastal Flooding



Source: Mason et. al., 1997

Areas subject to storm surge along the Arctic Ocean. Map adapted from Mason et. al., 1997:

- Low exposure means flooding is infrequent and generally is not severe when it occurs.
- Moderate exposure means flooding may be expected once every 3 – 5 years and the magnitude of floods may be sufficient to cause beach erosion several years or more inland and damage to structures as much as six feet above normal high-tide and surf levels.
- High exposure means significant coastal flooding every two years or so and the flooding may cause significant beach erosion and damage to structures more than 100 years inland if these are situated within 10 feet or less of the normal high-tide and surf elevations.

The National Oceanic and Atmospheric Administration (NOAA) maintains only one water level station within the Borough, located at Prudhoe Bay. According to the data, the average of the Mean High Water (MWH) and the Mean Low Water (MLW) is 0.69 feet. The mean range is the difference between MHW and MLW, which in the North Slope Borough is 0.51 feet. This very small range of tidal fluctuation makes little difference whether a storm arrives at low or high tide.

Impact

Critical impacts to communities in the North Slope Borough may include injuries and/or illnesses resulting in permanent disability, complete shutdown of critical facilities for at least 2 weeks, and more than 25 percent of property severely damaged. Specific impacts resulting from floods include water damage to boardwalks, infrastructure, buildings (both critical and non-critical facilities) and structural damage caused by floating debris such as ice. Referring to the flood history, North Slope Borough communities have experienced limited flood damage. An exception is Point Hope, which was relocated due to repetitive severe flooding. However, the potential exists for all Borough communities to experience critical flood damage (Table 3-5).

Probability

Recorded historical flooding information indicates communities within the North Slope Borough experience flooding every 1 to 13 years. Therefore the probability of a flood event impacting Borough communities is highly likely (Table 3-2). Both the Chukchi and Beaufort Seas are frozen much of the year, leaving only a short 4 month opportunity for storm surge, yet there are 15 recorded storm surge events among coastal communities.

3.4 Severe Weather

Nature

Winter weather includes heavy snows, ice storms, extreme cold, and high winds.

Heavy Snow generally means:

- Snowfall accumulating to 4 inches or more in depth in 12 hours or less.
- Snowfall accumulating to 6 inches or more in depth in 24 hours or less.

Snow Squalls are periods of moderate to heavy snowfall, intense, but of limited duration, accompanied by strong, gusty surface winds and possibly lightning.

A **Snow Shower** is a short duration of moderate snowfall.

Snow Flurries are an intermittent light snowfall of short duration with no measurable accumulation.

Blowing Snow is wind-driven snow that reduces surface visibility. Blowing snow can be falling snow or snow that already has accumulated but is picked up and blown by strong winds.

Drifting Snow is an uneven distribution of snowfall and snow depth caused by strong surface winds. Drifting snow may occur during or after a snowfall.

A **Blizzard** means that the following conditions are expected to prevail for a period of 3 hours or longer:

- Sustained wind or frequent gusts to 35 miles per hour or greater.
- Considerable falling and / or blowing snow reducing visibility to less than 1/4 mile.

Freezing Rain or **Drizzle** occurs when rain or drizzle freezes on surfaces. Excessive accumulation may immobilize a community and hamper rescue efforts.

Extreme Cold varies according to the normal climate of a region. In areas unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." In Alaska, extreme cold usually involves temperatures less than -40ºF. Excessive cold may accompany winter storms or high barometric pressure and clear skies.

Ice Storms The term ice storm is used to describe occasions when damaging accumulations of ice are expected during a freezing rain event. Freezing rain most commonly occurs in a narrow band within a winter storm that is also producing heavy amounts of snow and sleet in other locations.

Climatic Factors Influencing Severe Storms

Climatic influences upon regional weather activity are the El Nino/La Nina Southern Oscillation (ENSO) patterns, atmospheric composition and temperatures, and sea temperatures. The Governor appointed Alaska Climate, Ecosystems & Human Health Work Group is determining the pending impact to human health from a changing climate and subsequently, regional ecosystems.

History

Winter storms are a fairly common event in the North Slope Borough and communities are normally able to cope with little or no difficulty. This was not the case in January 2005, when the community of Kaktovik experienced an extreme winter storm. On January 7, 2005 the beginning of the storm hit Kaktovik, creating winds in excess of 70 miles per hour, with an ambient temperature of approximately minus35 degrees. The storm severely damaged the power grid, knocking out all power to the community for approximately three days.

Rescue and response efforts to the community were hampered by extreme weather conditions and zero visibility in the community. Response personnel reached the community on January 11th and began restoring the power grid. A large portion of the community remained without power until January 13th. As a result of the extreme cold and the damages inflicted by the high winds, the majority of the community suffered frozen pipes and damaged structures. The Kaktovik City Hall, the Kaveolook School and the North Slope Borough Police Station in Kaktovik suffered severe damages as a result, as did all the plumbed buildings in the community.

DHS&EM's Disaster Cost Index records the following severe weather disaster event which impacted Kaktovik:

Kaktovik Winter Storm, January 7-13, 2005 & FEMA declared (DR-1584) on March 14, 2005: *The Governor declared a statewide disaster to provide emergency relief to the City of Kaktovik suffering adverse effects of a record breaking winter storm, with temperatures as low as -85 degrees and winds exceeding 75 knots. The State conducted a wide variety of emergency actions, which included: emergency repairs to maintain & prevent damage to water, sewer & electrical systems, emergency resupply of essential fuels & food, & DOT/PF support in maintaining access to the community. Total monetary costs exceeded 3.6 million dollars.*

Location

All communities within the North Slope Borough are vulnerable to severe weather.

Extent

Severe weather experienced by the North Slope Borough include thunderstorms, lightning, hail, heavy and drifting snow, freezing rain/ice storm, extreme cold, and high winds. The Borough experiences periodic severe weather events such as the following:

- **Heavy Rain**
- **Heavy Snow**
- **Drifting Snow**
- **Freezing Rain and Ice Storms**
- **Extreme Cold**
- **Winter Storms**

Impact

The impact upon communities in the North Slope Borough is negligible (Table 3-2). Structures and infrastructure have largely been constructed to withstand annual occurrences of severe winter storms. Thus, there is a small potential for injuries, less than 10 percent of property would be damaged, quality of life would be degraded to a minor degree, and the shutdown of critical facilities and services would occur for less than 24 hours. High winds resulting from the storms would pose the greatest risk. They can combine with loose snow to produce blinding blizzard conditions and dangerous wind chills. Additionally, high winds have the potential to reach hurricane speed. Such winds may damage community facilities and infrastructure.

Probability

Severe winter storms occur annually in the North Slope Borough. Referring to Table 3-2, the probability of a severe winter storm is highly likely.

3.5 Ivu – Coastal Ice Override

Nature

Ivu, or ice override, occurs when floating sea ice is pushed ashore by wind and current. It is fairly rare as it requires very specific weather, oceanographic conditions and shoreline topology to develop. Ivus are usually associated with coastal storms and storm surge and rarely during calm weather. They usually develop during fall and early winter, but they can form whenever sea ice is present. For example, it is believed that one struck Barrow in May of 1957. The ice usually over-rides the beach a few tens of feet inland and the entire event is generally less than an hour long.

History

In his memoirs, entitled "50 Years Below Zero", Charles Brower provides the following description of the Ice Override event he witnessed in 1890.

> On Reaching Utkiavie a couple of days later the first thing we saw was a great ridge of ice piled up all along shore, with what was left of the old Ino smashed and twisted and buried underneath. If we hadn't built our house on the hill..!
>
> Even the fifty-foot bluff on which the village stood couldn't always be depended on for safety, according to Mungie. A few years before I came among them, a strong west wind, coupled with just the right current, had forced heavy ice almost to the beach; and this in turn pushed thinner inshore ice onto the very top of the bluff-right into the village. Several houses near the edge of were crushed with everyone inside. It had all happened in one night.

A winter storm occurring in 1974 drove the ice approximately 100 yards inland, toppling power lines along Stevenson Street. In a winter 1977 storm, heavy wind drove pack ice approximately 30 yards inland in the community of Barrow. In 1978, a 450-foot on shore ice movement was reported. There is evidence that other events in the area that have gone a significant distance inland.

(Previously noted historical event in the City of Barrow) A storm occurring in February 1989 storm caused piled shore ice of up to eight feet in height to be driven a reported 100 feet inland.

Location

The communities of Anaktuvuk Pass, Atqasuk and Nuiqsut are protected from ivu due to their inland locations. While the communities of Point Hope, Point Lay, Wainwright and Kaktovik have all the present conditions needed for ivu, local residents report no known incidents of ivu having occurred in the community.

Extent

The most vulnerable areas of the Borough are the low-lying coastal areas along the Chukchi Sea, Beaufort Sea, and Arctic Ocean. The ice usually over-rides the beach a few tens of feet inland.

Impact

The impact upon communities in the North Slope Borough is negligible (Table 3-2). Most buildings and infrastructure are located outside the hazard area. There is a small potential for injuries, less than 10 percent of property would be damaged, quality of life would be degraded to a minor degree, and the shutdown of critical facilities and services would occur for more than 24 hours. Specific impacts from an ivu event are similar to those resulting from ice jam events, including crushed infrastructure and buildings (both critical and non-critical facilities) and structural damage to buildings caused by ice being carried inland by a storm.

Probability

Historical information provided by community elders indicates ivu events are rare. Referring to Table 3-2, the probability is remote.

3.6 Wildland Fire

Nature

Fires can be divided into the following categories:

Structure Fires – Fires involving man-made structures.

Prescribed Fires – ignited under predetermined conditions to meet specific objectives, to mitigate risks to people and their communities, and / or to restore and maintain healthy, diverse ecological systems.

Wildland Fire – any non-structure fire, other than prescribed fire, in the wildland.

Wildland Fire Use – a wildland fire functioning in its natural ecological role and fulfilling land management objectives.

Wildland-Urban Interface Fires – fires burning in an, area where human development meets undeveloped wildland. The potential exists for extremely dangerous and complex fire conditions, which threaten public and firefighter safety.

Climatic Influence

A potential increase in global atmospheric temperature may influence weather activity in Alaska.

Hotter and drier summers and increased electrical storm activity would contribute to volatile and rapidly expansive tundra fires in the North Slope Borough.

History

Tundra Fires are a rare occurrence in the North Slope Borough. Sometime in 1984, sparks from the chimney of a hunting cabin caused a small wildland fire in an area approximately 15 miles north of the village of Point Hope. Residents and neighbors of the cabin rapidly extinguished this fire.

In the summer of 1993 a lightning strike caused a tundra fire near the neighboring community of Wainwright. The Wainwright Volunteer Fire Department responded to the fire, but was forced to call upon the Alaska Smokejumpers for assistance. Although community residents in Anaktuvuk Pass and Kaktovik can recall no event that threatened the community, a number of them advise that large forest fires in the interior often lead to poor air quality in the village. During the community meeting held in Kaktovik December 7, 2004, community residents advised that air quality and visibility were exceedingly poor throughout the summer of 2004 due to the large fires near the community of Fairbanks.

Table 3-9. Wildland Fires in North Slope Borough

Fire Year	Fire Name/Number	Acres Burned
1977	38	8,400
2003	Surprise Creek	550.1
1974	Tupikchak	100
1993	190	82,370
1993	178	16,740
2009	Baby Creek	286
1976	Dead Horse	2000
2012	Kucher Creek	18,850
2010	Niakogon Mountain	580
2012	Kigalik River	2,050
2012	Kigalik River 2	879.7
2010	Maybe Creek	6
2010	Knifeblade Ridge	20
2010	September Creek	2
1985	Way Up North #2	2000
2009	Baby Creek	286
2010	Niakogon Mountain	580
1994	FBK N 300	20
1992	Umiat SE 32	10
2010	Kutchik River	428
1993	BTTN 152	160
2008	Syndonia	2
2007	Kuparik	410.8
2004	Kuparik River	5
2011	Ugnuravik River	2
2012	Itkillik River	2311
2012	West Colville River	216.3
2007	Sagavanirktok	1630.7
1990	031054	20
2010	Anaktuvuk Pass	30
2012	Anaktuvuk Pass	4
1991	BTNN 70	600
1988	ARC SW 48	220
2004	Chandalar River	57

Source: Alaska Fire Service, 2015

Location

There are no wooded or wildland-urban interface areas within the Borough. However, secondary effects of distant wildland fires, such as poor air quality, can be found throughout the community. Over the past 50 years, 35 significant fire events have occurred within the North Slope Borough (Table 3-9, Figure 3-4).

Figure 3-4 North Slope Borough Fire History Map

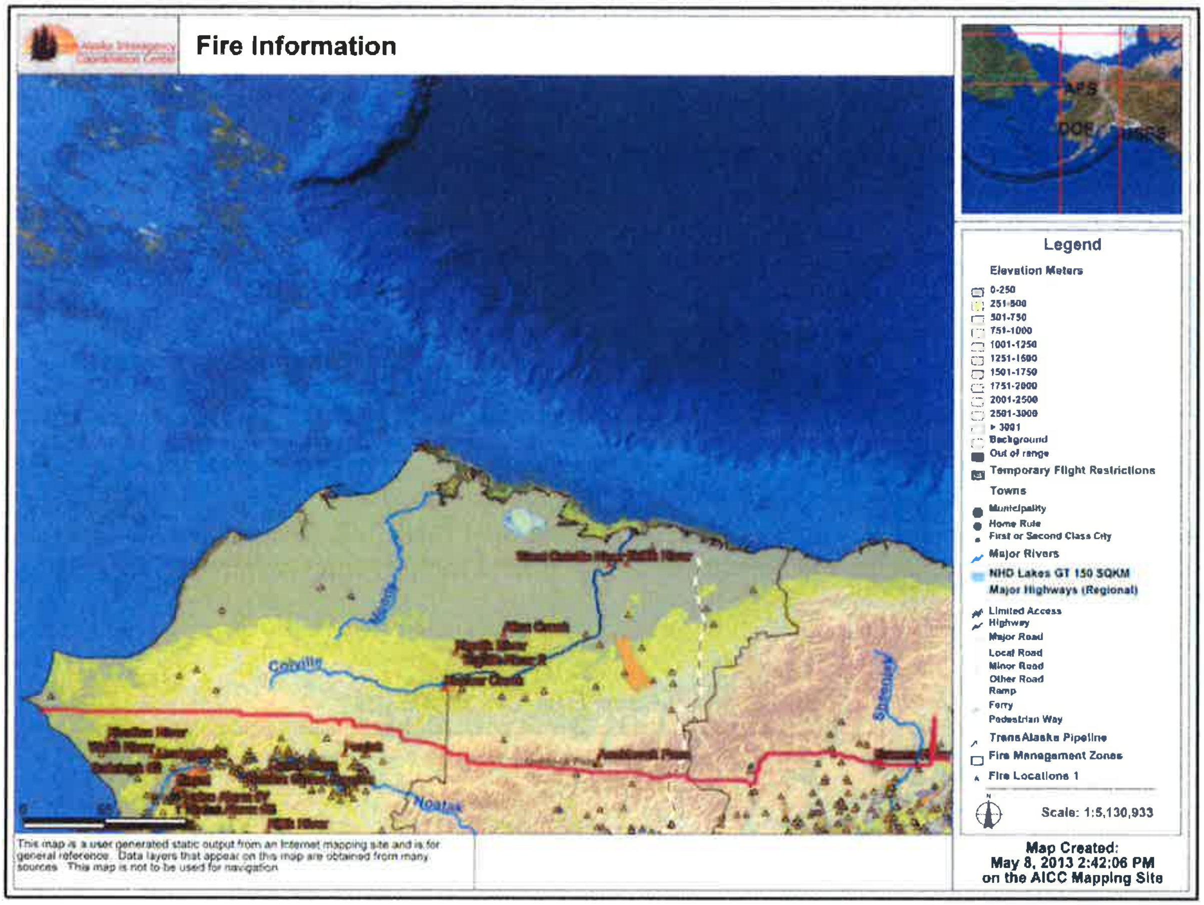


Figure 3-3 Source: Alaska Interagency Coordination Center Mapping Site, 2013

Extent

Given ideal conditions, wildland tundra fires may advance rapidly and endanger any community in the North Slope Borough. While conditions throughout the Borough are generally wet, one dry season combined with high winds may lead to a catastrophic wildland fire event. The entire population and all critical and non-critical facilities are likely to be affected by wildland fire events, thus the Borough is highly vulnerable to the effects of wildland fire.

Impact

Impacts to Borough communities are considered catastrophic with the potential for multiple deaths, complete shutdown of facilities for 30 or more days, and more than 50 percent of property severely damaged (Table 3-3). Most North Slope Borough communities are considered a Level I Isolated villages with no professional fire department. The only exceptions are the City of Barrow and the North Slope Borough which is headquartered in the City of Barrow. Both governments have a fire department. Other Borough communities administer Rural Basic Firefighter training for their volunteers. Residents have limited air and marine access to larger hub communities and must rely on their own firefighting resources for a significant period of time.

Probability

Given the history of wildland fires near the North Slope Borough (Table 3-6) and Figure 3-5, it is likely Borough communities will experience a wildland fire (Table 3-2). The potential is limited to the months of July, August and September, as the ground is either snow-covered or saturated during the rest of the year.

Figure 3-5 Wildland Fire Risk in Alaska

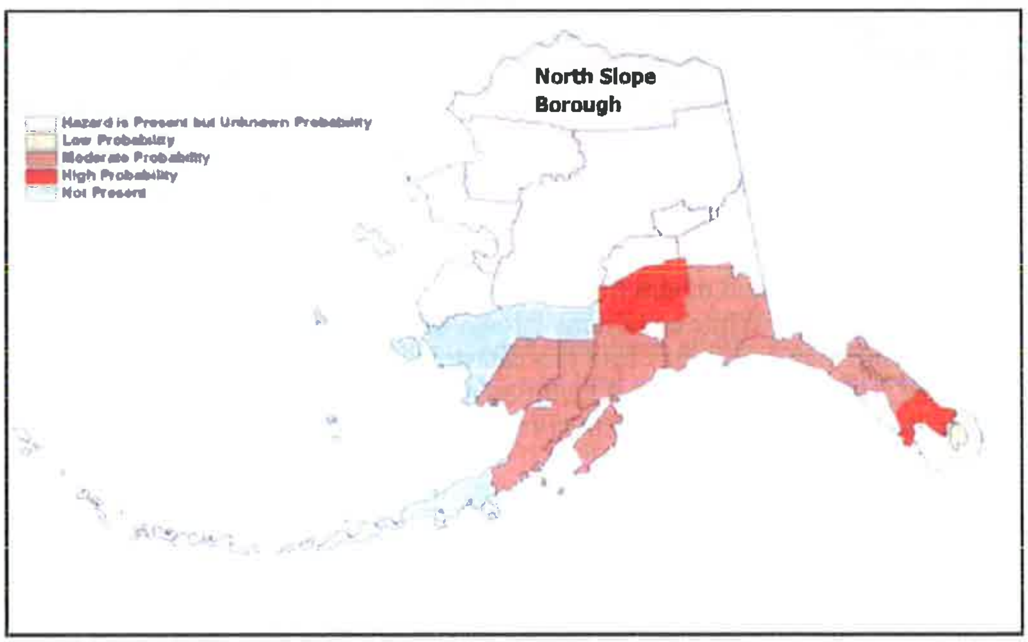


Figure 3-5 Source: Alaska Interagency Coordination Center

3.7 Ground Failure

- **Landslides**

Ground failure can occur in many ways. Types of ground failure in Alaska include landslides, land subsidence, and failures related to seasonally frozen ground, erosion, and permafrost.

Landslide is a generic term for a variety of down slope movements of earth material under the influence of gravity. Landslides usually occur in steep areas either above or under water. Some landslides occur rapidly, while others may take weeks or longer to develop.

Landslides may occur naturally or by human activities. They occur naturally when inherent weaknesses in the rock or soil combine with one or more external mechanisms such as water or seismic activity. Erosion may also contribute to landslides.

Human activities are usually associated with construction such as altering a slope, drainage patterns, groundwater level, and surface water runoff. For example, the addition of water to a slope from agricultural or landscape irrigation, roof downspouts, septic-tank effluent, or broken water or sewer lines may cause a landslide.

Three main factors influence landslides: topography, geology and water. Topology refers to the grade of the land, while geology addresses rock and soil composition. Water will tend to lubricate weak areas of soil and cause a landslide.

- **Seasonally Frozen Ground**

Frost action is the seasonal freezing and thawing of ground water interacting with development. Man-made structures such as porches, fence posts, and utility poles are gradually forced out of the ground by frost action in the winter, and tilted by uneven thaw action in the summer. It is a widespread problem in lower regions of Alaska. Typically, the North Slope Borough lies entirely within the permafrost zone and rarely experiences any thawing (Figure 3-6). However, residents report noticeably warmer summers and milder winters and have recently experienced minor frost heave damage to their buried utility lines throughout the North Slope Borough. If the warming trend continues, the effects of seasonally frozen ground may become systemic

Figure 3-6 Alaska Permafrost Map

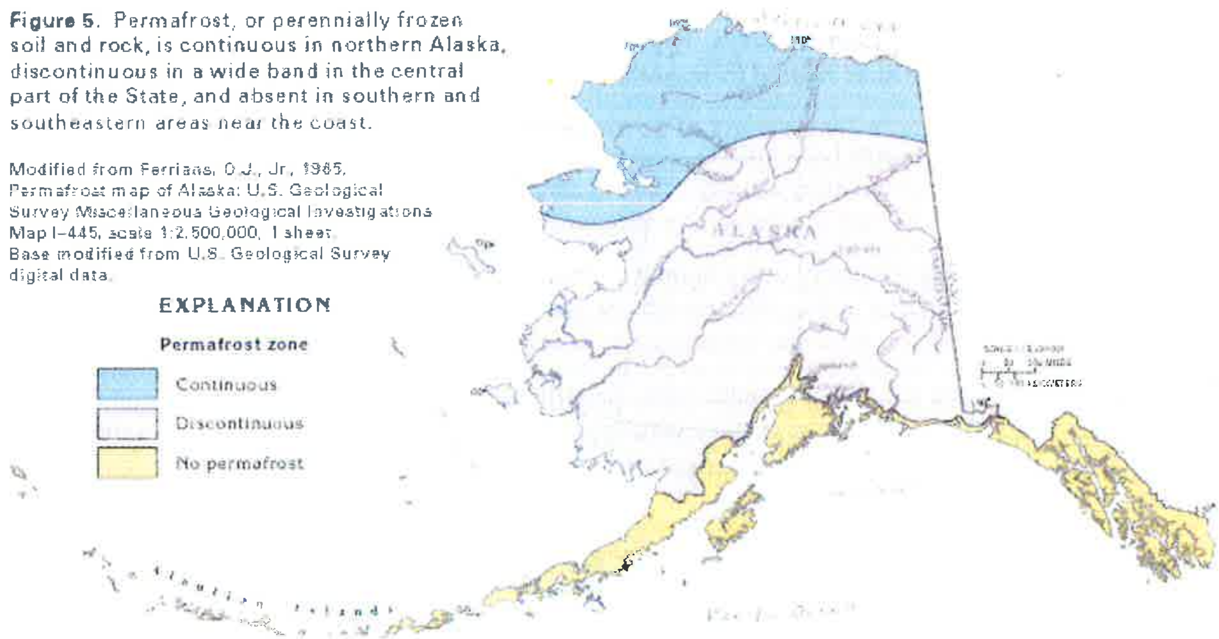


Figure 3-6 Source: United States Geological Survey (USGS)

➢ Permafrost

Ground failure related to permafrost is a significant problem in Alaska, however it has not historically been so in the community of Barrow. Permafrost is frozen ground in which a naturally occurring temperature below 32° Fahrenheit (0° Centigrade) has existed for two or more years. Permafrost is continuous in extent over most of the Arctic, including the community of Barrow, where measured recorded depths extend 1,330 feet.

Climatic Influence

Anecdotal evidence reveals a changing weather cycles to warmer summers and milder winters. Local builders remember only the top two feet of permafrost thawing during the summer months, but today it has doubled to approximately four feet.

Permafrost forms an extremely strong and stable foundation material if it remains frozen. However, if it thaws, the soil becomes extremely weak and slumps. Permafrost may thaw in response to natural or human activity. Subsidence from thawing permafrost has recently occurred in villages within the North Slope Borough.

History

- **Anaktuvuk Pass:** In Anaktuvuk Pass, residents reported a landslide 15 miles southeast of town near the John River sometime around 1997, while another occurred approximately 5 miles east of town on the backside of Ingstad Mountain. No debris reached the community from either landslide.

   - In Anaktuvuk Pass village residents report that during the extremely warm summer of 2004, evidence of subsidence was seen throughout the community. Residents reported the ground throughout the community dropped, including two areas of Main Street, approximately two feet. Some residents had to place gravel under their stairways, as subsidence caused the steps to sag and tilt. The floors of homes and businesses also sagged unevenly as evidence of subsidence in their permafrost foundations.
- **Atqasuk:** In the community of Atqasuk, residents reported their buildings had settled which they felt was a result of a thawing of the upper portion of the permafrost in the summer.
- **Kaktovik:** During a community meeting held in Kaktovik on December 7, 2004 community residents reported continued subsidence in the permafrost during the previous four years, and attributed it to the current weather pattern. Houses and other buildings were beginning to settle unevenly as a result.
- **Nuiqsut:** Although Nuiqsut is located in continuous permafrost, local residents note persistent ground subsidence over the previous 15 years. They believe the trend of warmer summers and more moderate winters to be causing the ground to shrink and settle, noting several homes and buildings which are now uneven.
- **Point Hope:** In Point Hope, subsidence is not a problem in the community, however the warmer summers and milder winters being experienced in the region has caused sink holes north of town on the Tigara Peninsula.
- **Point Lay:** Point Lay residents report that during the extremely warm summer of 2004, subsidence was throughout the community. Residents saw the ground beneath their feet drop on the average of four inches. Residents had to place gravel under their stairways as subsidence caused the steps to sag and tilt. The floors of homes and businesses also sagged unevenly as evidence of subsidence in their permafrost foundations.
- **Wainwright:** During the summer of 2004, community residents in Wainwright also reported some subsidence in their community, echoing observations and concerns stated by other North Slope Borough communities.

Location

The entire North Slope Borough lies within the region of continuous permafrost and is subject to subsidence (Figure 3-6).

As the area surrounding the communities of Atqasuk, Barrow, Kaktovik, Nuiqsut, Point Lay and Point Hope is mostly flat, landslides pose no risk to these communities. The community of Anaktuvuk Pass does have a limited risk of landslides.

Extent

Ground failure rarely causes death or injury. However, it occasionally damages property, development, and infrastructure.

Impact

For North Slope Borough communities, the impact of a ground failure event is negligible with minor injuries, less than 10 percent of property damaged, and little to no permanent damage to transportation, infrastructure, or the economy (Table 3-3).

Probability

Given the history of the North Slope Borough communities (Table 3-6) and Figure 3-6, it is likely Borough communities will experience a ground failure event (Table 3-2). The potential is limited to the summer season, June to October, as the ground is frozen the rest of the year.