EXECUTIVE SUMMARY

This document is the culmination of a cooperative partnership between local government, Alaska Division of Emergency Services (ADES), other State Agencies, Federal Agencies and the Federal Emergency Management Agency (FEMA). This plan meets the requirement for a State Hazard Mitigation Plan under the Stafford Act. It is a living document and will be refined and updated on a periodic basis. ADES would like to acknowledge the critical review and comments provided by many local communities and governmental agencies during the development process. Where possible, we have made every attempt to incorporate their comments in the final document.

It is vital for Alaska to have a proactive, unified approach to mitigation. Mitigation measures save lives, reduce injuries and prevent or decrease financial losses from the many hazards in Alaska. These measures include a range of techniques from public education, changes in land use, revised building construction practices and changes in fiscal policy. All of these techniques are discussed throughout the plan where appropriate. As funding sources become available, eligible projects will be submitted to the Disaster Policy Cabinet for approval as part of the Hazard Mitigation Grant Program (HMGP) process.

ADES formed the State Hazard Mitigation Plan Advisory Committee to thoroughly research the State's mitigation needs and provide technical expertise to the State Hazard Mitigation Officer. This committee was an invaluable source of input in drafting this plan. ADES intends to further utilize this committee in implementing mitigation strategies in Alaska. These criteria will be our public outreach goals: public officials at State and local levels must make a commitment to mitigation; public officials, emergency managers, planners and civic groups must convince the general public of the value of mitigation; and the general public must accept mitigation measures as opportunities to sustain the economic well being of the State.

Overall, the plan addresses the risks associated with hazards in Alaska, discusses hazard mitigation implementation for the State, satisfies the Federal requirement for hazard mitigation funding planning and identifies and prioritizes State-level mitigation activities. The base plan introduces the hazards in Alaska, governmental coordination and general mitigation measures. Subsequent hazard specific annexes contain more detailed information about each hazard and existing mitigation programs, success stories and both short and long-term mitigation goals.

This planning process resulted in many short- and long-term goals, that can be grouped into the following categories:

- Hazard mapping projects – to identify hazard prone areas.
- Encourage the incorporation of hazard mitigation in land use planning and building construction– to reduce vulnerability to hazards.
- Educate Alaskans about hazards and hazard mitigation.
- Improve assistance and provide incentives to local and tribal communities – to support local efforts in their attempts to make their communities safer.
- Pursue additional mitigation funding.

Many of the goals in this plan involve local communities. It is not the State's intent that these goals be unfunded mandates. However, the Federal government passed legislation in 2000 requiring states, local communities and tribal governments to have mitigation plans in place by November 2003 to be eligible for mitigation funding. ADES will make every attempt to secure funding and identify possible alternatives.

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ACKNOWLEDGEMENTS

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STATE OF ALASKA
HAZARD MITIGATION PLAN
March 2002

List of Appendices

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State of Alaska
Hazard Mitigation Plan

SECTION 1 - INTRODUCTION

Awareness, education, and preparedness, coupled with prediction and warning systems can reduce the disruptive impacts of natural disasters on communities. Mitigation measures save lives, reduce injuries and prevent or decrease financial losses attributed to damage from floods, wildfires, earthquakes, avalanches, landslides, debris flows, erosion, tsunamis, volcanoes and other natural, technological, or economic hazards. Measures employed to mitigate can vary from public education, to changes in land use and building construction practices, to changes in fiscal policy.

Hazard mitigation is any action taken to reduce or eliminate the long-term risk to human life and property from natural, technological, and economic hazards.

Goals and Objectives

The primary goals of hazard mitigation are:

- *Minimize loss of life and injuries,*
- *Minimize damages,*
- *Facilitate the restoration of public services,*
- *Promote economic development.*

To attain these goals, the State Hazard Mitigation Plan shall include measures to:

1. *Save lives and reduce injuries;*
2. *Prevent or reduce property damage;*
3. *Reduce economic losses;*
4. *Minimize social dislocation and stress;*
5. *Maintain critical facilities in functional order;*
6. *Protect infrastructure from damage; and*
7. *Protect legal liability of government and public officials.*

Many communities resist adopting mitigation measures because they are seen as restrictive, costly, without immediate tangible benefits, or are incompatible with community development. However, effective mitigation measures are designed with the future in mind. Consequently, the State is committed to convincing its constituents to view mitigation as an opportunity to provide sustainable economic development that improves the economic value and quality of life for the State, its communities and residents.

For mitigation strategies to be adopted and successful, three major criteria must be met:

- The State's public officials at State and local levels must make a commitment to mitigation
- Public officials, emergency managers, finance and insurance

specialists, engineers, planners and architects, civic groups, marketing specialists, educators, and researchers are key groups that must convince the general public to buy-in to mitigation
- Present and accept mitigation measures as opportunities to sustain the economic well being of the State

The State of Alaska must be prepared to capitalize on opportunities to minimize the impact of future disasters through mitigation. Every community in Alaska, whether incorporated or unincorporated, is encouraged to adopt a program to reduce the impacts of disasters. The question for many Alaskan communities should be: When the next disaster strikes, how can the impacts to the people and the community be minimized? Community responses to this question may take the form of any or all of the following:

1. Incorporate both structural and nonstructural mitigation measures in new development
2. Examine ways to reduce the vulnerability of existing structures
3. Develop and conduct mitigation training with support from the Federal Emergency Management Agency (FEMA), Alaska Division of Emergency Services (ADES) and other governmental entities
4. Foster cooperation among federal, State and local agencies to reduce or eliminate redundancy of effort or questions of jurisdiction
5. Ensure that community integrity is maintained in the event of a disaster

The physical impacts of hazard occurrences can be reduced in many ways including educating those who will be in harm's way, siting structures and functions away from hazards, and strengthening structures to reduce or eliminate damage when a hazard occurs. The State of Alaska must revise existing statutes and pursue processes to:

1. Expand the State's existing programs to develop hazard maps in and near urban areas at scales appropriate for land use planning. Types of maps needed include: active faults, earthquake soil class or site amplification, liquefaction susceptibility, landslide hazard, coastal and riverbank erosion, snow avalanche hazard, floodplains and tsunami inundation areas. Identifying, mapping, and evaluating hazards is crucial when developing hazard mitigation strategies.
2. Protect critical facilities including schools and hospitals. New structures should be located away from high hazard areas and existing structures should be surveyed to determine if the structures are disaster resistant. Require facilities and infrastructures constructed with public funds be built to minimize impacts from natural disasters. Develop hazard specific building codes and standards, which can be applied where appropriate.
3. Protect cultural facilities and historic sites. Through local actions and the Alaska Historic Preservation Office, identify and protect libraries, monuments, historic sites and other cultural resources.
4. Incorporate mitigation in new development. Revise Alaska Statutes to require, during platting, that development and residential subdivisions are

located to withstand natural disasters. Land use plans addressing hazard mitigation should be required as part of the community comprehensive plan. Floodplain and other natural hazard areas that have a high value for recreation, fish and wildlife reserves, open space or community use should be retained in public ownership.

Authority

The State of Alaska Hazard Mitigation Plan meets the requirement of the *Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988* (Stafford Act) for a 409 plan. It is intended that this plan further fulfills the Disaster Mitigation Act of 2000 (DMA 2000), Section 322 (a-d) plan requirements. Section 322 of the Act requires that states, as a condition of receiving federal disaster mitigation funds, have a mitigation plan that describes the process for identifying hazards, risks and vulnerabilities, identify and prioritize mitigation actions, encourage the development of local mitigation and provide technical support for those efforts. In addition, the Act requires local and tribal governments to also have mitigation plans.

A Guide to this Plan

This plan will provide a focus on mitigation as part of the State's emergency management efforts. The plan contains four sections:

Section 1: Introduction to the plan.
Section 2: The framework for Alaska's hazard mitigation goals.
Section 3: Hazard-specific annexes*:

The flood, wildfire, snow avalanche, volcano, earthquake, and tsunami & seiche annexes are included in this version of the plan. The remaining annexes will be completed as resources permit.

Completed	**Future Additions**
Flood	Weather
Wildfire	Landslides
Earthquake	Erosion
Volcano	Drought
Snow Avalanche	Technological
Tsunami & Seiche	Economic

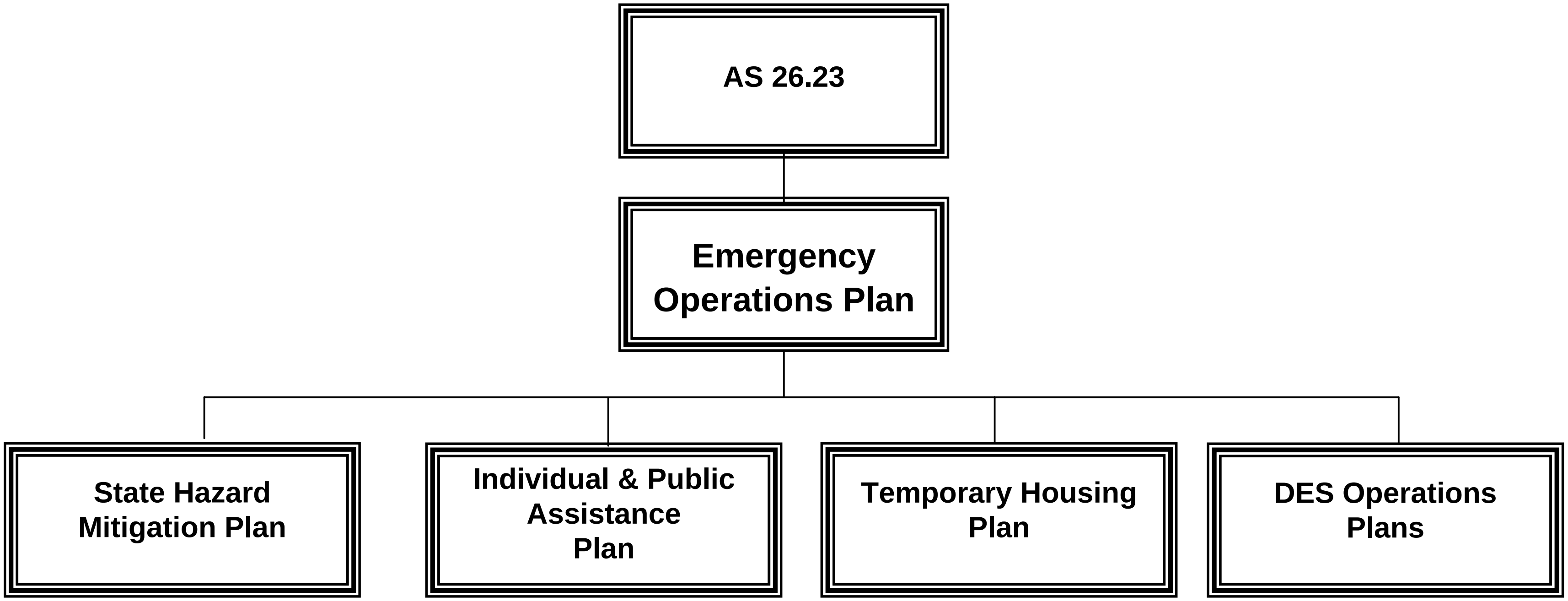
*Other hazards exist in the State including glacial surges, geomagnetic interference, asteroid impacts and epidemics. They are not discussed in this plan because they have a low probability of occurrence and limited available mitigation options at this time. As the situation changes, new hazard annexes will be added.

Section 4: Appendices with supporting or specialized information.

The plan is designed to:

- Introduce the risks associated with many of the hazards that occur within Alaska.
- Address hazard mitigation implementation for the State.
- Meet the requirements for hazard mitigation funding programs.
- Identify and prioritize State-level mitigation activities.

Relationship of the State Hazard Mitigation Plan to the State's Emergency Management Authority



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SECTION 2 - COORDINATING HAZARD MITIGATION ACTIVITIES

State Coordination

Hazard mitigation activities in Alaska need to be coordinated at the State, local, tribal, and federal levels. All levels of government need to be working towards a common goal to maximize the benefits of hazard mitigation.

The State Hazard Mitigation Plan, and all related documents, will become part of the Alaska Emergency Management System (AEMS). The goal of SEMS is to standardize emergency management activities at the State level ensuring activities and information are dealt with in a coordinated and efficient manner and allows for the provision of standardize support for communities.

Role of the State Hazard Mitigation Officer (SHMO)

The SHMO is responsible for implementing State-wide hazard mitigation activities in Alaska. He or she also provides expertise, guidance, advice and assistance to communities, the private sector, and to State, federal and local agencies regarding mitigation. In addition, the SHMO establishes requirements and determines entitlements for several grant programs.

For the purposes of this plan, the SHMO's role is to coordinate with other agencies with roles for implementing mitigation measures. The SHMO will also support implementation activities by helping lead agencies identify, coordinate and obtain technical and financial resources. The SHMO will also coordinate progress reports and manage the Hazard Mitigation Grant Program (HMGP).

The SHMO chairs the State Hazard Mitigation Plan Advisory Committee (SHMPAC). SHMPAC was recently established to assist with the development of the SHMP. The committee is a source of ideas and information with approximately 50 members representing State, local, tribal, and federal agencies and organizations.

All potential HMGP projects are initially submitted to ADES. ADES identifies member agencies of the SHMPAC to assist with selecting and prioritizing projects in accordance with the SHMP's goals, prior to submittal to the Governor's Disaster Policy Cabinet (DPC) for further consideration and approval.

Role of the Governor's Disaster Policy Cabinet (DPC)

The DPC was first addressed in the State Emergency Operations Plan on May 6, 1994 and was first activated September 20, 1995. Its mission is to provide recommendations to the Governor for the following:

- For policy direction on response and recovery operations, which are coordinated and/or implemented by the State's emergency management system.
- Ensure cooperation and coordination among State departments and agencies involved in the State's emergency response and recovery efforts.
- On issues related to ongoing State operations, which might be impacted by the activation of the State's emergency management system.
- Policy guidance related to potential requests for a State or Presidential Disaster Declaration.

The role of the DPC has evolved to include approving requests for mitigation project funding, approve long-term recovery projects that rely on State funds, and supports and approves the State's commitment to disaster relief fund efforts.

The members of the DPC are the commissioners of the following departments:

- Military and Veterans Affairs (chair)
- Environmental Conservation
- Natural Resources
- Public Safety
- Transportation and Public Facilities
- Administration
- Community and Economic Development
- Health and Social Services
- Law
- Director, Office of Management and Budget
- Representative, Governor's Office

Other departments/agencies participate as required based on the particular nature of the disaster emergency

State and Local Coordination

Hazard mitigation projects have the biggest effect on the community where they occur, making coordination essential between the State and local governments. This plan outlines State-wide hazard mitigation goals. These goals are not intended as unfunded mandates. Individual communities should decide for themselves, with assistance from State, federal, local governments and other agencies, what mitigation measures are most appropriate and important. Local circumstances, which locals know best, determine the most appropriate mitigation measures. By developing a local hazard mitigation plan, each community can determine mitigation goals and identify tools, such as zoning ordinances or capital improvement projects, they can use to achieve those goals. When projects are being considered by other organizations, including State agencies, local communities should have the opportunity to address any concerns or competing interests.

Complete local control is not always possible, as local communities must meet program specific criteria to qualify for some assistance programs. State and federal assistance programs are available for mitigation efforts because it is acknowledged that communities have limited resources. For HMGP projects, the federal government funds 75% of a project and the State, local community or applicant funding the remaining 25%. Other cost-sharing programs are also available. Appendix 5 documents many of the available funding sources.

Local Hazard Mitigation Planning

The State Hazard Mitigation Plan is implemented through State and federal agencies and adds impetus for developing local hazard mitigation plans. Hazard mitigation planning is essential at the local and tribal level. Without community support, the success of any mitigation program is limited. Many mitigation measures can only be implemented at the local level, such as controlling and regulating development and policies regarding infrastructure provisions. It is also vital to tailor mitigation priorities and measures to meet local conditions. What works in one community might be unsuitable or impractical for another community. One issue that needs more attention is how unincorporated communities, such as Tok or Hyder, can adopt, implement, and enforce a hazard mitigation program.

The Disaster Mitigation Act of 2000 (DMA 2000) requires local and tribal governments to have a FEMA approved mitigation plan by November 2003 to remain eligible for HMGP funding.

The FEMA Region 10 Director may grant an exception to the plan requirement in extraordinary circumstances. Small and impoverished community may qualify for this exception. According to DMA 2000 §201.4, a small and impoverished community is a community of 3,000 or fewer residents, identified by the State as a rural community, and is not a remote area within the corporate boundaries of a larger city; is economically disadvantaged due to an average per capita annual income not exceeding 80 percent of national per capita income; the local unemployment rate exceeds the most recently reported average yearly national unemployment rate by one percentage point or more; and any other factors identified in the State Plan where the community is located. Please see Appendix 9 for a list of the 150 Alaska communities meeting this criteria as of March 6, 2002.

FEMA gives Indian tribal governments the opportunity to fulfill the requirements of Section 322 as a grantee or subgrantee. An Indian tribal government may choose to apply directly to FEMA for HMGP funding and would then serve as a grantee. As such. it must meet State level responsibilities to include developing a State level hazard mitigation plan. Or it may apply through the State, and meet the same local government or subgrantee responsibilities as not-tribal communities or subgrantees.

Multi-jurisdiction plans may be acceptable provided each participant has taken part in the planning process and has officially adopted the plan. The State plan cannot be adopted as a multi-jurisdiction plan.

Some of the criteria for local and tribal plans, as contained in the implementation guidance for DMA 2000 are:
- Documentation of the planning process.
- A Risk Analysis which includes:
  - A description of previous hazard events.
  - A description of the type, location and extent of all hazards that can affect the jurisdiction.
  - A description of the jurisdiction's vulnerability to hazards.
- A mitigation strategy.
- A plan maintenance strategy.
- Documentation that the plan has been formally adopted by the governing body of the jurisdiction.

The State is committed to supporting local efforts in several ways including funding (when available), training and technical support. A local and tribal hazard mitigation plan template is being developed by FEMA to aid communities in preparing mitigation plans. Local plans should be consistent with the State plan to ensure they are not working at cross-purposes.

It is acknowledged that many communities may need assistance in developing hazard mitigation plans. DMA 2000 authorizes up to 7% of available HMGP funds to be used for State, local or tribal government mitigation plans. Additionally, 5% of available HMGP funds can be used for discretionary projects. Planning activities fall under this category. The criteria for prioritizing communities and local jurisdictions that would get planning grants needs to be developed but will favor communities with the highest risks, repetitive disasters, intense development pressures, a demonstrated cooperation with completing initiatives, and participating in the mitigation process.

Local hazard mitigation plans should be coordinated with other plans, business practices and governmental operations. For example, local communities should incorporate mitigation concepts and goals in their community comprehensive plans, transportation plans, and capital improvement programs. It will take time to implement of all the goals highlighted in the local plan. The changes required will depend on the mitigation decisions made by the community.

SECTION 3 - HAZARD FRAMEWORK

Chapter 1 - Risk Assessment

The goal of mitigation is to reduce the future impacts of a hazard including property damage, disruption to local and regional economies, and the amount of public and private funds spent to assist with recovery. However, mitigation should be based on risk assessment.

A risk assessment is measuring the potential loss from a hazard event by assessing the vulnerability of buildings, infrastructure and people. It identifies the characteristics and potential consequences of hazards, how much of the community could be affected by a hazard, and the impact on community assets.

A risk assessment consists of three components: hazards identification, vulnerability analysis and risk analysis. Technically, these are three different items but the terms are sometimes used interchangeably.

Hazards Identification

The first step in conducting a risk assessment is to identify and profile hazard events and their effect on the jurisdiction. A hazard does not always affect the entire jurisdiction equally, so it is important to determine the effects on different areas. A map showing the spatial extent of each hazard should be created.

The following matrix identifies the hazards found in each borough or census area with their probability of occurrence, if known, rated low, moderate or high. This information was obtained from ADES information and borough Emergency Operations Plans (EOP) or Hazard and Vulnerability Analyses (HVA). A summary of community EOPs and HVAs was used for census areas.

Hazard Matrix

	Flood	Wildfire	Earthquake	Volcano	Snow Avalanche	Tsunami & Seiche	Weather	Landslides	Erosion	Drought	Technological	Economic
Aleutians East Borough	N	N	Y	Y	N	Y	Y	Y	N	N	Y	Y
Aleutians West Census Area	N	N	Y	Y	N	Y	Y	Y	N	N	Y	Y
Municipality of Anchorage	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	U
Bethel Census Area	Y	N	Y	N	N	N	Y	N	N	U	Y	U
Bristol Bay Borough	N	N	Y	Y	N	N	Y	N	N	U	Y	Y
Denali Borough	Y	Y	Y	U	Y	N	Y	Y	N	U	Y	U
Dillingham Census Area	Y - M	Y - M	Y - L	Y - L	Y - L	Y - M	Y - M	Y - L	N	Y - M	Y - H	U
Fairbanks North Star Borough	Y	Y	Y	Y	N	N	Y	N	Y	U	Y	U
Haines Borough	Y - H	Y - M	Y - H	Y - L	Y - H	Y - L	Y - H	Y	U	Y	Y - H	U
City and Borough of Juneau	Y - M	Y - M	Y - M	U	Y - H	Y - L	Y - M	Y - M	U	Y - L	Y - M	U
Kenai Peninsula Borough	Y - M	Y - M	Y - H	Y - H	Y	Y - M	Y - M	Y	Y	Y	Y - H	U
Ketchikan Gateway Borough	Y	L	Y	U	Y	Y	Y	Y	N	U	Y	U
Kodiak Island Borough	Y - H	Y - M	Y - H	Y - H	Y - L	Y - M	Y - H	Y - H	Y - M	Y - L	Y - H	U
Lake and Peninsula Borough	Y	Y - M	Y	Y	Y - L	Y	Y	Y	Y	U	Y	U
Matanuska-Susitna Borough	Y - H	Y - H	Y - H	Y - H	Y - M	N	Y - M	Y	Y	Y - L	Y - H	U
Nome Census Area	Y	Y	Y - H	U	N	Y - L	Y	N	Y	U	Y	U
North Slope Borough	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U
Northwest Arctic Borough	Y	Y	Y - M	N	N	N	Y	N	Y	U	Y	Y
Prince of Wales-Outer Ketchikan Census Area	Y	Y	Y	U	Y	Y	Y	Y	Y	Y - L	Y	U
City and Borough of Sitka	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U
Skagway-Hoonah-Angoon Census Area	Y - H	Y - M	Y - H	Y - L	Y - H	Y - M	Y - H	Y	Y	Y	Y - H	U
Southeast Fairbanks Census Area	Y	Y	Y	U	Y	N	Y	Y	Y	Y	Y	U
Valdez-Cordova Census Area	Y	Y - M	Y	U	Y	Y	Y	Y	Y	U	Y	U
Wade Hampton Census Area	Y	Y	Y	Y	N	N	Y	N	Y	U	Y	U
Wrangell-Petersburg Census Area	Y - L	Y - H	Y - M	U	Y - L	Y - M	Y - M	Y - L	U	Y - L	Y - M	U
City and Borough of Yakutat	Y	Y - M	Y	U	Y	Y	Y	U	U	U	Y	U
Yukon-Koyukuk Census Area	Y	Y	Y	N	Y	N	Y	Y	Y	U	Y	Y

Y: Hazard is present in jurisdiction but probability unknown
Y – L : Hazard is present with a low probability of occurrence
Y – M : Hazard is present with a moderate probability of occurrence
Y – H: Hazard is present with a high probability of occurrence
N: Hazard is not present
U: Unknown if the hazard occurs in the jurisdiction

Vulnerability Assessment

Step two is to identify the jurisdiction's vulnerability (the people and property that are likely to be affected). It includes anyone who enters the jurisdiction including employees, commuters, shoppers and others. Populations with special needs such as hospitals, prisons, or areas with large non English-speaking populations, also need to be identified because they can be more vulnerable to hazard events. Inventorying the jurisdiction's assets to determine the number of buildings, their value, and population in hazard areas can also help determine vulnerability. Identifying hazard prone critical facilities is vital because they are necessary during the response and recovery activities.

Critical facilities include:

- Essential facilities which are necessary for the health and welfare of an area and are essential during the response of a disaster. Examples include hospitals, schools, police and fire stations.
- Transportation systems such as: airways, highways, railways, and waterways.
- Lifeline utility systems such as water treatment plants, waste water treatment plants and communication systems.
- High potential loss facilities such as dams or military installations.
- Hazardous material facilities.

Other items to identify include economic elements, areas that require special considerations, historic, cultural and natural resource areas and other jurisdiction-determined important facilities.

Risk Analysis

The next step is to calculate the potential losses to determine which hazard will have the greatest impact on the jurisdiction. In addition, the risk analysis must result in a multi-hazard approach to mitigation. One such approach might be through a composite loss map showing areas that are vulnerable to multiple hazards. For example, there might be several schools exposed to one hazard but one school may be exposed to four different hazards. Only a multi-hazard approach reveals this and helps show where mitigation efforts need to be targeted.

The State does not have a completed state-wide, systematic risk assessment at this time. Appendix 7 contains information about critical facilities as part of an informal risk assessment. Information from local risk assessments will be incorporated, as the data becomes available. **For security reasons, access to this information will be restricted.**

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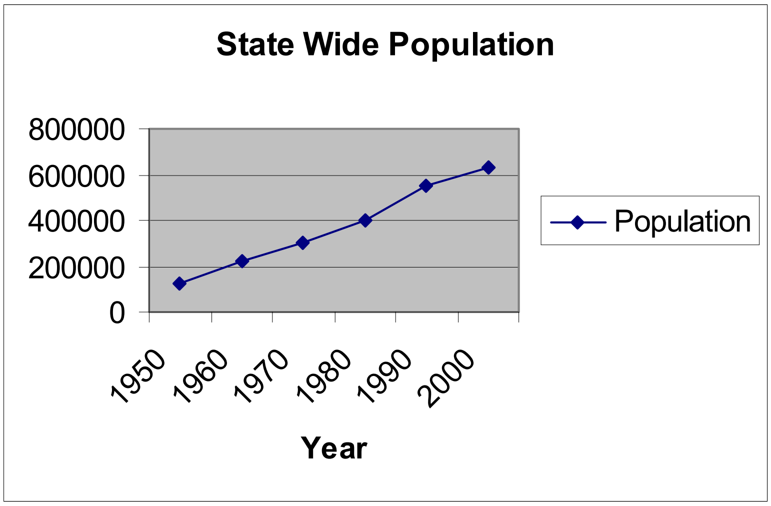
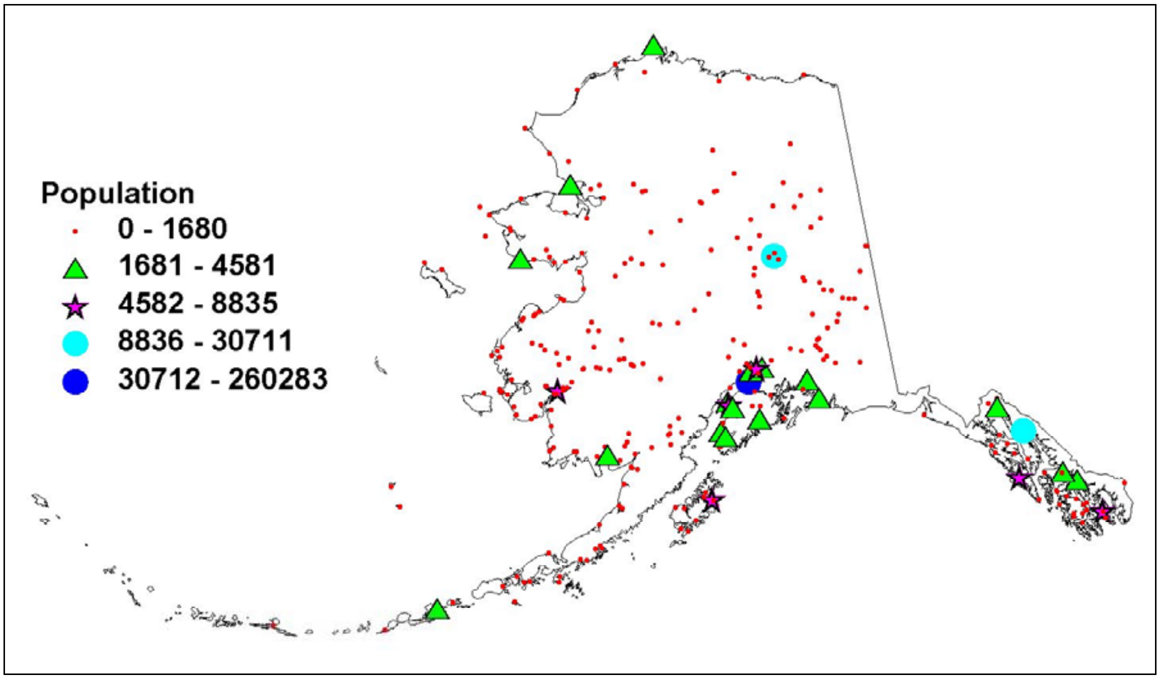
Chapter 2 - Population

According to the US Census, the population of Alaska has been increasing from just over 225,000 residents in 1960 to over 625,000 in 2000.

Year	1960	1970	1980	1990	2000
Population	226,167	300,382	401,851	550,074	626,932



The population is not equally distributed across the State (see map below). Most of the population is concentrated in the Municipality of Anchorage. Fairbanks and Juneau are the next most populous cities with just over 30,000 residents each. Most Alaskan communities are small, with populations under 1,000.



Alaska's Population Disbursement.

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Chapter 3 - Development Trends

Alaska has also experienced significant increases in development in recent years. Most of the residential development has occurred in the Anchorage and Fairbanks areas as well as the Matanuska-Susitna and Kenai Peninsula Boroughs. Bristol Bay Borough and Lake & Peninsula Borough have experienced enormous growth in seasonal housing.

Please see Appendix 8 for more detailed information about Alaska's population and development trends.

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Chapter 4 - Hazards in Alaska

This chapter serves as an introduction to many of the hazards that can occur in Alaska. The information will be supplemented by additional hazard specific data in related annexes. Additional information is also available in the State of Alaska Emergency Operations Plan.

There are more than 235 communities within Alaska in addition to boroughs, tribal organizations, and an Indian reservation. The size and diversity of these jurisdictions are as varied as the terrain and environment of Alaska and they have varied governmental powers and authorities ranging from no organized government to home rule municipalities.

Alaska's communities and their residents are exposed to many different hazards as proven by several recent disasters such as avalanches during the Central Gulf Coast Storm of 2000, structural losses from the 1995 Miller's Reach fire, and the 1995 South Central Fall Floods. These disasters have high costs associated with them. This plan is to help reduce the costs associated with future disasters.

A hazard cannot be treated in isolation, as there are inter-relationships between hazard agents. Frequently, one hazard event triggers another. For example, coastal storms often trigger floods and landslides. Wildfires can increase erosion and flooding risks. Earthquakes can trigger tsunamis. As a result, all possible consequences of a hazard need to be considered when deciding the most appropriate mitigation actions. It is also important to consider all the hazards that could occur in an area when deciding which mitigation activities to undertake. Some mitigation measures could worsen the effects from other hazards such as installing tile roofing to reduce fire damage in a seismically active area.

Flood

Flooding is a natural event from which no state in this country is immune. It occurs when rain, snow, or glacial melt causes a waterway to exceed its capacity. It is of great concern in Alaska because there are more than 3,000 rivers, three million lakes with over 5% of the State (29,000 square miles) is covered with glaciers. The Yukon River is almost 2,000 miles long and the third longest river in the U.S. These sources provide a multitude of opportunities for flooding.

While there are many different types of flooding, Alaska primarily experiences rainfall-runoff, snowmelt, and ice jam floods. Rainfall-runoff flooding, the most common, usually occurs in the late summer and early fall. Snowmelt flooding occurs in the spring.

Ice jam floods occur after an ice jam develops, causing water to rise upstream behind the jam. When the jam fails (releases), the stored water causes downstream flooding. Damage from ice jam floods is usually worse than from rainfall-runoff or snowmelt floods because the floods are usually higher, the water levels change more rapidly, and the ice causes physical damage. Ice jams usually develop where the channel slope decreases, gets shallower, or where constrictions occur such as at bridges, bends in the river, headwaters and reservoirs. During spring breakup, ice jams commonly dam water along big rivers. This flooding is exacerbated by snowmelt. Large floods in recent years on the Kenai, Susitna, Kuskokwim, and Yukon rivers were all caused by ice jams and snow melt.

A fourth type of flooding that is important in Alaska is a glacial outburst flood, called a jökulhlaup. They are the result of a sudden release of water from a glacier or glacially dammed lake resulting in rivers rapidly rising downstream. This can happen on many Alaskan rivers, including the Kenai River. On January 18, 1969, a glacial lake formed by the Skilak Glacier released. The Kenai River rose quickly to more than nine feet above the previous highest water level.

Sometimes, glacial outburst flooding is predictable, but not always. This is true for most types of flooding. To develop flood predictions, the National Weather Service (NWS) and ADES operates a flood-forecasting network in the most populated parts of Alaska.

Predictions are also difficult for many of the smaller rivers because of the short time span between when the precipitation occurs and the flooding starts. For example, in 1986 a storm front stalled over Seward, causing 18 inches of rain in 24 hours. If the storm had not stalled, it would not have been a problem.

Wildfire

Wildfire is an important issue in Alaska because of the vast expanses of tundra and 129 million acres of forested land in the State. The abundant amount of fuel, in addition to topography and weather, influence wildfire behavior.

There are four different types of wildfires:

- Wildland fire
- Urban Interface fire
- Firestorms
- Prescribed fires and prescribed natural fires

Spruce bark beetle infested trees.

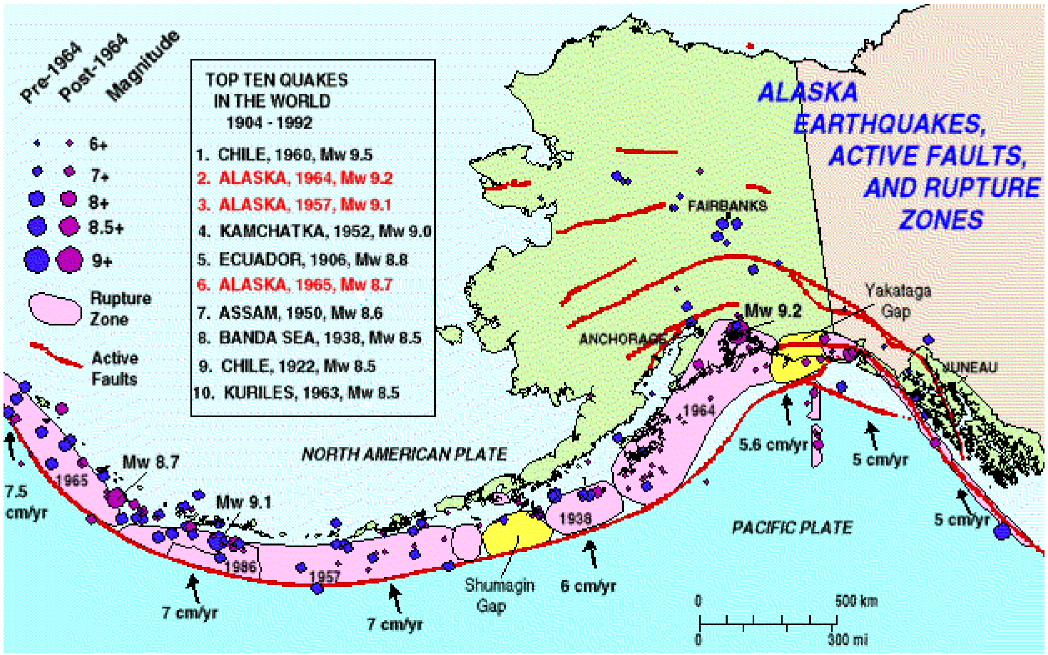
Many wildfires do not present a threat to people or property because they are in unpopulated parts of the State. This situation is changing as more development is occurring in wooded areas, placing people and property at risk.

The fire risk has also been increasing in recent years due to the spruce bark beetle infestation. The beetles lay their eggs under the bark of the trees and the emerging larvae eat the phloem, which is what trees use to transport nutrients from their needles to their roots. If the phloem loss is significant, the tree will die. The dead trees are very dry and therefore highly flammable. This will present an even bigger problem in the coming years as the trees start to fall, littering the forest floor with flammable material.

Earthquakes

On Good Friday, March 27, 1964, North America's strongest recorded earthquake, with a moment magnitude of 9.2, rocked central Alaska. On a global level, three of the ten strongest earthquakes ever recorded occurred in Alaska. Each year Alaska has approximately 5,000 earthquakes, including 1,000 that measure above 3.5 on the Richter scale.

Alaska is vulnerable to three types of earthquakes. One type is called a *subduction zone* earthquake, which is caused by one crustal plate moving beneath another plate. This is the case in South-central Alaska and along the Aleutian Islands where the Pacific Plate dives beneath the North American plate. This type of action usually leads to the Earth's largest earthquakes, such as the Good Friday earthquake. Volcanoes are also associated with plate convergence. Good examples are the volcanoes located on the Alaska Peninsula and on the Aleutian Islands.



Alaska earthquakes, active faults, and rupture zones. (Image courtesy of UAF/GI & USGS)

Another type of earthquake that is common in Alaska is known as a *transform fault* earthquake. These earthquakes occur when crustal plates slide by each other. This is the geologic setting offshore of South-eastern Alaska, where the North American plate and the Pacific plate slide past each other on the

Fairweather-Queen Charlotte fault. This is the same type of movement as on the San Andreas fault in California.

Earthquakes can also occur where secondary faults branch off the main boundary fault. For example, the Denali fault is a secondary fault that runs west of Douglas Island, through Haines, then curves parallel to the Alaska Highway and up past Mt. McKinley.

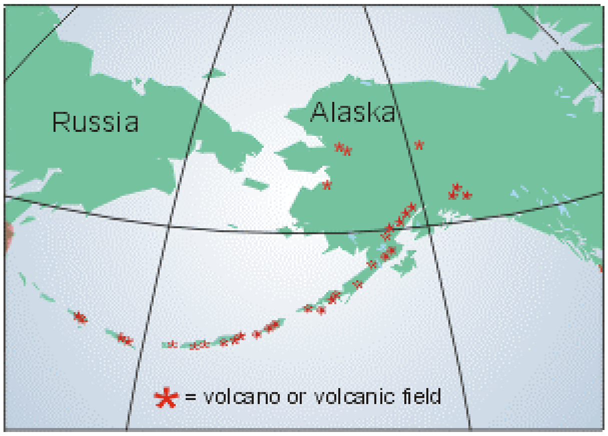
Thirdly, Alaska can experience *intraplate* earthquakes which occur within a tectonic plate, sometimes at great distance from the plate boundaries. They can have magnitudes into the 7s. Shallow earthquakes in the Fairbanks area would be considered intraplate earthquakes. In fact, there have been three magnitude 7 earthquakes within 50 miles of Fairbanks within the past 90 years.

Earthquakes occur on different parts, or segments, of faults at different times. The places on major faults with the highest potential earthquake hazard are where there have not been any recent large earthquakes; these are called "*seismic gaps*." The Yakataga seismic gap is one place in Alaska that is considered to have a very high probability of a major earthquake in the next few decades.

Earthquakes can trigger secondary hazards including landslides, avalanches, tsunamis, uplift, subsidence, infrastructure failures and soil liquefaction.

Volcanoes

Alaska is home to more than 80 major volcanic centers, 41 of which have been active in the last 250 years. On average, there are one or two eruptions or reports of volcanic unrest each year. Over half of the State's population lives within 100 miles of an active volcano.



Volcanoes and volcanic fields in Alaska.

The single greatest volcanic hazard in Alaska is airborne ash, fine fragments of rock blown high into the atmosphere during explosive volcanic eruptions. Coarse particles fall near the volcano but the fine particulates are carried downwind as an eruption cloud posing a hazard to aircraft and populations even hundreds or thousands of miles away. Ash is extremely abrasive, does not dissolve in water, and is heavy and slippery when wet. Inhaling ash can be dangerous, especially for children, the elderly and those with breathing problems. Ash can also affect machinery such as cars and electrical

Volcanic eruption.

generators. Volcanic ash nearly caused the greatest loss of life of any disaster event in Alaska. During the 1989 eruption of Mount Redoubt, a commercial airliner, with 245 passengers and crew aboard, flew into an ash cloud resulting in a loss of power to all four engines.

Lahars (volcanic mudflows), pyroclastic flows and surges, lava flows, debris avalanches, volcanic gases and tsunami generating landslides are also potential hazards during a volcanic eruption. The severity of each of these hazards depends on the type of eruption and distance from the volcano.

The Alaska Volcano Observatory (AVO), which is a cooperative program of the U.S. Geological Survey (USGS), Alaska Division of Geological & Geophysical Surveys (DNR/DGGS), and the University of Alaska Fairbanks Geophysical Institute (UAF/GI), monitors the seismic activity at 23 of Alaska's 41 active volcanoes in real time. In addition, satellite images of all Alaskan and Russian volcanoes are analyzed daily for evidence of ash plumes and elevated surface temperatures. Russian volcanoes are also a concern to Alaska as prevailing winds could carry large ash plumes from Kamchatka into Alaskan air space. AVO also researches the individual history of Alaska's active volcanoes and produces hazard assessment maps for each center.

Snow Avalanches

A snow avalanche is a slope failure consisting of a mass of fluidized snow sliding down a hillside. The damage caused by an avalanche varies based on the avalanche type, the consistency and composition of the avalanche flow, the flow's force and velocity, as well as the avalanche path. Avalanches usually occur on slopes between 25 and 50 degrees, with most starting between 30 and 40 degrees. They can be triggered by both natural and human factors.

Site of the February 2000 Cordova Avalanche.

Alaska often has the highest annual per capita deaths and injuries caused by avalanches. This is because some of the most-traveled roads pass through avalanche-prone areas and because there is a high frequency of backcountry avalanches triggered by the many hikers, skiers, and snowmachine users.

There is growing exposure to this hazard as development continues to occur in avalanche prone areas and participation in winter recreational activities increases.


Dog team searching for victims of a snowmachine-triggered avalanche. Photography by Bruce Tremper, courtesy of avalanche.org

Tsunamis & Seiches

Tsunamis are ocean waves that are generally triggered by vertical motion of the sea floor during major earthquakes. Near ocean or undersea landslides or volcanic eruptions can also generate tsunamis. They can be generated locally or a great distance from where they landfall. Warning time can be limited when the tsunami is triggered close to the impacted coastline.

The most vulnerable areas of the State are the low-lying coastal areas in the Gulf of Alaska and bordering the Pacific Ocean. While volcano-generated tsunamis may be rare, they are a threat to the Aleutian Chain and parts of Cook Inlet, including Homer and Seldovia. The coastline of the Bering Sea is considered to have a very low vulnerability to tsunamis.


Damage to Kodiak Island from the 1964 earthquake generated tsunami.

The 1964 Good Friday earthquake generated major tsunami activity. The earthquake and related aftershocks caused tsunami activity in Alaska, Hawaii and along the west coast of North America. Additionally, several tsunamis were generated in Alaska by local undersea landslides. The tsunami activity was responsible for 106 deaths in Alaska and 16 along the U.S. West Coast. The 1958 Lituya Bay landslide caused a tsunami stripping trees to an elevation of over 1700 feet.

A seiche is a water wave in an enclosed or partly enclosed basin that varies in period depending on the dimensions of the basin. They are sometimes incorrectly referred to as locally generated tsunamis. Seiches are locally generated, allowing very little warning time. Earthquakes, landslides, avalanches, high winds or changes in atmospheric pressure can all be triggering events. Seiches can result in very high run-ups on land.

Weather

Weather hazards include winter weather, thunder and lightning, hail, high wind, storm surge and coastal storms.

Winter weather includes heavy snows, ice, aufeis (known as glaciation of streams, rivers, affecting road surfaces and infrastructure), and extreme cold.

> Heavy snow can bring a community to a standstill by inhibiting transportation, knocking down trees and utility lines, and by causing structural collapse in buildings not designed to withstand the weight of the snow. Repair and snow removal costs can be significant.
>
> Ice buildup can collapse utility lines and communications towers as well as make transportation difficult. Ice can also become a problem on roadways if the temperature warms up just enough for precipitation to fall as freezing rain rather than snow.
>
> Aufeis, sometimes called glaciation or icing, forms during the winter when emerging ground water freezes. Stream glacial flooding can lead to aufeis development when water is forced out of the stream channel because ice formed from the *bottom up* not from the *top down*. If aufeis occurs on a roadway, it makes travel difficult. For example, the Steese Highway frequently has an aufeis problem in the winter months. In the mid 1980's, several homes in Fox suffered from an aufeis event occurring at the well head. The homes filled up 6 feet deep, then froze.
>
> Extreme cold can lead to hypothermia and frostbite which are both serious medical conditions. Cold causes fuel to congeal in storage tanks and supply lines, stopping electric generators. Without electricity, heaters do not work, causing water and sewer pipes to freeze or rupture. Extreme cold can also interfere with transportation if the ambient temperature is below an aircraft's minimum operating temperature. Extreme cold increases the likelihood of ice jams and flooding. If extreme cold conditions are combined with low/no snow cover, the ground's frost level can change creating problems for underground infrastructure.

Thunderstorm events are caused by the turbulence and atmospheric imbalance that arise from combining:

- unstable rising warm air,
- adequate moisture to form clouds and rain, and
- the upward lift of air currents resulting from interacting weather fronts (warm and cold), sea breezes, or mountains.

Lightning exists in all thunderstorms. It is caused by a buildup of charged ions within the thundercloud. When lightning connects with a grounded object, electricity is released which can be harmful to humans. Lightning can also start fires.

Hail is associated with thunderstorms. Hailstones are ice formations that are greater than 0.75 inches in diameter that fall with rain. The size and severity of the storm determine the size of the hailstones. In Alaska, hailstorms are fairly rare and cause little damage, unlike the hailstorms in Mid-western states.

High winds occur in Alaska when there are winter low-pressure systems in the North Pacific Ocean and the Gulf of Alaska. They can reach hurricane force and have the potential to seriously damage port facilities, the fishing industry and community infrastructure (especially above ground utility lines).

High winds can also be a localized problem where a pressure differential occurs across a mountain range (for example, a Chinook wind), such as those found in Anchorage’s Hillside area. On April 1, 1980, winds up to 120 miles per hour occurred in the Anchorage area, destroying several houses and airplanes as well as causing power failures that took several days to repair. Juneau’s Taku wind creates problems with the Snettisham power lines, causing power failures.

A coastal storm is a generic term for a storm that strikes a coastal area. Types of coastal storms include hurricanes, tropical storms, and Nor’easters. However, in Alaska, they are usually just called coastal storms. They can produce high winds, flooding and erosion. The intensity, location and the land’s topography influence the storm’s impact. Another factor that influences the damage done to the shoreline by coastal storms, particularly in northwest Alaska, is whether or not the shore ice is solid enough to protect against erosion and physical damage to community infrastructure.

Fierce storm conditions do not have to be present to cause damage. North-western communities suffer from “Silent Storms” where high-water storm surges erode and undercut the banks melting the permafrost.

Storm surge is when the water level of a tidally influenced body of water increases above the high tide mark. Storm surge is generally associated with winter low-pressure systems or coastal storms. They most commonly occur from late fall to early spring. The problem is especially severe during the highest tides of the monthly cycle.
Storm surge is controlled by four main factors:

- Intensity (wind speed) of the storm
- Low barometric pressures
- Landfalling during astronomical tide
- Coastline configuration

Landslides

A landslide refers to the downward and outward movement of slope-forming materials reacting under the force of gravity. Landslides usually consist of natural soil, rock, artificial fill or a combination of those items. The term covers a range of events including mudflows, mudslides, rock flows, rockslides, debris flows, debris avalanches, debris slides, and earth flows.

There are four types of landslides, which are classified according to their type of material and type of movement.

- Slides: a downward displacement of material along one or many failure surfaces
- Flows: fast moving soils, rocks, and organic materials that have been mixed with air and water and going downhill. They contain a high water content and resemble viscous fluids when in motion
- Lateral Spreads: material is laterally displaced. They can be produced through liquefaction
- Falls & Topples: a fall is when rock or other material breaks free from a cliff or slope and moves by free fall, bouncing, or rolling. Topples are a mass of rocks or soil rotating forward from a slope at a point that is below the mass' center of gravity

Geology, precipitation, topography, and cut and fill construction practices all influence landslide activity. They are often the result of seismic activity, flooding, volcanic activity, heavy precipitation, construction work, or coastal storms. Landslides can also trigger secondary hazards, such as tsunamis and flooding. Flood hazards are created where a landslide blocks a river valley and acts as a temporary dam. When the basin behind the landslide dam fills, it can drain catastrophically as the water rapidly erodes the loosely deposited material. In Alaska, as elsewhere, the greatest risks from landslides occur where buildings, roads, and other facilities are located on or near steep slopes, or on soil materials that are susceptible to failure during severe earthquakes or heavy precipitation.

Erosion

Erosion is a process that involves the gradual wearing away, transportation, and movement of land. However, not all erosion is gradual. It can occur quite quickly as the result of a flash flood, coastal storm or other event. Most of the geomorphic change that occurs in a river system is in response to a peak flow event. It is a natural process but its effects can be exacerbated by human activity.

Erosion is a problem in developed areas. The disappearing land threatens development and infrastructure. There are 3 main types of erosion that affect human activity in Alaska:

- Coastal erosion

- Riverine erosion
- Wind erosion

Coastal Erosion

Coastal erosion is the wearing away of land and loss of beach, shoreline, or dune material because of natural activity or manmade influences. It can occur gradually or suddenly. Usually erosion is a long-term event but happens quickly during storm events.


Coastal erosion. Shishmaref, AK.

A 1971 study by the U.S. Army Corps of Engineers (USACE) showed that less than 11% of Alaska's coastline was undergoing "significant" erosion.
It is primarily a problem along the western and northern coast as well as the Cook Inlet. Along the majority of Alaska's coast it is not a significant problem as there is limited development in these areas. However, the problem can be quite serious on a local level. Several native communities, such as Barrow, Shishmaref, Kivalina, and Point Hope are affected by this problem.

Riverine Erosion

Riverine erosion results from the force of flowing water in and adjacent to river channels. This erosion affects the bed and banks of the channel and can alter or preclude any channel navigation or riverbank development. In less stable braided channel reaches, erosion and deposition of material are a constant issue. In more stable meandering channels, episodes of erosion may only occur occasionally. Examples of riverine erosion are found throughout Alaska that threaten both public and private property. Riverine erosion on the meandering Matanuska River, near Palmer, presently threatens the stability of several houses and some infrastructure. Riverine erosion problems also exist on other rivers including the Kenai, Kuskokwim, and Yukon Rivers.

Wind Erosion

Wind erosion occurs when wind is responsible for the removal, movement and redeposition of land. It can cause a loss of topsoil, which can hinder agricultural production. The blowing dust can also reduce visibility and have a negative effect on air quality. The Mat-Su Valley is a known area of wind erosion as it can get gusts of up to 100 miles per hour.

Drought

A drought is commonly defined as a period of time of very low precipitation and is fairly rare in Alaska. Drought severity depends on duration, intensity, and geographic extent as well as the demand on the water supply. This hazard is complicated because there is no easily identifiable beginning or end, and because the impacts are not very obvious and can affect a wide area.

There are four ways to define drought:

Meteorological: a degree of dryness. Measures lack of actual precipitation compared to an expressed average.
Agricultural: defined in regard to soil moisture deficiencies relative to what the plant life needs.
Hydrological: relates to the effects of the lack of precipitation on streams, rivers, lakes, and groundwater levels.
Socioeconomic: when the demand for water is greater than the supply. This can be caused from a reduction in supply, an increase in demand or both.

A drought may result in crops not maturing, land values declining, wildlife and livestock becoming malnourished, increases in unemployment and contribute to an increased wildfire hazard. It can also lead to a shortage of water for residential, industrial, recreational, and navigational purposes.

Technological

Technological hazards are those that are not natural in origin. Alaska faces a wide variety of technological hazards including:

- Dam failure
- Hazardous material accidents,
- Security threats (including terrorism and Weapons of Mass Destruction (WMD))
- Infrastructure failures
- Oil spills
- Urban Fires (including “bush” communities and cruise ships)

The consequences of technological disasters are significant because they frequently occur in Alaska. For example, the 1989 Exxon Valdez oil spill is the largest in American history. Over 11 million gallons of crude oil was released into Prince William Sound. It cost over $2 billion in clean up costs and even more in environmental damage. It also affected 1,300 miles of coastline and countless numbers of wildlife with some still not in pre-spill condition.

An oil coated sea otter. Image courtesy *Exxon Valdez* Oil Spill Trustee Council.

Power outages are a type of common infrastructure failure in Alaska. They are often caused by power plant fires and result in additional damages, such as water and sewer system freeze-ups. For example, in 1975 a Bethel power plant burned down causing the local utilities to freeze. This resulted in a Federal Disaster Declaration. In 1961, the military considered evacuating Fort Greeley when a power outage occurred during extended -60°F weather.


Cruise ship in Ketchikan. © Alaska Division of Tourism

Recent cruise ship fires, including a multiple fatality fire on the 'Universe Explorer' demonstrate the potential for high losses of life in some of the more remote or inaccessible areas of the State. Cruise ship traffic has increased dramatically in the last few years, and is predicted to continue to increase in the future. The smaller fire departments in South-east Alaska have little or no capability for responding to major cruise ship fires.

Economic

A large section of the Alaskan economy is resource-based. Catastrophic events such as earthquakes, tsunamis, wildfires, and storms can have severe economic impacts on Alaska's resource-based economy. Moreover, the economic impacts from other conditions, such as a severe decline in resource availability or in market prices, can be as devastating to individuals and communities. In recent years, low salmon returns have combined with low market prices to create economically disastrous conditions in western and northwestern Alaska, resulting in the governor's issuance of disaster or economic disaster declarations or administrative orders in 1997, 1998, 2000, and 2001.

Chapter 5 - Hazard Mitigation Framework

Mitigation Measures

A multi-objective planning process for hazard mitigation may help a community find the specific mitigation measures that will yield benefits across the widest range of goals.

Communities should develop and adopt policies with respect to hazard mitigation and risk reduction. The measures taken need to be suitable for the hazards being addressed. Understanding the nature of hazards as well as what is vulnerable is vital to developing effective mitigation measures.

Mitigation measures can be grouped into three main categories:

- Protective,
- Preventive, and
- Educational

Protective

Protective measures try to protect a structure or facility from damage during a hazard event. They might not be able to completely eliminate damage but they can help minimize it.

Protective mitigation measures:

- Reduce exposure to hazards
- Facilitate restoration of facilities
- Preserve functionality of facilities

An example of a protective mitigation measure is to seismically upgrade a bridge to withstand an earthquake.

Structural/Community Protective Works: These measures are designed to control the hazard and restrict the exposed area. Examples include dams, levees and landslide/avalanche containment structures.

Culverts.

The measures can be very expensive as they usually involve constructing an engineering work, require maintenance to keep their effectiveness and have the potential to make things worse in the long run. For example, if a flood exceeds the design standard of the levee, the damages incurred may be greater than if the levee never existed in the first place.

Retrofitting or Rehabilitation: Retrofitting or rehabilitating existing structures and facilities can protect against future damage. The costs associated with these activities can be quite high and not be cost effective.

In some cases, the work can be done incrementally or as part of routine maintenance.

Protection of Critical Facilities: The protection of critical facilities is important because they are vital during the response and recovery phase of a disaster. Critical facilities include, but are not limited to, hospitals, schools, and water treatment systems. Communities should establish policies regarding the placement and design of future facilities.

Preventive

Preventive mitigation measures try to limit the exposure to hazards, which prevents disaster damage from occurring. For example, a preventative measure might be buying out or relocating homes in an avalanche area. Communities have many tools that can be used to implement preventive mitigation measures. The most common tools are described below.

Land Use Planning: Communities can use comprehensive land use plans, transportation plans, etc. to guide development away from hazard prone areas.

Zoning: The division of a community into areas, and establishing development criteria for each area is known as zoning. It can:

- Prevent new development in hazard prone areas.
- Preserve or establish low densities in hazardous areas.
- Provide incentives to retrofit structures (density bonuses).
- Control changes in use and occupancy of existing structures in hazard prone areas.
- Establish performance standards.
- Require special use permits.

Subdivision Regulations: These regulations determine how a parcel of land can be divided into smaller parcels. It is wise to incorporate mitigation measures into subdivision regulations before a parcel of land is divided, as this allows for a wider variety of options. Mitigation measures may require configuring lot arrangements differently or clustering housing units closer together to dramatically reduce damage or loss from a disaster.

Preservation of Open Space: Communities should try to preserve existing open space in hazard prone areas. This prevents putting more people and structures at risk.

Preservation of wildlife habitat.

Acquisition, Relocation, or Elevation: These measures are extremely effective in removing individuals from harm and reducing repetitive loss. Land acquisition usually requires the government to buy the land and convert it to open space in perpetuity. Structures on a property can be relocated to safer areas. Elevating structures above the base flood elevation can protect them from future floods. There are special National Flood Insurance Program (NFIP) provisions and possible funding for these mitigation measures.

Building Codes: Building codes are a compilation of laws, regulations, ordinances, or other statutory requirements adopted by a government legislative authority relating to the physical structure of buildings. Their purpose is to establish the minimum acceptable requirements to preserve public health, safety, and welfare as well as to protect property in the developed environment. The minimum requirements are based on the physical properties of construction materials, natural scientific laws, the hazards of climate, geology, and use of a structure.

Building code enforcement is important to ensure that mitigation measures are implemented correctly. It is also cheaper and easier to incorporate mitigation into new structures than to retrofit existing ones.

Building codes are reviewed and adopted by the Division of Fire Prevention every three years. The Division makes changes necessary to tailor the code to Alaska's conditions. The building code applies to all new construction, repair, remodel, addition or change of occupancy of any building/structure or installation or change of fuel tanks, except for residential housing that is a triplex or smaller and is enforced by the Division of Fire Prevention. Some jurisdictions, namely Anchorage, Juneau, Fairbanks, Kenai, Seward, Kodiak, Sitka, and Soldotna have the ability to adopt and enforce their own building codes provided they are at least as restrictive as the State adopted code.

Capital Improvements Program (CIP): Capital improvement programs serve as a guide to community funding for physical improvements over a given time period. How funding is allocated can affect what is at risk. For example, the CIP can allocate funds to replace or strengthen vulnerable or critical facilities such as hospitals. The community can also choose not to invest in an area, thus restricting future development in hazard prone areas.

Education

Educating people about hazards and what they can do to protect themselves and their property is an important component to any mitigation strategy.

Outreach: It is the process of educating the entire community about what can be done to mitigate and prepare for hazards. Examples include but are not limited to:

- Community meetings
- School activities and presentations
- "Quake Cottage" earthquake simulations
- Inserts into utility bills
- Ads in the media
- Workplace training
- Booths at fairs and home shows
- Brochure and pamphlet distribution

The "Quake Cottage" at the Kodiak Crab Festival

Technical Assistance: There are several programs at various agencies that can assist communities with hazard mitigation activities. These programs provide help to local communities without the capability to undertake, risk assessments, cost-benefit analysis, etc. For example, FEMA publishes technical documentation about hazard resistant construction practices. Another program is the Department of Community and Economic Development's (DCED) Division of Community & Business Development's (DCBD) Floodplain Management Program. Its mission is to reduce public and private sector losses and damage from flooding and erosion by providing coordination, funding, and technical assistance to NFIP communities. The DCBD serves as the Governor's appointed State coordinating agency for the NFIP and the Flood Mitigation Assistance Program (FMA). Both programs are regulated by FEMA.

Disclosure Requirements: These requirements call for informing people of possible hazard exposure before they purchase a piece of property. This enables them to make informed, rational decisions about the risk(s) associated with the property.

SECTION 4 - HAZARDS IN ALASKA

Section 4 consists of annexes devoted to specific hazards as well as an "all hazards" annex for issues that are relevant to multiple hazards. Each annex documents some of the State's mitigation successes and existing mitigation programs. In addition, it describes the State's short-term and long-term mitigation goals. The lead agencies, support agencies, timelines, and resources needed for are each goal listed.

For the purposes of this plan:

- Short term activities are those that agencies are capable of completing within the next two years
- Long term activities are those which will take longer than two years to complete.
- Possible funding sources for short and long term goals will be found in Appendix 5.
- Lead agencies are responsible for guiding the implementation of the mitigation measures identified in this plan. They should educate people within their agency about mitigation and why it is important. They are the appropriate entity to identify to the SHMO any inconsistencies that existing programs or activities have with the mitigation plan.
- Support agencies assist lead agencies in implementing mitigation measures. They should also educate people within their agency about mitigation and why it is important. They are the appropriate entity to identify to the SHMO any inconsistencies that existing programs or activities have with the mitigation plan. Other affected agencies should be considered a support agency even if they are not specifically identified in this plan.
- Timeline refers to the target implementation date.
- Resources refers to the means to commit or implement each goal, if known. They are expressed as a level of effort in full time equivalent (FTE) staff members.

Mitigation goals are ranked according to their priority (high, medium, low priority).

The hazard potential maps are intended to provide an overview of areas that are exposed to the hazard and their probability of occurrence. These maps are for illustrative purposes and should not be the basis for decision making.

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ANNEX A - "ALL-HAZARDS"

This annex will address the many mitigation actions, programs and policies that pertain to a variety of hazards.

Existing Programs and Strategies

Public Education

ADES operates booths at several State fairs and other important functions including the Alaska Tanana Valley Fair in Fairbanks, the Alaska State Fair in Palmer, the Kodiak Crab Festival, the Alaska Municipal League, the Alaska Federation of Natives Convention, and the Alaska Municipal Clerks Workshop, providing information on hazards in Alaska as well as mitigation and preparedness measures. These activities provide excellent opportunities to reach many Alaska residents.

Other public education opportunities include school presentations, outreach trips to potential flood communities, an annual Emergency Management Conference, public information media campaigns, numerous presentations and briefings for professional organizations and community groups (Chamber of Commerce, Rotary Club, media outlets, etc.), and training sessions and exercises with partner agencies/groups.

Kenai Peninsula Borough's (KPB) Office of Emergency Management also conducts extensive public education. They have hosted several seminars devoted to hazard mitigation and preparedness and have made information available through their website and community office.

Anchorage recently started its A.W.A.R.E. Together program which was designed to educate the citizens of Anchorage about the municipality's response in the event of a disaster, and to train citizens to respond and to be self-sufficient. A.W.A.R.E. stands for Anchorage: Watchful, Alert and Ready for Emergencies. Through A.W.A.R.E. Together, the Municipality of Anchorage empowers the community through a variety of programs.

- A.W.A.R.E. Academy. This four hour basic disaster preparedness class trains residents to respond properly in the event of an emergency. To date, over 1,000 residents have registered for this free class.
- A.W.A.R.E. Aid. Through partnerships with the American Red Cross and the American Heart Association, A.W.A.R.E. Aid provides free CPR training to graduates of the A.W.A.R.E. Academy.
- A.W.A.R.E. Schools. Through a partnership with the American Red Cross, the Corporation for National and Community Service and the Anchorage School District, all 26,000 K-6th grade students in the Anchorage School District will receive basic emergency response training.
- A.W.A.R.E. Coalition. The A.W.A.R.E. Coalition is a forum for public safety professions in the public and private sector. Through the A.W.A.R.E.

Coalition, the municipality will be able to better identify and coordinate resources that will enhance effective response in the event of an emergency.

- A.W.A.R.E. Neighborhoods. Using elements of FEMA's CERT training and the Red Cross' Disaster Resistant Neighborhoods, local Anchorage neighborhoods will learn to work together to increase self-sufficiency in the event of a major disaster.

Hazard Mitigation Successes

Short Term Actions

High Priority

Publish the* State Hazard Mitigation Plan *on the ADES web site.

Disseminate information and promote mitigation.

Lead: ADES
Support:
Timeline: 6 months

Establish the State Hazard Mitigation Plan Advisory Committee.

The Advisory Committee, chaired by the State Hazard Mitigation Officer, will consist of representatives from State, federal local and tribal governments and agencies, academic institutions, and the private sector. The duties of the advisory committee will include reviewing and identifying known hazards to present a unified mitigation management strategy. The committee will also review and prioritize mitigation grant proposals and make recommendations to the Governor.

Lead: ADES
Support: Membership
Timeline: Immediately upon acceptance of the plan by the Governor of Alaska

Medium Priority

***Annually review and revise the* State Hazard Mitigation Plan.**

As a minimum, the plan should be updated annually and following any Presidential Disaster Declaration.

Lead: ADES
Support: Affected State Agencies
Timeline: annually or 90 days from date of Presidential Disaster Declaration

Improve hazard mitigation technical assistance for local governments.

Encourage local efforts by providing hazard mitigation training, current hazard information, and facilitating communication with other agencies.

Lead: ADES
Support: Applicable State agencies
Timeline: on-going

Monitor State Hazard Mitigation Plan implementation.

Ensure that the measures and policies outlined in this plan are implemented correctly by conducting an annual review based on the annual progress report from each lead agency. The progress report form will be found in Appendix 18. The progress reports will be submitted by November 1 to allow enough time for the plan to be updated before the end of the calendar year. This date was chosen to avoid conflicting with federal and state fiscal year -end activities.

Lead: ADES
Support: DCED, DOT&PF, AVO, other lead agencies
Timeline: on-going

Long Term Goals

High Priority

1. ***Promote mitigation education of the public.***

   Many mitigation measures can be implemented at the individual or household level. It is important to raise awareness about what can be done to protect oneself and property from hazards. Local officials need to inform residents about all hazards and risks in their area. It is also vital to convey information about the availability of insurance for dwellings and property against most perils. In most cases, insurance can offset losses not covered by government assistance programs.

   Lead: ADES
   Support: DCED, ARC, ADOI
   Timeline: on-going

2. ***Develop and disseminate guidance for local and tribal hazard mitigation plans.***

   Needed to fulfill DMA 2000, Sec 322, Mitigation Planning requirements after FEMA implementation guidance is published.

   Lead: ADES
   Support: DCED, tribal governments & organizations
   Timeline: 6 months

3. ***Encourage all Alaskan local communities and tribal governments to have a Hazard Mitigation Plan.***

Hazard mitigation plans are required to qualify for Hazard Mitigation Grant Program funding resulting from a Presidentially Declared Disaster. Hazard mitigation plans should be developed before a disaster occurs. However, post-disaster plans must be prepared and submitted with HMGP project applications and receive State and FEMA approval before funding will be released.

Lead: ADES
Support: DCED, DEC, DNR
Timeline: on-going

4. ***Develop workshops for State and local officials.***
   Develop workshops to educate State and local officials about what mitigation tools are available and how they can be incorporated into daily operations. Workshops addressing the development of local and Tribal hazard mitigation plans also need to be developed.
   Lead: ADES
   Support: DCED, State/Federal agencies
   Timeline: on-going

5. ***Prepare Statewide and area specific hazard maps.***
   Statewide maps of individual hazards are useful for conveying the general distribution of a hazard, but are inadequate for land-use and emergency management decisions. Detailed hazard maps at scales useful for planning and decision making (normally 1:63,360 or larger scale) should be prepared in Geographical Information System (GIS) format for all urban and developing areas. Where possible, the maps should convey quantitative information about each hazard that is useful for design and planning.
   Lead: ADES, DNR/DGGS
   Support: DCED, DEC, UAF/GI
   Timeline: on-going

6. ***Update existing topographic and orthophoto map coverage of the entire State, to include generating high resolution digital elevation models (DEMs).***
   Accurate maps are critical for hazard identification, risk assessment (e.g. improved slope mapping for avalanche susceptibility or inundation mapping) monitoring, and accurate portrayal of hazard information for emergency management and educational uses. Priorities should include populated areas, including coastlines exposed to tsunami and storm action, active volcanoes, and areas prone to specific hazards. DEMs are used by geophysicists to detect deformation at active volcanoes, however the poor quality of existing digital topographic information hampers analysis. Pre-disaster maps and photographs are also essential for post-disaster assessment and emergency response.
   Lead: USGS, DNR
   Support: FEMA, NOAA, AGDC

Timeline: 10 years

Medium Priority

7. ***Encourage communities to undertake or update hazard analysis and vulnerability assessments including identifying critical facilities and lifelines.***
   Hazard and vulnerability assessments should be conducted and kept current to reflect changing conditions. They may be contained within an EOP or as a stand-alone document. Updates should occur biennially or after any significant community change. These assessments will help with the survival of critical facilities and lifelines essential in any community. They will allow both State agencies and community leaders access to information to identify areas to focus their mitigation efforts.
   Lead: ADES
   Support: DCED, DEC, DNR/DGGS, ALCOM
   Timeline: on-going

8. ***Develop additional hazard mitigation annexes.***
   Continue developing annexes on hazards that affect Alaska to enhance the State Hazard Mitigation Plan.
   Lead: ADES
   Support: DCED, DNR, DPS, AVO, NWS, WC&ATWC, UAF/GI, FEMA, emergency management organizations from other states
   Timeline: on-going

9. ***Encourage communities to incorporate hazard mitigation plans in local land use plans and zoning ordinances.***
   Hazard mitigation plans addressing land use will encourage or require development away from hazardous areas.
   Lead: ADES
   Support: DCED, DEC
   Timeline: on-going

10. ***Develop workshops for critical facility managers.***
    Develop workshops to educate critical facility managers about available mitigation tools and how they can be incorporated into facility operations.
    Lead: FEMA
    Support: ADES
    Timeline: on-going

11. ***Encourage adoption of a state-wide policy requiring all State facilities, or facilities being constructed with public funds, to be located, designed, built, and operated to minimize risk from hazards, and insured to reduce future costs to the public.***
    This will be an expansion of Administrative Order 175 (AO175), as it is in the State's best interest to protect its investment from all hazards instead of

limiting protection to flood and erosion hazards. The Administrative Order should be circulated to all Departments to ensure compliance.

Lead: Governor's Office
Support: ADES, DPC, DLAW, DCED
Timeline: 10 years

12. ***Encourage the development of disaster recovery plans consistent with hazard mitigation tenets and opportunities.***

A community has many rebuilding options during the recovery process. With a plan in place, a community can easily implement changes to their community's land use and building construction practices. Without a plan, mitigation opportunities and more beneficial community design options may be overlooked. Preplanning can help avoid poor spur-of-the-moment decisions that may have long-lasting negative ramifications.

Lead: ADES
Support: DCED, DNR, DOT&PF, DEC
Timeline: on-going

13. ***Improve communication systems to ensure sustainability and compatibility.***

Communication systems often fail when they are needed the most; during a disaster or emergency. The physical infrastructure could fail, the system could become overloaded, or the equipment could be incompatible with other systems operating in the area. Coordinated communication plans and compatible equipment improve communication continuity.

Lead: DMVA
Support: ADES, DPS, DNR, DEC
Timeline: 5 years

14. ***Support the Alaska Land Mobile Radio (ALMR) Project***

The goal of the ALMR project is to build a land mobile radio communications system that will provide each participating agency autonomous day-to-day communications and the ability to transition to a full featured interoperable system when needed. Sharing of a common radio infrastructure will eliminate duplications of capital investment projects, thus reducing the total communications cost for each participating agency.

Lead: ALMR Executive Council
Support: DCED, DEED, DC, DEC, ADF&G, AKRR,
Timeline: 5 years

Low Priority

15. ***Establish a fund to promote local governments' hazard mitigation efforts.***

Many communities lack the financial resources to develop and implement a comprehensive mitigation program. It is in the State's long-term interest to promote these activities.

Lead: Legislature
Support: DCED, DEC, ADES
Timeline: 5 years

16. ***GIS standard for hazard maps.***
All GIS hazard-map data released for distribution should be prepared and documented according to Federal Geographic Data Committee (FGDC) standards for geospatial data and metadata, and should be compatible with GIS software in use by State agencies.
Lead: ADES, DNR/DGGS
Support: DCED, DEC, UAF/GI
Timeline: on-going

17. ***Encourage urban communities to implement redundant community alert warning systems.***
Redundant community alert warning systems will ensure communication of warnings if primary systems should fail.
Lead: ADES
Support: DPC, NWS, DOS, USCG, DOJ
Timeline: on-going

18. ***Revise existing real estate disclosure laws to assure adequate notice to future property owners about potential hazard risks.***
Ensure that people are aware of the risks they face. Currently, the Residential Real Property Transfer Disclosure Statement, which is required whenever an interest in residential property is transferred, only asks the seller to declare if the property is located within an avalanche area or floodplain or has had damage from natural causes including earthquakes and landslides. The disclosure statement should be expanded to ask if the property is in any known hazard areas.
Lead: Governor's Office, Legislature
Support: ADES, DCED, DLAW
Timeline: 5 years

19. ***Promote community preparedness information transfer to residents.***
The responsibility for emergency management is at the community level. It is essential for them to be prepared, as it will take time for any assistance to arrive in the event of a disaster. A substantial number of communities should be contacted annually to fulfill the federal funding requirements of Alaska's Emergency Management Program Grant (EMPG).
Lead: ADES
Support: DCED, FEMA, WC&ATWC, UAF/GI, NWS
Timeline: on-going

20. ***Encourage communities to establish a hazard mitigation team.***

Agencies and organizations within a community should collectively address hazard mitigation issues to ensure they are not pursuing different or conflicting goals. For example, the transportation department may want to construct or improve roads in a floodplain while the planning department wants to discourage development in that area. Community residents should also be involved in the process.

Lead: DCED
Support: ADES, DEC, DOT&PF
Timeline: on-going

21. ***Review existing Alaska Statutes.***

Examine existing Alaska Statutes to strengthen mitigation options. Modifying statutes and regulations can streamline the permitting process and make it easier to implement worthwhile mitigation measures. Ensure statutes complement each other with respect to mitigation strategies.

Lead: Governor's Office, DLAW
Support: ADES, DNR, DOT&PF, DEC
Timeline: 3 years

ANNEX B - FLOODS

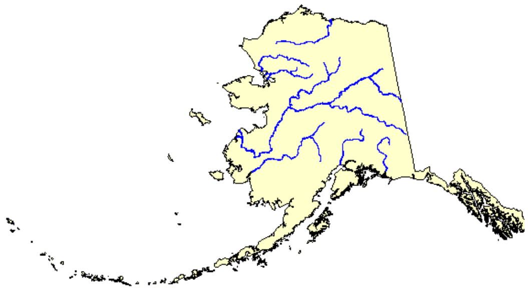
Flooding is a natural event and damages occur when humans interfere with the natural process by altering the waterway, developing watersheds, and/or building inappropriately within the floodplain. Most of Alaska's communities and transportation facilities are located along large rivers and are subject to flooding. This flooding threatens life, safety and health; causes extensive property loss; and results in damage in excess of three-quarters of a million dollars annually.

Hazard Characterization

Flood Experience

Alaska has had a lot of experience with flood events. One of the most flood-prone cities in the State is Skagway because of its location on a river delta. The entire town is within the 100-year floodplain. As a result, the city has experienced ten flood disasters in the 1900s alone.

The Fairbanks area has a history of flooding from the Chena River. Major flooding in June and July 1964 was caused by rapid snowmelt from large snowpacks in interior Alaska. In August 1967, twice the area's annual precipitation fell in just a few days. The resulting floods put about 95% of Fairbanks under water, causing 6 deaths, $85 million in damages, and the evacuation of 12,000 people.


Alaska's Major Rivers.

In October 1986, the State was affected by a significant flooding event over a three-day period and Seward was subjected to 18 inches of rain which resulted in the largest flood the town had ever experienced. The flooding disrupted transportation routes throughout South-central Alaska and eliminated land access to Seward. Damage to Seward, other parts of the Kenai Peninsula, and the Matanuska-Susitna Borough was estimated at about $20 million.


1995 Flood in Kenai.

The area experienced severe flooding again in September 1995 and the Seward Highway had to be closed after rain swept across a quarter-mile stretch of the highway near Milepost 3. In Girdwood, officials shut down the wastewater treatment plant when large volumes of mud and water overwhelmed it. This caused raw sewage to be washed into local creeks. In the Kenai area, some people living near the Kenai and Kasiloff rivers had to rely on boats for transportation and residents of the Kenai Keys and Poacher's Cove areas were encouraged to evacuate.

Flooding in Russian Mission. Photograph courtesy M. Bird, ADES.

On October 19-20, 1998 flooding occurred in the communities of Haines and Klukwan, as well as the City and Borough of Juneau, after the worst two-day rainfall in fifty years (over 6 inches of rain fell within a 48-hour period) occurred in Southeast Alaska. The flooding and associated mudslides and water erosion caused extensive damage to many road systems and properties.

Types of Flooding

Flooding in Alaska can be broken into a number of categories including rainfall-runoff floods, snowmelt floods, ground-water flooding, ice jam floods, flash floods, fluctuating lake levels, alluvial fan floods and glacial outburst floods. Alaska also experiences coastal flooding from storm surge but this will be discussed in Annex J. These are not exclusive categories as a flood event could have elements of more than one type.

Rainfall-Runoff Floods

A typical rainfall event occurs in mid to late summer. The rainfall intensity, duration, distribution and geomorphic characteristics of the watershed all play a role in determining the magnitude of the flood.

Runoff flooding is the most common type of flood. They usually result from weather systems that have prolonged rainfall associated with them.

Snowmelt Floods

Snowmelt floods usually occur in the spring or early summer. The depth of the snowpack and spring weather patterns

Timing of events

Many floods are fairly predictable based on rainfall patterns. For coastal areas of Alaska, most of the annual precipitation is received from September through February with October being the wettest. In Interior Alaska, the wettest period is June through November with August the wettest month. This rainfall leads to flooding in late summer and fall. Spring snowmelt increases runoff, which can cause flooding. It also breaks the winter ice cover, which causes localized ice-jam floods. Glacial outburst floods occur mostly in mid-summer through late fall. Other types do not have this seasonal component.

influence the magnitude of flooding. Snowmelt floods can also be caused by glacial melt.

Ground-water Floods

Ground-water flooding occurs when water accumulates and saturates the soil. The water-table rises and floods low-lying areas, including homes, septic tanks, and other facilities. It has been a significant problem in Fairbanks, especially downstream of the Chena Lakes dam. When high water is impounded behind the dam, the water table rises and floods low-lying areas. Ground-water flooding also occurs in basements of structures along the Chena River when the river stage remains high for more than a few days.

Ice Jam Floods

Ice jams can form during fall freeze up, in midwinter when stream channels freeze forming anchor ice and during spring breakup when the existing ice cover gets broken into pieces and the pieces get stuck at bridges or other constrictions. When the ice jam fails, it releases the collected water. Ice jams have caused large floods on the Kenai, Susitna, Kuskokwim and Yukon Rivers.


Flooding in Alakanuk during breakup. Photo courtesy of DCED.

Water collects upstream from a jam, flooding an area by creating a lake-like effect that has a large areal extent. The effect is analogous to a dam. Little damage typically occurs from the current upstream of the jam but significant damage can result from flooding. The downstream effect is very different. Once the jam is breached there is usually a rapid draining of the water dammed behind the jam. Not only does the downstream stage rise substantially once the jam is breached, but there is substantial current, which can cause erosion and significant damage. Additionally, the rising water causes the ice to float and the increased velocities move the ice further downstream. The motion of large solid blocks of ice are often very destructive.

Flash Floods

These floods are characterized by a rapid rise in water. They are often caused by heavy rain on small stream basins, ice jam formation or by dam failure. They are usually swift moving and debris filled, causing them to be very powerful and destructive. Steep coastal areas in general are subject to flash floods. Debris slides are often associated with heavy rains. The Kodiak and Seward areas, as well as South-east Alaska, are prone to flash floods.

Fluctuating Lake Level Floods

Generally, lakes buffer downstream flooding due to the storage capacity of the lake. But when lake inflow is excessive, flooding of the area around the lake can occur. The Kenai Lake area sees periodic flooding due to rainfall, snowmelt, and glacier-dammed lake releases.

Alluvial Fan Floods

Alluvial fans are areas of eroded rock and soil deposited by rivers. When various forms of debris fills the existing river channels on the alluvial fan, the water overflows and is forced to cut a new channel. Fast, debris filled water causes erosion and flooding problems over large areas. Alluvial fan flooding frequently causes road closures and infrastructure damages along the Richardson, Haines, and Dalton Highways. The Seward and Girdwood areas are also prone to this type of flooding.

Glacial Outburst Floods

A glacial outburst flood, also known as a jökulhlaup, is a sudden release of water from a glacier or a glacier-dammed lake. They can fail by overtopping, earthquake activity, melting from volcanic activity, or draining through conduits in the glacier dam.

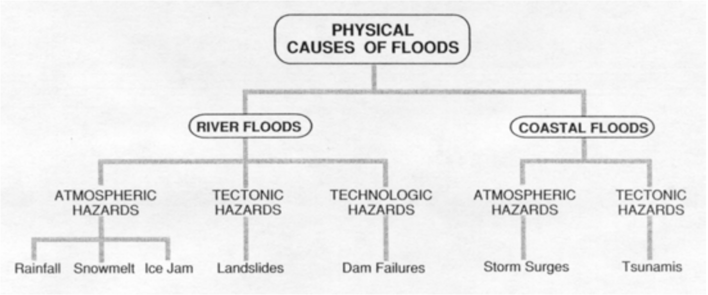
Subglacial releases occur when enough hydrostatic pressure occurs from accumulated water to “float” the glacial ice. Water then drains rapidly from the bottom of the lake.

Glacial outburst flooding is possible in many parts of the State. A USGS study of glacier dammed lakes and outburst floods in Alaska found 750 glacier dammed lakes in South-central and South-eastern Alaska and in adjacent Canada which drain into rivers entering Alaska. The Copper, Snow, and Kenai Rivers all have periodic outbursts (2 – 5 year frequency). Kennicott Glacier at McCarthy has an annual event. The Tazlina River has frequent events.

In May 1986, Hubbard glacier blocked the entrance to the Russell Fjord, turning it into a lake. The water level rose over 80 feet. Later that year, in October, the water overtopped the glacier and the lake drained to sea level in just a few hours. This was not a typical event, however, because it was caused by the sudden advance of a glacier.

In December 1961, Summit Lake in British Columbia, Canada drained into the Salmon River, severely damaging the dike that protects Hyder, Alaska. Summit Lake has actually been releasing on a fairly regular basis since the 1960s. During the events, the flow of the Salmon River usually triples. In the 1960s, flooding events appeared to happen every other year but they have become more of an annual event now.

Another fairly frequent event occurs on the Tulsequah Glacier near Juneau. In this case, Tulsequah Lake and Lake Nolake which is five miles further north, have both been involved. They release into the Tulsequah and Taku Rivers. For example, Tulsequah Lake caused an event on July 21-24, 2001 while Nolake was responsible for the event that occurred from August 8-10. These floods generally do not cause much damage except they usually inundate the airstrip near the mine on the Tulsequah River. The debris and sediment also cause changes to the river channel before and after a flood making both rivers difficult to navigate.



Physical causes of floods. From Smith 1996.

Other problems related to flooding are deposition and stream bank erosion. Deposition is the accumulation of soil, silt, and other particles on a river bottom or delta. For example, 4 foot diameter boulders were found after flood events in Lowell Creek in Seward and in Gold Creek in Juneau. Deposition leads to the destruction of fish habitat and presents a challenge for navigational purposes. Deposition also reduces channel capacity, resulting in increased flooding or bank erosion. Stream bank erosion involves the removal of material from the stream bank. When bank erosion is excessive, it becomes a concern because it results in loss of streamside vegetation, loss of fish habitat, and loss of land and property. For example, the lower Matanuska River has had excessive bank erosion that resulted in loss of homes and property. Many Alaskan villages have had bank erosion threats that led to constructing expensive bank protection structures. Erosion will be discussed in more detail in Annex K.

Existing Programs and Strategies

River Watch

River Watch is a program with ADES and NWS's River Forecast Center, created to warn communities of impending flooding and to issue flood warning/watch forecasts during spring break up. An important component of the program is educating communities about flood preparedness. Also important is data analysis and aerial reconnaissance of the Yukon and Kuskokwim Rivers. Reconnaissance information is communicated to State Emergency Coordination Center (SECC) and the affected communities. Community residents can use this valuable data and lead-time to prepare for the impending flooding by moving personal belongings to higher ground, storing fresh water, and other activities.


Elevation in action (photo courtesy of DCED)

National Flood Insurance Program (NFIP)

NFIP makes Federally backed flood insurance available in communities that have adopted and are enforcing floodplain management ordinances. At present, there are 27 participating communities in Alaska with 2,400 NFIP policies in place. Three communities participate in the Community Rating System (CRS) which adjusts the rates paid based on mitigation measures undertaken by the community. These communities are the Municipality of Anchorage, Kenai Peninsula Borough, and the City of Valdez. NFIP is administered locally by DCED.

Flood Mitigation Assistance (FMA) Program

FMA is managed by DCED. This is a federal (75/25% cost share) grant program to help states and NFIP communities with flood mitigation planning actions. The program can give planning grants, project grants or technical assistance funds.

Administrative Order 175

State of Alaska AO 175 calls for State agencies to consider flooding and erosion issues during the siting and construction phases of State owned and financed construction projects.

Flood Hazard Mitigation Successes

City of Seward

In 1988, the City of Seward adopted a Floodplain Management Ordinance that regulates the development of property located in a FEMA designated flood zone. Subdivisions within the City are required to document properties located within a designated flood zone. The floodplain limits must be identified on the plat noting that portions of the subdivision are located within a mapped FEMA Flood Zone, and that development must comply with Seward City Code Chapter 15.25 Floodplain Management.

Don Sheldon Hanger Building

The historic Don Sheldon Hanger Building in Talkeetna was elevated using Flood Mitigation Assistance Grant funding. It is now being turned into a community theater.

State of Alaska

The State Fire Marshal and Alaska Division of Energy have signed a Memorandum of Agreement requiring that uplift protection be provided when a fuel tank farm is in an area subject to flooding.

1995 South Central Fall Flood

In the aftermath of the 1995 South Central Fall Flood, the State received over $ 1 Million in HMGP funding. The funding was used on the following six projects:

- Replaced the Alaska Railroad bridge at Railroad Milepost 4.8, located on the West Fork of Salmon Creek, as the old bridge trapped debris, causing upstream flooding.
- Installed stream and precipitation gauges throughout the KPB in cooperation with USGS.
- Installed National Oceanic & Atmospheric Administration (NOAA) weather radio transmitters in the KPB.
- Purchased Mobile Emergency Sirens for KPB.
- Installed armor protection on the Lowe River Levee in Valdez.
- Helped fund the Seward Comprehensive Flood Mitigation Project consisting of:
  - Elevating controls of a downtown sewer lift station.
  - Increasing the flow capacity of the culvert at Fourth Avenue (the fish ditch).
  - Removing debris from the Resurrection River.

Short Term Goals

Long Term Goals

Medium Priority

1. ***The State should support elevation, flood proofing, buyout or relocation of structures repetitively or substantially damaged that are covered by flood insurance policies.***

   Raising, flood proofing or relocating components of villages or communities will dramatically reduce or eliminate future repetitive losses. According to 44 CFR 206.434, participation in relocation projects requires:
   - the removal or demolition of residences from vacated flood-prone areas to prevent re-occupation.
   - Ensuring vacated areas are prohibited from habitation for perpetuity.
   - Allowing only temporary structures in flood-prone areas to prevent future repetitive flood loss.

   Lead: DCED
   Support: ADES
   Timeline: on-going

2. ***Encourage the elevation, flood-proofing, buyout or relocation of structures repetitively or substantially damaged that are in areas ineligible for NFIP.***

   This would primarily involve unorganized communities in the unorganized borough but may include other entities lacking the ability to participate in

NFIP. These communities need special consideration as alternative funding sources and strategies are required.

Lead: DCED
Support: ADES, DOT&PF, DEED, DEC
Timeline: on-going

3. ***Encourage communities and boroughs that participate in the NFIP to apply for the CRS portion of the NFIP as a means of reducing risk.***
   Flood insurance premium rates are reduced, based on a community's CRS classification. Communities must document how additional mitigation activities are being implemented. This rewards the communities, through lower insurance rates, for their flood mitigation activities. Participation in the NWS StormReady Program can also help improve a community's CRS rating.

   Lead: DCED
   Support: ADES, DOT&PF, DEED, DEC
   Timeline: on-going

4. ***Encourage FEMA to create special considerations for Alaska building conditions and engineer certification to the CRS program.***

   Lead: DCED
   Support: ADES, DOT&PF, DEED, DEC
   Timeline: on-going

5. ***Encourage land use planning.***
   Communities should utilize available land use planning tools, including comprehensive land use plans, zoning, subdivision regulations, and storm water management regulations.

   Lead: DCED (as they guide community development activities)
   Support: ADES, DOT&PF, DEED, DEC
   Timeline: on-going

6. ***Develop a program to replace undersize culverts at important road crossings.***

   Lead: DOT&PF
   Support: ADF&G, DNR, DEC, USACE, USGS, EPA, NMFS
   Timeline: on-going

Low Priority

7. ***Encourage NFIP participation by all Boroughs and communities.***
   Support DCED's efforts to increase NFIP participation. Help them improve floodplain ordinance enforcement capability within the communities by providing education and training. This is essential because many smaller, flood-prone communities are unable to enforce floodplain ordinances for several reasons including lack of resources and training.

   Lead: DCED
   Support: ADES, DNR, DOT&PF&PF, DEC

Timeline: on-going

8. ***Encourage relocation of flood-prone villages.***
   Relocation of flood-prone communities will prevent repetitive losses and substantial damages. According to 44 CFR 206.434, participation in relocation projects requires:
   - Removal or demolition of residences from vacated flood-prone areas prevent re-occupation.
   - Ensuring vacated areas are prohibited from habitation in perpetuity.
   - No construction of permanent structures, only temporary structures open on all sides (e.g. picnic shelters, kiosks etc.), public restrooms and other approved facilities. This measure protects lives and prevents future, repetitive property flood loss.

   Lead: DCED
   Support: ADES, DOT&PF, DEED, DEC
   Timeline: on-going

9. ***Require flood damage prevention ordinances as a condition of State/Federal disaster assistance following a flood.***
   Lead: DCED
   Support: ADES, DOT&PF, DEED, DEC
   Timeline: on-going

10. ***Support the improvement of forecasting and warning systems.***
    This increases the time people have to evacuate safely. It will require the installation of additional stream and precipitation gauges as well as other equipment. It also requires a denser stream gauge network for additional information gathering. This could be done by supporting NWS's Advanced Hydrologic Prediction Services (AHPS) activities.
    Lead: NWS
    Support: ADES, USGS, DCED, DOT&PF
    Timeline: on-going

    USGS funding (50% match)may be available for additional stream gauges and to perform studies for proposed activities. Additionally, USGS can provide real-time gauge information through internet communication. The remaining 50% of the funding must be identified prior to USGS program involvement.

11. ***Improve and expand the mapping of flood-prone areas.***
    Continue mapping and documenting flood information around the State. Floodplain mapping in Alaska faces an inadequate volume of data and insufficient funding. In some areas, flood estimates are based on uncalibrated and overly conservative assumptions. These estimates depict unreasonably high discharge rates, e.g. Juneau's Mendenhall River valley shows large areas of inundation when in reality, the 100-year flood does not

overtop the bank since the river is very incised due to glacial (isostatic) rebound.

Lead: DCED
Support: ADES, USACE, UAF/GI, FEMA, DNR/DGGS, DEED, USGS
Timeline: on-going

12. ***Pursue legislation that requires communities to pay the 25% non-federal share of funding received as a result of a federally declared flood disaster unless the community has a floodplain ordinance in place.***
Consideration should be given to implementing higher regulatory standards for those communities that have floodplain management ordinances in place but still experience recurring events with repetitive losses. Model village floodplain and model damage prevention ordinances are included in Appendix 12. Special consideration should also be given to communities that do not have the ability to establish and enforce a floodplain ordinance.

Lead: Governor's Office, Alaska Legislature
Support: ADES, DCED, DOT&PF, DLAW
Timeline: 5 years

13. ***Minimize hazard risks associated with alluvial fans by identifying and maintaining debris corridors.***
These corridors would be designed to convey floodwaters and isolate sediment deposits. Develop strategies or incentives to preclude developing private lands within these corridors. Permitting issues will need to be addressed.

Lead: DOT&PF
Support: ADES, DCED, DNR, UAF/GI, DEC
Timeline: on-going

14. ***Research feasible opportunities for habitat preservation and stream enhancement.***
Encourage communities to adopt habitat protection corridors along streams and rivers and provide habitat tax credits for property owners who improve steam/river habitat or maintain a vegetative buffer adjacent to streams or rivers. This can help absorb floodwaters and minimize erosion.

Lead: ADF&G
Support: ADES, DEC, DNR, Local Communities
Timeline: on-going

15. ***Encourage the adoption of Model State Legislation for Floodplain Management contained in the 1990 Flood Mitigation Plan.***
The Model State Legislation for Floodplain Management proposed that the State develop and implement floodplain management standards and that local and tribal governments regulate hazard areas.

Lead: Governor's Office, Alaska Legislature
Support: ADES, DCED, Local Communities, AML

Timeline: on-going

16. ***Develop an interagency agreement on bank stabilization and debris clearance among resource and permitting agencies.***

An interagency agreement would help develop consensus about river bank and riverbed management. Among topics for coordination would be refining the permitting process and annual maintenance of drainage systems to help minimize flooding by reducing the potential for debris jams.

Lead: ADES or DCED
Support: ADES, DCED, DOT&PF, ADF&G, NMFS, USGS, USACE, DNR, DEC, EPA
Timeline: on-going

17. ***Research the feasibility of establishing a fund for structural or channel modifying mitigation projects.***

This fund would help pay for projects that are beyond a community's resources. Studies should be conducted prior to allocating funding to determine if this is the most appropriate solution.

Lead: ADF&G,
Support: ADES, USACE, DCED, DOT&PF, DEC, USACE, NMFS, EPA, USGS
Timeline: on-going

18. ***Encourage mitigation at the watershed level.***

Mitigation activities need to be coordinated throughout a river's watershed to ensure that actions taken in one area do not worsen the flooding in other areas. Other issues that should be addressed at this level include groundwater recharge, transport of nutrients, wetland habitat, etc.

Lead: DNR
Support: ADES, DCED, DOT&PF, DEC, ADF&G local jurisdictions
Timeline: on-going

19. ***Sanding of Ice Jams.***

Investigate the feasibility of re-instituting a program of sanding riverine ice to reduce the formation of ice jams.

Lead: ADES
Support: ADF&G, DOT&PF, NWS
Timeline: 2 years

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ANNEX C - WILDFIRE

Wildfires occur in every state in the country and Alaska is no exception. Each year, between 600 and 800 wildfires, mostly between March and October, burn across Alaska causing extensive damage.

Hazard Analysis/Characteristics

Wildfire is a generic term for any uncontrolled rural fire. The majority of wildfires are started as the result of human activity (including arson and debris burns) and lightning.

Wildfires can be divided into four main categories, which are described below.

Wildland Fire – These usually occur in forests or parkland. They primarily use natural vegetation for fuel.

Urban Interface Fire – These occur where the natural and human environments co-exist and use both as fuel sources. They are of most concern because they threaten lives and development.

Firestorms –They are usually the result of extreme weather conditions and will burn until conditions change or they run out of fuel. They are very hard to suppress and can endanger the lives of the fire fighters trying to suppress the blaze.

Prescribed fires and prescribed natural fires – These are fires that are intentionally set or left to burn because of their environmental benefits.

Wildfire. Image courtesy of FireWise

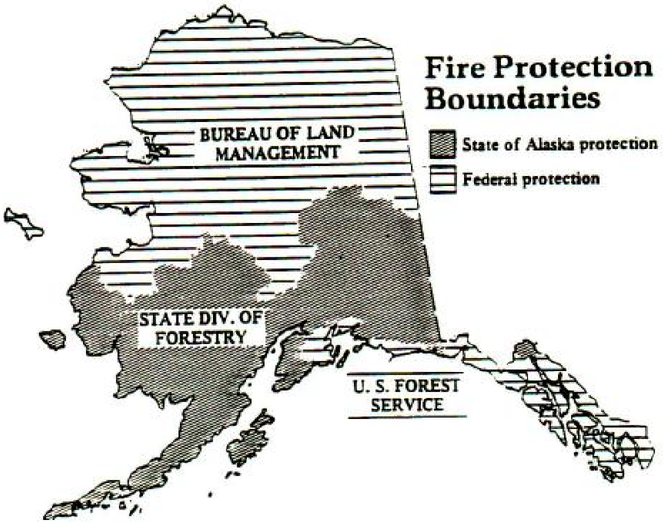
Fuel, weather, and topography influence wildfire behavior. Fuel determines how much energy the fire releases, how quickly the fire spreads and how much effort is needed to contain the fire. Weather is the most variable factor. Temperature and humidity also affect fire behavior. High temperatures and low humidity encourage fire activity while low temperatures and high humidity help retard fire behavior. Wind affects the speed and direction of a fire. Topography directs the movement of air, which can also affect fire behavior. When the terrain funnels air, like what happens in a canyon, it can lead to faster spreading. Fire can also travel up slope quicker than it goes down.

Wildfire risk is increasing in Alaska due to the spruce bark beetle infestation. The beetles lay eggs under the bark of a tree. When the larvae emerge, they eat the tree’s phloem, which is what the tree uses to transport nutrients from its roots to its needles. If enough phloem is lost, the tree will die. The dead trees dry out and become highly flammable.

Wildfire Management in Alaska

In Alaska, wildfire management is the responsibility of three agencies: Division of Forestry, Bureau of Land Management (BLM) (through the Alaska Fire Service (AFS)) and U.S. Forest Service (USFS).

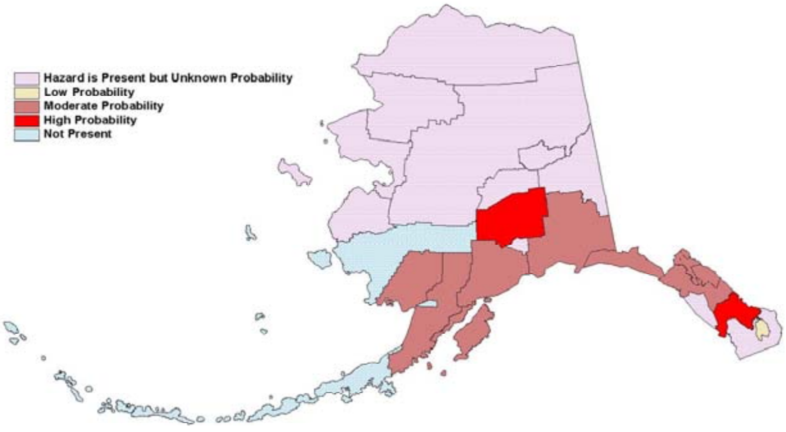
Each agency provides fire-fighting coverage for a portion of the State regardless of land ownership.
These agencies have cooperated to develop a state-wide interagency wildfire management plan.



Fire Protection Areas. Image courtesy of Division of Forestry.

1996 Miller's Reach Fire.

These three agencies and others, work together to fight fire. The 1996 Miller's Reach Fire was one of the worst wildfires in State history. It involved 37 fire departments, and over 100 different agencies and organizations. In addition, 1,800 fire-fighting and support personnel had responded within the first 48 hours. It took almost two weeks for the fire to be contained and during this time it burned 37,336 acres and destroyed 344 structures.



Areas with wildfire potential.

Existing Programs and Strategies

Alaska FireWise

The Alaska FireWise Program is designed to educate people about wildfire risks and mitigation opportunities. It is part of a national program that is operated in the State by the Alaska Wildfire Coordinating Group (AWCG).

Wildfire Hazard Mitigation Successes

1996 Miller's Reach Fire

Tok, AK. . This house survived a wildfire almost untouched due to the defensible space surrounding the structure and the use of metal siding and roofing. The only visible damage is to the plastic rain gutters, which softened due to the heat and fell to the ground. Image courtesy of Alaska Visitor Information Services.

As a result of the Miller's Reach fire, more than $1.5 million was available for wildfire mitigation measures. This money was used to fund 13 projects:

- Launch a television public awareness campaign to educate homeowners on creating defensible space to minimize impacts of urban interface fires.
- Create a wildfire fire prevention pilot project to educate the public via workshops and other one-on-one interaction.
- Conduct fuel management for the City of Houston, creating defensible space around several city owned critical facilities and clearing fallen black spruce (which is highly flammable) at the Little Susitna River Campground.
- Create a defensible space demonstration project around the Big Lake Public Safety Building.
- Create a defensible space demonstration project through a passive defensible space display. Construct a kiosk containing photos of fire damage and defensible space explanation displays.
- Install a dry hydrant system to reduce the response times to fires and greatly minimizes impact to watershed areas.
- Install the South Houston Water Supply to provide a dependable year round water supply at a central location to 3 fire department headquarters.
- Construct fire breaks within the Matanuska-Susitna Borough, which can be used as emergency evacuation routes.
- Improve access to Castle Park on Prator Lake by improving the turning radius to the fire tanker truck fill site, therefore decreasing response time.

Tok, AK. Defensible space surrounding this house helping make it FireWise. Image courtesy of Alaska Visitor Information Services.

- Improve the Homesteaders Community Center Building by installing steel siding, smoke alarms and carbon monoxide detectors and creating defensible space.
- Install a metal roof for the Mid-Valley Senior Center.
- Install an automated weather data collection system to provide accurate and timely reports of weather patterns, which allows firefighters to do their job more effectively.
- Create a Fire Mitigation Officer position to assist the Matanuska-Susitna Borough in fire education and awareness. This position evolved into the State fire mitigation officer position and is funded by a grant from AWCG.

Kenai Peninsula Borough Project Impact

Wildfire mitigation was one of the focuses of KPB's Project Impact program. Through this program they were able to host information sessions and distribute educational materials. A three-mile firebreak was constructed along Funny River Road to provide a safer evacuation route for local residents. Spruce bark beetle killed trees were removed, developing defensible space on 752 lots, which affected three businesses and almost 170 homes. They also established demonstration projects to show homeowners how to create defensible space.

Defensible space and located near a water source. Image courtesy of FireWise.

Short Term Goals

High Priority

1. ***Promote FireWise building design, siting, and materials for construction.***
   FireWise building design, siting, and materials for construction are a way to reduce a structure's vulnerability to wildfire. Examples of these are locating a structure near a water body, using dry hydrants, and ensuring there is easy access to the structure.
   Lead: State Fire Marshal
   Support: Legislature, DNR/DOF, BLM/AFS, USFS, local jurisdictions
   Timeline: 2 years

Medium Priority

2. ***Conduct outreach activities to encourage the use of Firewise landscaping techniques.***
   Lead: DNR/DOF
   Support: ADES, ADF&G, local jurisdictions
   Timeline: on-going

Low Priority

3. ***Encourage the creation of firebreaks.***
   Firebreaks greatly assist in controlling wildfires. They can be developed in the form of roads and natural water channels. The firebreaks would also provide transportation corridors.
   Lead: DNR/DOF
   Support: BLM/AFS, USFS, ADF&G, DOT&PF, DEC, local jurisdictions
   Timeline: 2 years

Long Term Goals

High Priority

1. ***Enforce compliance with fire regulation and requirements.***
   Lead: State Fire Marshall's Office
   Support: DPS, DLAW, local jurisdictions
   Timeline: on-going

Medium Priority

2. ***Encourage urban interface fire assessments.***
   The State should encourage local jurisdictions susceptible to wildfire to conduct an urban interface wildfire hazard assessment.
   Lead: DNR/DOF,
   Support: BLM/AFS, USFS, Local Communities
   Timeline: 10 years

3. ***Encourage the evaluation of emergency plans with respect to wildfire assessment.***
   All boroughs and communities should develop or evaluate emergency plans to ensure consistency with the wildfire assessments.
   Lead: ADES
   Support: SERC, LEPCs,
   Timeline: on-going

4. ***Encourage fuel management programs.***
   Identify, organize and monitor the various programs responsible for fuel management in the wildland /urban interface. The programs should include: salvage logging operations, hazardous tree felling, creating a central disposal site for contract tub grinding, chipping and open burning during approved burn periods, and providing chipper access to homeowners. The program should also create and coordinate opportunities for removal, transportation and marketing unwanted forest fuel.
   Lead: DNR/DOF
   Support: BLM/AFS, USFS, DEC, local jurisdictions
   Timeline: on-going

Low Priority

5. ***Encourage real-time availability and use of satellite data to evaluate fire potential.***
   Lead: DNR/DOF
   Support: BLM/AFS, USFS,
   Timeline: on-going

6. ***Encourage revision or development of building codes and requirements.***
   Building codes should be revised in wildfire prone areas. The codes should promote using nonflammable building material where appropriate, and adopting a residential fire code, a wildland/urban interface code, and support or promote Firewise communities.
   Lead: State Fire Marshal's Office
   Support: DCED, DNR, DEC, local jurisdictions
   Timeline: on-going

ANNEX D - SNOW AVALANCHES

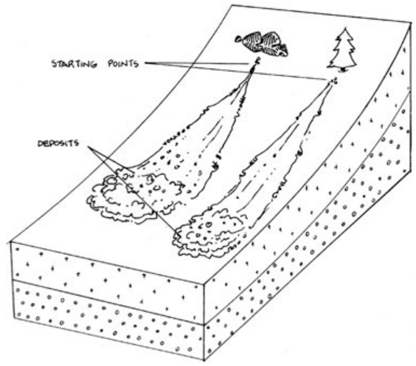
Alaska experiences many snow avalanches every year. The exact number is undeterminable as most occur in isolated areas and go unreported. Avalanches tend to occur repeatedly in localized areas and can sheer trees, cover communities and transportation routes, destroy buildings, and cause death. Alaska leads the nation in avalanche accidents per capita.

Hazard Analysis/Characterization

A snow avalanche is a swift, downhill-moving snow mass. The amount of damage is related to the type of avalanche, the composition and consistency of the material in the avalanche, the force and velocity of the flow, and the avalanche path.

Avalanche Types

There are two main types of snow avalanches; loose snow and slab. Other types that occur in Alaska include: cornice collapse, ice, and slush avalanches.



Loose snow avalanche. Image courtesy of the Canadian Avalanche Association.

Loose Snow Avalanches

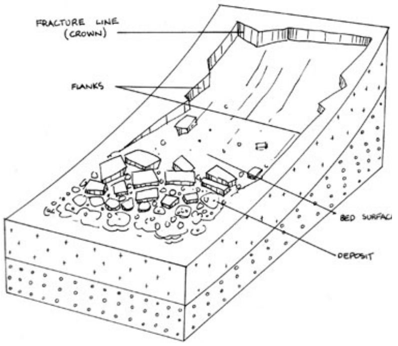
Loose snow avalanches, sometimes called point releases, generally occur when a small amount of uncohesive snow slips and causes more uncohesive snow to go downhill. They occur frequently as small local cold dry ‘sluffs’ which remove excess snow (involving just the upper layers of snow) keeping the slopes relatively safe. They can be large and destructive, though. For example, wet loose snow avalanches occur in the spring are very damaging. Loose snow avalanches can also trigger slab avalanches.

Loose snow avalanches typically occur on slopes above 35 degrees, leaving behind an inverted V-shaped scar. They are often caused by snow overloading (common during or just after a snowstorm), vibration, or warming (triggered by rain, rising temperatures or solar radiation).

Slab Avalanches

Slab avalanches are the most dangerous types of avalanches. They happen when a mass of cohesive snow breaks away and travels down the mountainside. As it moves, the slab breaks up into smaller cohesive blocks.

Slab avalanches usually require the presence of structural weaknesses within interfacing layers of the snowpack. The weakness exists when a relatively strong, cohesive snow layer overlies weaker snow or is not well bonded to the underlying layer. The weaknesses are caused by changes in the thickness and type of snow covers due to changes in temperature or multiple snowfalls. The interface fails for several reasons. It can fail naturally by earthquakes, blizzards, temperature changes or other seismic and climatic causes, or artificially by human activity. When a slab is released, it accelerates, gaining speed and mass as it travels downhill.



Slab avalanche. Image courtesy of the Canadian Avalanche Association.

The slab is defined by fractures. The uppermost fracture delineating the top line of the slab is termed the “crown surface”, the area above that is called the crown. The slab sides are called the flanks. The lower fracture indicating the base of the slab is called the “stauchwall”. The surface the slab slides over is called the “bed surface”. Slabs can range in thickness from less than an inch to 35 feet or greater.

Cornice Collapse

A cornice is an overhanging snow mass formed when by wind blowing snow over a ridge crest or the sides of a gulley. The cornice can break off and trigger bigger snow avalanches when it hits the wind-loaded snow pillow.

Ice Fall Avalanche

Ice fall avalanches result from the sudden fall of broken glacier ice down a steep slope. They can be unpredictable as it is hard to know when ice falls are imminent. Despite what some people think, they are unrelated to temperature, time of day or other typical avalanche factors.

Slush Avalanches

Slush avalanches occur mostly in high latitudes such as the Brooks Range. They have also occurred in the mountain areas of Alaska's Seward Peninsula and occasionally in the Talkeetna Mountains near Anchorage. Part of the reason they are more common in high-latitudes is because of the rapid onset of snowmelt in the spring. Slush avalanches can start on slopes from 5 to 40 degrees but usually not above 25 to 30. The snowpack is totally or partially water saturated. The release is associated with a bed surface that is nearly impermeable to water. It is also commonly associated with heavy rainfall or sudden intense snowmelt. Additionally, depth hoar is usually present at the base of the snow cover.

Slush avalanches can travel slowly or reach speeds over 40 miles per hour. Their depth is variable as well, ranging from 1 foot to over 50 feet deep.

Avalanche Terrain Factors

There are several factors that influence avalanche conditions, with the main ones being slope angle, slope aspect and terrain roughness. Other factors include slope shape, vegetation cover, elevation, and path history. Avalanches usually occur on slopes above 25 degrees. Below 25º, there usually is not enough stress on the snowpack to get it to slide. Above 60º, the snow tends to 'sluff' off and does not have the opportunity to accumulate. Avalanches can occur outside this slope angle range, but are not as common.

Slope aspect, also termed orientation, describes the direction a slope faces with respect to the wind and sun. Leeward slopes loaded by wind-transported snow are problematic because the wind-deposited snow increases the stress and enhances slab formation. Intense direct sunlight, primarily during the spring months, can weaken and lubricate the bonds between the snow grains, weakening the snowpack. Shaded slopes are potentially more unstable because the weak layers are held for a longer time in an unstable state.

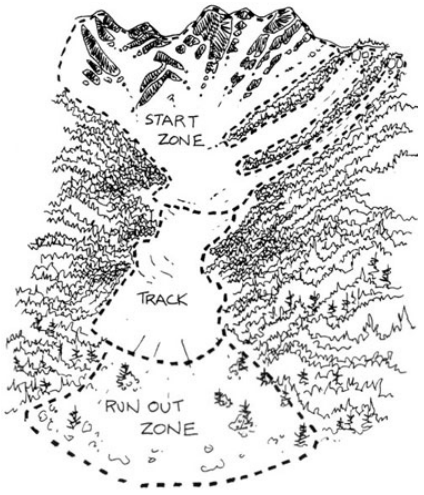
Terrain influences snow avalanches because trees, rocks, and general roughness act as anchors, holding snow in place. However, once an anchor is buried by snow, it loses its effectiveness. Anchors make avalanches less likely but do not prevent them unless the anchors are so close together that a person could not travel between them.

Avalanche Path

The local terrain features determine an avalanche's path. The path has three parts: the starting zone, the track, and the run-out zone.

The starting zone is where the snow breaks loose and starts sliding. It's generally near the top of a canyon, bowl, ridge, etc., with steep slopes between 25 and 50 degrees. Snowfall is usually significant in this area.

The track is the actual path followed by an avalanche. The track has milder slopes, between 15 and 30 degrees, but this is where the snow avalanche will reach maximum velocity and mass. Tracks can branch, creating successive runs that increase the threat, especially when multiple releases share a run-out zone.



Avalanche path. Image courtesy of the Canadian Avalanche Association.

The run-out zone is a flatter area (around 5 to 15 degrees) at the path base where the avalanche slows down, resulting in snow and debris deposition.

The impact pressure determines the amount of damage caused by a snow avalanche. The impact pressure is related to the density, volume (mass) and velocity of the avalanche.

Impact pressures		Potential Damage
KPa	Lbs/ft^2	
2-4	40-80	Break windows
3-6	60-100	Push in doors, damage walls, roofs
10	200	Severely damage wood frame structures
20-30	400-600	Destroy wood frame structures, break trees
50-100	1000-2000	Destroy mature forests
>300	>6000	Move large boulders

Avalanche impact pressures related to damage. Source Mears 1992.

History

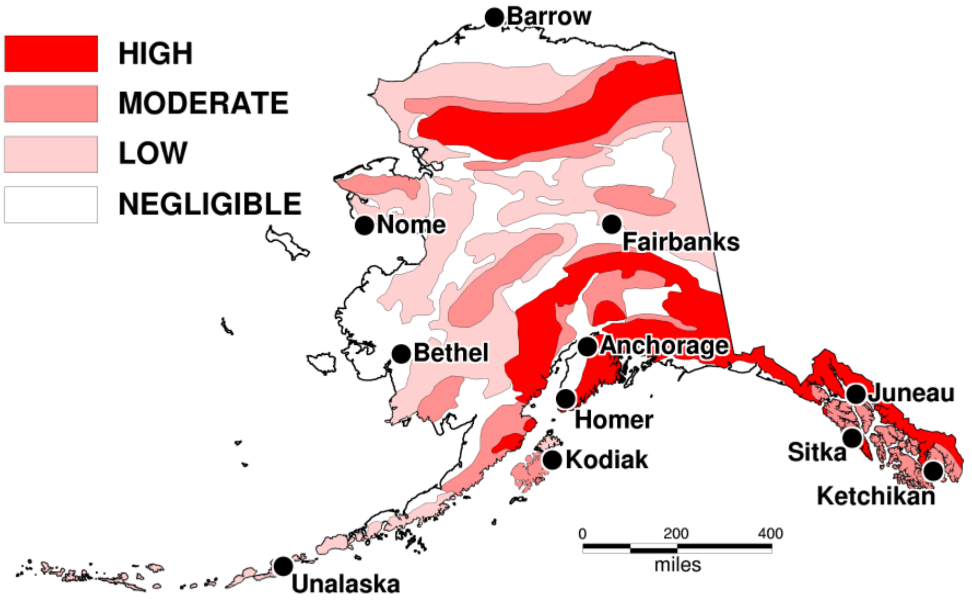
Alaska has a long history of snow avalanches. It has been estimated that there have been over 4,500 avalanche events in the past 200 years. The Palm Sunday avalanche, April 3, 1898 is considered to be the deadliest event of the Klondike gold rush. The Chilkoot Trail, near Skagway, experienced multiple slides that day, including three with fatalities. The first fatal slide killed three people. The second one killed the entire Chilkoot Railroad and Transportation Company crew who were trying to evacuate an avalanche prone area further up the trail. The third slide occurred in about the same location as the second killing approximately 70 people who were following the trail left by the construction crew. The exact death toll is unknown because of the transient nature of those involved and inefficiencies in the identification process.

Avalanche on the Chilkoot Trail. Image Courtesy of MSCUA, University of Washington Libraries, Hegg 203.

Late 1999 and early 2000 saw avalanches in Cordova, Valdez, Anchorage, Whittier, Cooper Landing, Moose Pass, Summit, Matanuska Susitna Valley, and Eklutna from the Central Gulf Coast Storm. The most damaging avalanche occurred in Cordova. The Cordova avalanche occurred near milepost 5.5 of the Copper River Highway and was approximately ½ mile wide resulting in one death, at least 10 damaged structures and about 1 million dollars in damage. Avalanches had struck in that spot before, including one in 1971.

Juneau is considered to be one of the largest urban avalanche hazard areas in the nation. In the past 100 years, more than 70 buildings within 10 miles of downtown Juneau have been hit, damaged or destroyed by avalanches. At present, Juneau has over 50 buildings, including one hotel, in avalanche zones; plus an expressway and a boat harbor.

Snow avalanches can occur in most of the State. All major highways, railroads, and several towns face an avalanche danger. This map shows the areas that face a snow avalanche threat.



SNOW AVALANCHE POTENTIAL IN ALASKA

Adapted from Hackett, S.W., and Santeford, H.S., 1980, Avalanche Zoning in Alaska: Journal of Glaciology, v. 26, no. 94, p. 385.

Existing Avalanche Programs and Strategies

Avalanche Awareness Month.

The Alaska State Legislature adopted and the Governor signed Senate Concurrent Resolution (SCR) 16 proclaiming the month of November as *Avalanche Awareness Month.* It urges further education on recognizing avalanche risks, response to avalanches, and using appropriate equipment in avalanche areas. It also urges schools, community groups and other public and private agencies to increase public awareness.

Alaska Mountain Safety Center (AMSC)

The AMSC is a non-profit organization specializing in avalanche hazard evaluation, mitigation, forecasting and education. The AMSC also operates the

Alaska Avalanche School which offers field-oriented classes on mountain safety training and avalanche hazard evaluation.

South-east Alaska Avalanche Center (SEAAC)

Established in 1995, the South-east Alaska Avalanche Center is an educational nonprofit corporation which provides snow avalanche safety education and information for the region from Yakutat to Ketchikan. The SEAAC conducts a variety of courses, workshops, and for the general public, specific projects, and emergencies. The programs are particularly strong in the areas of urban, highway, snowmobile, snowboard, and heli-ski avalanche safety.

Avalanche Hazard Mitigation Successes

Home Buyout/Relocation Project in Valdez, and Cordova, AK

HMGP funding was used to buyout or relocate several homes in the cities of Valdez and Cordova, AK. The project removed individuals from the high hazard avalanche zone.

Alaska Railroad Avalanche Program

The Alaska Railroad Avalanche Program is a three-year program to improve existing avalanche risk management tools and create new control systems. The program involves improving data acquisition and management, improving explosive delivery support, upgrading snow clearing and explosives-control equipment and the constructing a central avalanche office and secure gun storage facility in Girdwood.

Chugach Electric

In the winter, before Chugach Electric sends any of its maintenance crews to do work in a known avalanche area, it requires an avalanche assessment to be done first to ensure worker safety.

Avalanche Ordinances

Juneau, AK

The City and Borough of Juneau adopted an avalanche ordinance in 1987, which restricted development in avalanche areas to single family houses that are built to withstand avalanche impact loads. Any other development requires a conditional use permit.

Cordova and Valdez, AK

The Cities of Cordova and Valdez have adopted avalanche district ordinances following the loss of life and destruction of property during the Central Gulf Coast Storm event, December 1999 through February 2000.

Short Term Goals

Medium Priority

1. ***Encourage re-establishment of the Alaska Avalanche Warning Center.***
   The Alaska Avalanche Warning Center would be able to provide information about avalanche risks, avalanche forecasts, catalog avalanche paths and history, assist in identifying hazardous areas and mitigation opportunities as well as conduct public education. The center was considered one of the best in the country before its disbandment. The center is required by Alaska Statute (AS) 18.76.010.
   Lead: Governor's Office, Legislature
   Support: ADES, DPS, DOT&PF, DNR
   Timeline: 2 years

Long Term Goals

High Priority

1. ***Encourage the relocation of existing development from known avalanche areas.***
   It is not a question of *if* an avalanche will strike these areas. It is only a question of *when* and whether people will be injured or killed and how much damage will result. There needs to be a concentrated effort to relocate development from known avalanche areas.
   Lead: DPS
   Support: ADES, DCED, DOT&PF, DNR
   Timeline: on-going

Medium Priority

2. ***Promote avalanche education.***
   Education is the best way to reduce fatalities, injuries, and property damage from avalanches. Residents, recreational enthusiasts, elected officials, and others need to be aware of the dangers associated with avalanches and how to avoid them. A community avalanche warning sign program would greatly enhance an active outreach program. (See Goal 6 below)
   Lead: DPS,
   Support: ADES, DCED, DNR
   Timeline: on-going

3. ***Encourage artificial avalanche release and snow management.***
   Promote the use of artificial release and avalanche control measures to include: pre-positioning avalanche release equipment and deflection structures in existing developed avalanche prone areas.
   Lead: DPS
   Support: ADES, DOT&PF, DNR

Timeline: on-going

4. ***Encourage avalanche hazard mapping.***
The State should work with FEMA and other agencies to prepare an avalanche/landslide inventory with maps depicting avalanche hazard areas. This information will guide prioritization of communities for further study and land management activities. Combine the above information with existing information into a database to be easily available to all users.
Lead: FEMA, USGS, DNR/DGGS
Support: ADES
Timeline: on-going

5. ***Encourage communities to develop avalanche overlay zones.***
Development of these zones would provide several benefits, for example: communities could require building to a more stringent standard to ensure structures would be able to withstand potential avalanches or to allow recreational or building use during non-avalanche season.
Lead: DCED
Support: ADES
Timeline: on-going

6. ***Encourage avalanche safety training for snowmachiners.***
Snowmachiners frequently trigger avalanches with deadly consequences. Training programs to teach people how to identify high-risk conditions and what to do if they are caught in an avalanche could save numerous lives annually. This could be done through a variety of mechanisms including voluntary avalanche safety courses and encourage manufacturers and vendors to distribute avalanche awareness videos with their products.
Lead: ADES
Support:
Timeline: 5 years

Low Priority

7. ***Establish a Community Avalanche Warning Sign program.***
This voluntary program would assist communities in identifying their avalanche potential, planning for the hazard and conducting outreach activities to educate the public about avalanche hazards and what they can do to protect themselves. Snow Avalanche warning signs would be developed by ADES to ensure consistency throughout the State. Sign placement guidelines will be developed.
Lead: ADES
Support:
Timeline: 10 years

ANNEX E - VOLCANOES

Hazard Analysis/Characterization

Alaska is home to 41 historically active volcanoes stretching across the entire southern portion of the State from the Wrangell Mountains to the far Western Aleutians. An average of 1-2 eruptions per year occur in Alaska. In 1912, the largest eruption of the 20th century occurred at Novarupta and Mount Katmai, located in what is now Katmai National Park and Preserve on the Alaska Peninsula.

A volcano is a vent at the Earth's surface through which magma (molten rock) and associated gases erupt, and also the landform built by effusive and explosive eruptions.

Volcanoes display a wide variety of shapes, sizes, and behavior, however they are commonly classified among three main types: cinder cone, composite , and shield.

Types of Volcanoes

Cinder cones

A cinder cone is the simplest type of volcano. They are built from particles and blobs of congealed lava ejected from a single vent. As the lava is blown into the air, it breaks into small fragments that solidify and fall as cinders and bombs around the vent to form a circular or oval cone. Most cinder cones have a bowl-shaped crater or craters at the summit and are rarely more than a thousand feet above their surroundings. Cinder cones may form as flank vents on the sides of larger composite or shield volcanoes. They often occur in clusters and produce lava flows. Cinder cones are common in western North America as well as other volcanic terrain. Some Alaskan cinder cones are found in the following locations:

- St. Michael (in western Alaska along the southern Norton Sound shoreline)
- Ingakslugwat Hills (in western Alaska's Yukon Delta region near the village of St. Mary's)
- St. Paul Island (one of the Pribilof Islands in the Bering Sea)
- Table Top-Wide Bay (a satellite vent of Makushin Volcano near Unalaska in the Aleutian Islands)

Composite volcanoes


Redoubt Volcano is one of the active volcanoes of the Cook Inlet region. Steam and volcanic gas rise above the summit crater of the volcano following the 1989 to 1990 eruptions. Iliamna Volcano is on the skyline at left. Photograph courtesy of C. Neal, USGS.

Composite volcanoes, sometimes called stratovolcanoes, are typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, blocks, and bombs and may rise as much as 8,000 feet above their bases. Some of the most conspicuous and beautiful mountains in the world are composite volcanoes, including Mount Shasta in California, Mount Hood in Oregon, Mount St. Helens and Mount Rainier in Washington, Mt Fuji in Japan, Mt. Vesuvius in Italy, and Shishaldin in Alaska.

Composite volcanoes have a principal conduit system through which magma from a reservoir deep in the Earth's crust rises to the surface repeatedly to cause eruptions. The volcano is built up by the accumulation of material erupted through the conduit and increases in size as lava, ash, etc., are added to its slopes. Stratovolcanoes tend to erupt explosively because of the silica-based nature of magmas associated with these volcanoes. Some stratovolcanoes produce enormous explosive eruptions that destroy a large part of the volcano itself, leaving a wide, roughly circular depression called a caldera. Eruptions that produce calderas are among the most explosive and largest eruptions known.


Mount Wrangell, the shield volcano on the right skyline, is the only volcano in the Wrangell Mountains to have had documented historical activity consisting of several minor eruptions in the early 1900's. Image courtesy B. Cella, U.S. National Park Service.

Most Alaskan volcanoes are stratovolcanoes, including Redoubt, Spurr and Iliamna.

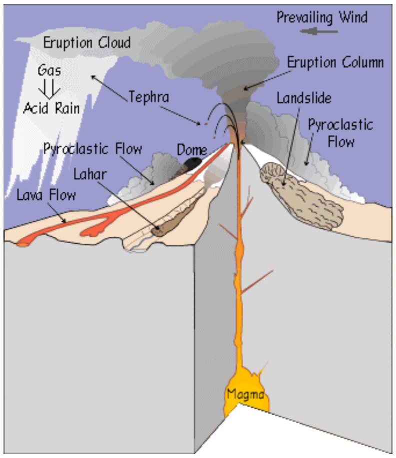
Shield volcanoes

Shield volcanoes are formed by lava flowing in all directions from a central summit vent, or group of vents, or rift zones building a broad, gently sloping cone with a dome shape. They are built up slowly by the accretion of thousands of highly fluid lava flows that spread widely over great distances, and then cool in thin layers. Some of the largest volcanoes in the world are shield volcanoes including Mauna Loa in Hawaii. In Alaska, Wrangell, Yunaska, and Sanford are examples of shield volcanoes.

Volcanoes are also categorized according to the age of their eruptive activity. Active volcanoes are those that are currently erupting or showing signs of unrest, such as unusual earthquake activity or significant new gas emissions. Dormant volcanoes are those that are not currently active, but could become restless or erupt again. Extinct volcanoes are those that are considered unlikely to erupt again. This can be difficult to determine as a volcano could go tens of thousands of years, or longer, between eruptions. There are over 80 volcanic centers in the State but only 41 are considered active.

Volcanic Hazards

Volcanic eruptions create the following hazards:



Volcanic hazards.

Lava Flows

Lava flows are streams of molten rock that flow from a volcano. The distance traveled by a flow is dependant on several variables including viscosity, volume, slope steepness and obstructions in the flow path. A typical flow is between 6 and 30 miles.

Lava flows cause damage by burning, crushing, or burying everything they contact. They can also melt ice and snow, causing flooding or move into a wooded area triggering wildfires.

A pyroclastic flow sweeping down the north flank of 1,282-m (4,206 ft)-high Augustine Volcano. Image courtesy M.E. Yount, USGS.

Pyroclastic Flows

Pyroclastic flows are high-density mixtures of hot gasses and dry rock that are usually released explosively from a volcano. They are hazardous because of their rapid movement and high temperatures. They travel at speeds of 30 to +90 miles per hour and can destroy or sweep away objects due to the impact of debris or associated high winds, or cause burns.

Pyroclastic Surges

Pyroclastic surges are turbulent low-density clouds of rock debris, air, and other gases that move over the ground at speeds similar to pyroclastic flows. There are two types: hot surges consisting of dry materials over 212ºF and cold surges consisting of cooler rock debris and water or steam.

Aerial view, Novarupta Dome, Katmai Vicinity, Alaska. Image courtesy of Gene Iwatsubo, USGS.

Lava Domes

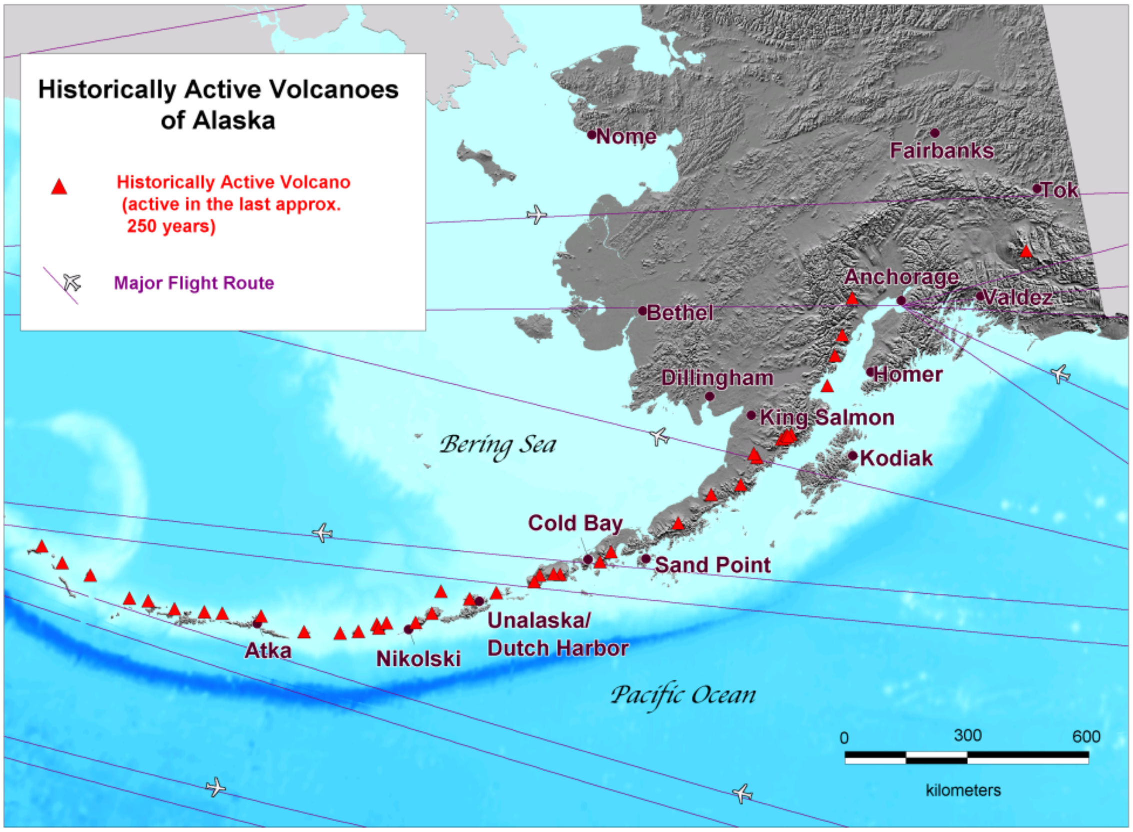
Volcanic or lava domes are formed when viscous lava erupts slowly from a vent. This causes it to solidify near the vent forming the dome instead of flowing away from the vent. A dome grows largely by expansion from within. As it grows its outer surface cools and hardens, then shatters, spilling loose fragments down its sides. Volcanic domes commonly occur within the craters or on the flanks of large composite volcanoes. Novarupta Dome was formed during the 1912 eruption of Katmai Volcano, Alaska, measures 800 feet across and 200 feet high.

Volcanic Ash and Bombs

Cleaning up ash from the 1992 Mt. Spurr eruption. Photographer Bill Roth, courtesy of Anchorage Daily News (file 920917).

Clean-up ater 1992 Mt. Spurr eruption. Photographer Erik Hill, courtesy of Anchorage Daily News (file 920819).

Volcanic ash, also called tephra, is fine fragments of solidified lava ejected into the air by an explosion or rising hot air. The fragments range in size, with the larger falling nearer the source. Ash is a problem near the source because of its high temperatures (may cause fires), burial (the weight can cause structural collapses), and impact of falling fragments. Further away, the primary hazard to humans are decreased visibility and inhaling the fine ash. Ash will also interfere with the operation of mechanical equipment including aircraft. In Alaska, this is a major problem as many of the major flight routes are near historically active volcanoes.



Alaska's active volcanoes and a schematic depiction of selected major air routes across Alaska.

Volcanic Gases

Volcanic gases consist mostly of steam, carbon dioxide, and sulfur and chlorine compounds, but may include other substances. The gases can damage eyes, respiratory systems and cause suffocation. They can also be very corrosive.

Lateral Blasts

Debris avalanche deposits form hummocky topography. Image courtesy of USGS.

Lateral blasts are inflated mixtures of gases, ash, and hot rock debris. They may be hundreds of feet thick and travel at speeds up to 370 miles per hour. They cause damage through abrasion, impact, burial, and heat. They may also trigger pyroclastic flows or surges.

Debris Avalanches

Debris avalanches are is a sudden downward movement of unconsolidated material (mostly rock and soil). They occur without warning and travel quickly. Debris avalanches can extend for miles and cover up to 300 square miles, causing damage from impact or burial.

Debris Flows

Lahars from the 1989 to 1990 eruptions of Redoubt Volcano inundated this structure near the mouth of Drift River. Photograph courtesy of C. Gardner, USGS.

Debris flows, also known as lahars, are rapidly flowing mixtures of rock debris and water that originate on the slopes of a volcano. They form in a variety of ways, primarily by the rapid melting of snow and ice by pyroclastic flows, intense rainfall on loose volcanic rock deposits, breakout of a lake dammed by volcanic deposits, and as a consequence of debris avalanches. They generally have the consistency of wet cement and have the ability to destroy or bury anything in their path.

Historic Volcanic Activity

Novarupta ash fall compared to that from recent Alaskan eruptions. Image courtesy of USGS.

The largest volcanic eruption of the 20th century occurred at Novarupta Volcano in June 1912. It started by generating an ash cloud that grew to thousands of miles wide during the three-day event. Within four hours of the eruption, ash started falling on Kodiak, darkening the city. It became hard to breathe because of the ash and sulfur dioxide gas. The water became undrinkable and unable to support aquatic life. Roofs collapsed under the weight of the ash. Some buildings were destroyed by ash avalanches while others burned after being struck by lightning from the ash cloud. Similar conditions could be found all over the area. Some villages ended up being abandoned, including Katmai and Savonoski villages. The ash and acid rain also negatively affected animal and plant life. Large animals were blinded and many starved because their food was eliminated.

The ash fall from this eruption was significantly greater than the recent eruptions of Redoubt, Spurr and Augustine Volcanoes. Fourteen earthquakes of magnitude 6 to 7 were associated with this event. At least 10 Alaskan volcanoes are capable of this type of event.

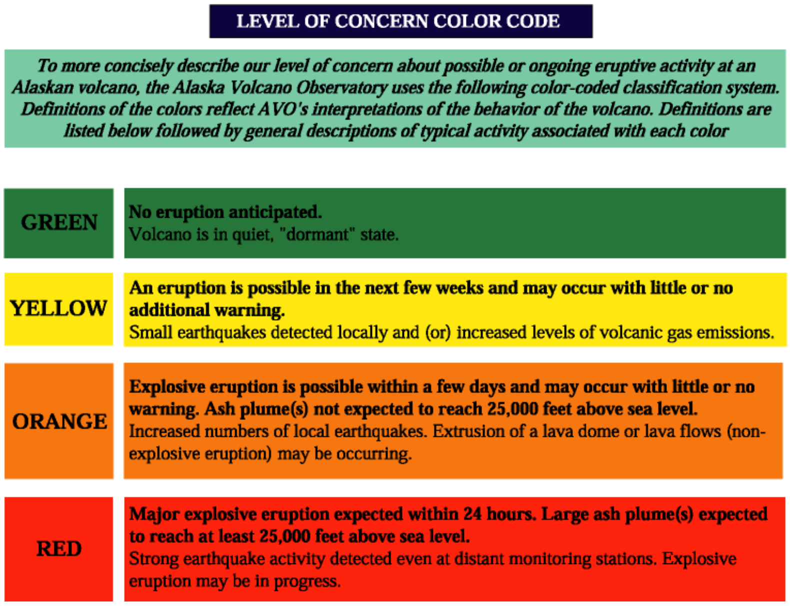
A more recent eruption occurred on Augustine Volcano in 1986. An ash plume disrupted air traffic and deposited ash in Anchorage. A dome formed in the crater, and caused some to fear it would subsequently collapse and trigger a tsunami along the east shore of Cook Inlet, as happened in 1883.

Redoubt Volcano erupted in 1989-1990 and debris flows caused temporary closing of the Drift River Oil Terminal. KLM's 747 jet aircraft, flight 867, temporarily lost power in all four engines when it entered the volcanic ash plume. It would have crashed into the mountains had they not be able to restart their engines about 4,000 feet (1,219 meters) above ground.

Hazard Identification and Assessment

The responsibility for hazard identification and assessment for the active volcanic centers of Alaska falls to the Alaska Volcano Observatory and its constituent organizations (USGS, DNR/DGGS, and UAF/GI). AVO is in the process of publishing individual hazard assessments for each active volcano in the State. As of 2002, published or in-press hazard assessments cover the following volcanoes: Hayes, Spurr, Redoubt, Iliamna, Augustine, the Katmai Group, Aniakchak, Shishaldin, Akutan, and Makushin. Additional reports for Shishaldin, Kanaga, Great Sitkin, Westdahl, Dutton, Okmok are expected within the next year or two. Each report contains a description of the eruptive history of the volcano, the hazards they pose and the likely effects of future eruptions on populations, facilities, and ecosystems.

AVO has the primary responsibility to monitor all of Alaska's potentially active volcanoes and to issue timely warnings of activity to authorities and the public. During episodes of volcanic unrest or eruption, AVO is also the agency responsible for characterizing the immediate hazards and describing likely scenarios for an evolving volcanic crisis. AVO uses a 4-color Level of Concern Color Code to succinctly portray its interpretations of the state of activity and likely course of unrest at a given volcano.



LEVEL OF CONCERN COLOR CODE

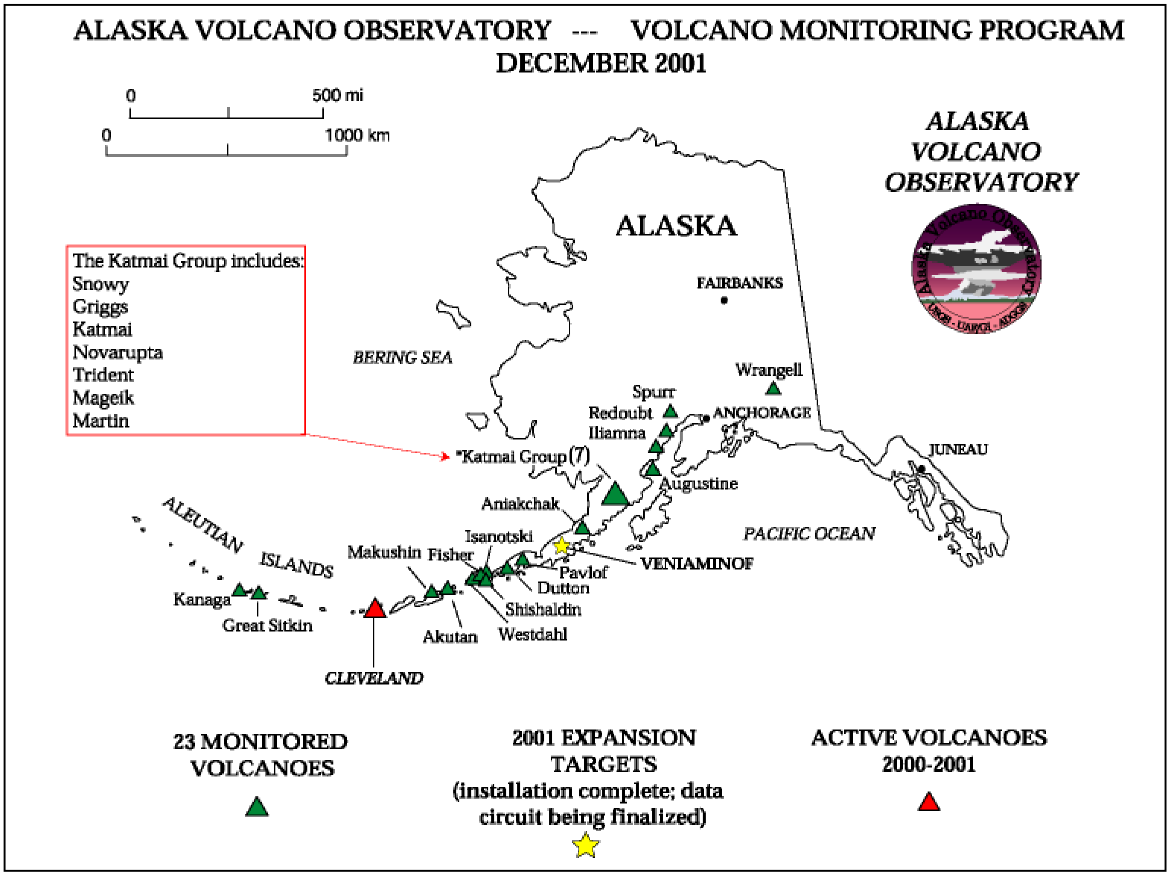
To more concisely describe our level of concern about possible or ongoing eruptive activity at an Alaskan volcano, the Alaska Volcano Observatory uses the following color-coded classification system. Definitions of the colors reflect AVO's interpretations of the behavior of the volcano. Definitions are listed below followed by general descriptions of typical activity associated with each color

GREEN	**No eruption anticipated.** Volcano is in quiet, "dormant" state.
YELLOW	**An eruption is possible in the next few weeks and may occur with little or no additional warning.** Small earthquakes detected locally and (or) increased levels of volcanic gas emissions.
ORANGE	**Explosive eruption is possible within a few days and may occur with little or no warning. Ash plume(s) not expected to reach 25,000 feet above sea level.** Increased numbers of local earthquakes. Extrusion of a lava dome or lava flows (non-explosive eruption) may be occurring.
RED	**Major explosive eruption expected within 24 hours. Large ash plume(s) expected to reach at least 25,000 feet above sea level.** Strong earthquake activity detected even at distant monitoring stations. Explosive eruption may be in progress.

Basic information about vulnerable assets and populations are identified in these assessments. However, DCED and other State agencies could work with AVO map data to integrate quantitative, current information regarding communities and other at-risk elements to improve our analysis of vulnerability.

One of the most vulnerable sectors is the aviation industry that is at risk from the effects of airborne volcanic ash. The significant trans-Pacific and intrastate air traffic in Alaska, directly over or near 41 potentially active volcanoes, has necessitated development of a strong communication and warning link between AVO, other government agencies with responsibility in aviation management, and the airline and air cargo industry.

Existing Programs and Strategies



Alaska Volcano Observatory

The Alaska Volcano Observatory, a joint program of USGS, DNR/DGGS, and UAF/GI, is the State's principal agency with responsibility to assess, monitor, and issue early warning of volcanic activity and hazards in Alaska. AVO was formed in 1988, and uses federal, State, and university resources to monitor and study Alaska's hazardous volcanoes, to predict and record eruptive activity, and to mitigate volcanic hazards to life and property.

As of January 2002, AVO maintains seismic monitoring networks on 23 of Alaska's 41 active volcanoes. Data from these networks are recorded 24 hours per day and examined for precursory signs of eruptive activity. Several times a day, AVO also examines satellite images of Alaskan, Kamchatkan, and northern

Kuril volcanoes for signs of eruptive activity or possible precursory heating of the ground. These two primary data streams are used routinely to assess the likelihood and character of volcanic activity. Additional monitoring methods such as space-based satellite radar interferometry, are under development.

AVO regularly disseminates information about the status of volcanoes in Alaska and neighboring Kamchatka. Each week, AVO distributes a written status report to more than 100 recipients at federal, State, local agencies, the media and the public via Internet, fax, and recorded message line. During volcanic crises, or if precursors to eruptive activity are noted, AVO follows a rigid emergency call-down protocol, as well as using Internet and fax outlets to notify authorities, the media, the aviation industry, and the public.

Volcano Hazard Mitigation Successes

Alaska Volcano Observatory

Since the formalization of AVO in 1988, AVO scientists have responded to numerous volcanic crises in Alaska, providing early warning for explosive eruptive events at Redoubt (1989-90) and Mt. Spurr (1992) and assisting in successful crisis management during the 1996 intrusive event and earthquake swarm on the island of Akutan. Advanced warning of eruptions and accurate analysis of data from seismic monitoring networks and satellite platforms has prevented needless evacuations and economic impacts to the aviation industry. Finally, AVO has worked closely with Russian scientific colleagues in Kamchatka to monitor, track, and disseminate warnings of eruptions and ash clouds from volcanoes in the Russian Far East that may also threaten Alaskan air space.

Interagency Plan for Volcanic Ash Episodes

In December, 1989, the aforementioned KLM flight 867 that encountered an ash cloud from Redoubt Volcano, highlighted a serious weakness in the aviation and volcanic ash warning system. Following this incident, a consortia of Federal, State, and private sector parties worked to develop an improved early warning system and ash avoidance protocols for the heavily traveled North Pacific airways. In Alaska, this effort resulted in the growth and increased capacity of the Alaska Volcano Observatory and formal adoption of a Alaska Interagency Plan for Volcanic Ash Episodes (signatories include USGS, NOAA/NWS, Federal Aviation Administration (FAA), Department of Defense (DOD) /United States Air Force (USAF), and ADES. In future versions, the Unites State Coast Guard (USCG) will also participate. The plan documents specific responsibilities and protocols for each agency before, during, and after a volcanic event. Since the 1989 KLM ash encounter, no serious ash-aircraft incidents have been reported in Alaska, despite dozens of additional eruptions.

This multi-agency early warning and response program is a model endorsed by the International Civil Aviation Organization and emulated in many volcanically active regions around the world.

Short Term Goals

Medium Priority

1. ***Ensure all Alaskan communities at risk from volcanic eruptions are aware of the hazard and what can be done to mitigate risk.***
   Special emphasis is needed in remote communities on the Alaska Peninsula and in the Aleutian Islands. Each community should include volcanic hazards in their EOP. AVO should work with ADES to ensure appropriate materials and information are available to support this effort. Some outreach is already conducted during AVO field work in communities near volcanoes. AVO can contribute to outreach efforts by providing personnel for presentations and materials for (traveling) exhibits and programs. AVO can also distribute free USGS literature on volcano hazards.
   Lead: ADES, AVO
   Support: USGS, DNR/DGGS, UAF/GI, ARC, DEC, Alaska Public Lands Information Center, local jurisdictions, Native corporations
   Timeline: on-going

2. ***Conduct specific outreach to the Alaskan aviation community regarding the hazards posed by Alaskan and Russian volcanoes.***
   AVO staff already speak and meet frequently with cooperating agency employees, representatives, and gatherings of Alaska's aviation community to share information regarding volcano hazards. AVO publishes a 2-page section on volcano hazards in the Alaska Supplement, an FAA publication that is widely used by pilots using Alaska airspace. In the next year, AVO will be revising a freely available fact sheet on Volcano Hazards and Aviation Safety and producing a similar document describing the Russian program to mitigate this risk from Kamchatkan volcanoes.
   Lead: AVO
   Support: ADES, FAA, NWS, Alaska Air Carriers Association
   Timeline: on-going

3. ***Ensure volcanic hazards are addressed in the on-going revision of the State EOP.***
   Incorporate results of AVO's volcano hazard assessment as they become available.
   Lead: ADES
   Support: AVO, USGS, DNR/DGGS, UAF/GI
   Timeline: as needed and requested from the State during plan revisions

4. ***Revise the Alaska Interagency Plan for Volcanic Ash Episodes to include the U.S. Coast Guard and make this plan available publicly online.***
   By agreement, this plan is updated every other year. The 2001 plan is in the final stages of signature acquisition. Including the USCG will foster improved

cooperation and information sharing with a valuable partner in public safety. Widely disseminating the plan will increase awareness of volcano hazards, mitigation planning, and advances in volcano risk management.

Lead: AVO
Support: NWS, ADES, USAF, FAA
Timeline: on-going; next plan due in 2003

Long Term Goals

High Priority

1. ***Compile an integrated volcano hazard and risk assessment for the Cook Inlet and surrounding areas.***

   Lead: USGS
   Support: DNR/DGGS, UAF/GI
   Timeline: on-going as part of individual volcano hazard assessments; further data collection and integration of hazard analysis to be done

Medium Priority

2. ***Publish volcano hazard assessments for all of Alaska's active volcanoes.***

   As of 2002, first generation hazard assessments for nearly half of the 41 active volcanoes in Alaska are complete or in process. As resources allow, AVO will continue to investigate, assess, and publicize the geologic history and hazards posed by the remaining active volcanoes.

   Lead: AVO
   Support: USFWS, DOD
   Timeline: on-going

3. ***Expand real time seismic monitoring to high-priority western Aleutian volcanoes.***

   Lead: AVO
   Support: USFWS, DOD
   Timeline: in progress; first installations scheduled for 2003

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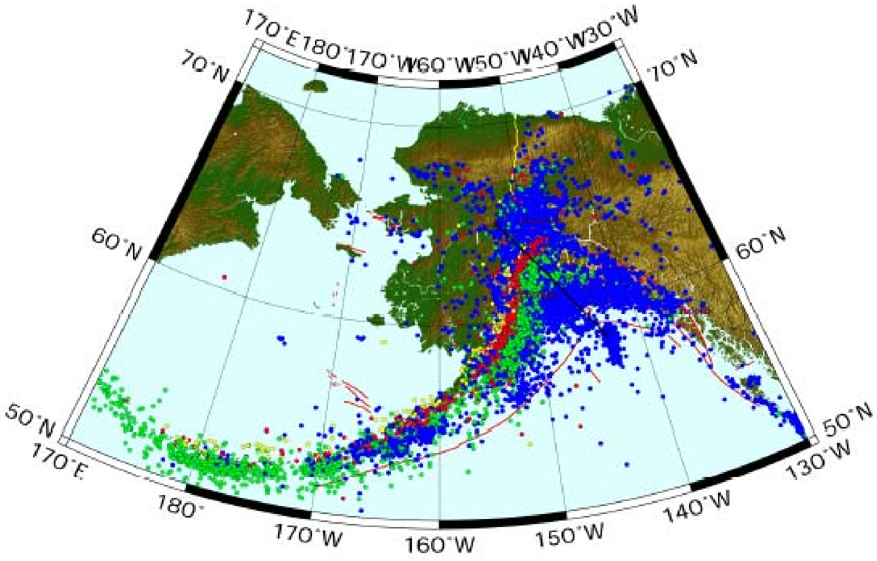
ANNEX F - EARTHQUAKES



Earthquakes in Alaska 1988-1999.

Approximately 11% of the world's earthquakes occur in Alaska, making it one of the most seismically active regions in the world. Three of the ten largest quakes in the world since 1900 have occurred here. Earthquakes of magnitude 7 or greater occur in Alaska on average of about once a year; magnitude 8 earthquakes average about 14 years between events.

Hazard Analysis/Characterization

Most large earthquakes are caused by a sudden release of accumulated stresses between crustal plates that move against each other on the earth's surface. Some earthquakes occur along faults that lie within these plates. The dangers associated with earthquakes include ground shaking, surface faulting, ground failures, snow avalanches, seiches and tsunamis. The extent of damage is dependent on the magnitude of the quake, the geology of the area, distance from the epicenter and structure design and construction. A main goal of an earthquake hazard reduction program is to preserve lives through economical rehabilitation of existing structures and constructing safe new structures.

Ground shaking is due to the three main classes of seismic waves generated by an earthquake. P (primary) waves are the first ones felt, often as a sharp jolt. S (shear or secondary) waves are slower and usually have a side to side movement. They can be very damaging because structures are more vulnerable to horizontal than vertical motion. Surface waves are the slowest, although they can carry the bulk of the energy in a large earthquake. The damage to buildings depends on how the specific characteristics of each incoming wave interact with the buildings' height, shape, and construction materials.

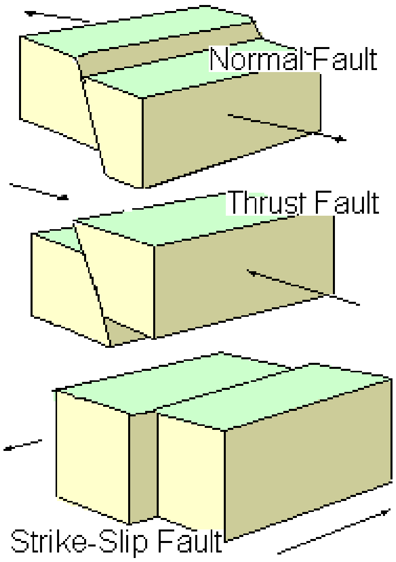
Richter Scale
On the Richter scale, magnitude is expressed in whole numbers and decimals. A 5.0 earthquake is a moderate event, 6.0 characterizes a strong event, 7.0 is a major earthquake and a great earthquake exceeds 8.0. The scale is logarithmic and open-ended.

Earthquakes are usually measured in terms of their magnitude and intensity. Magnitude is related to the amount of energy released during an event while intensity refers to the effects on people and structures at a particular place. Earthquake magnitude is usually reported according to the standard Richter scale for small to moderate earthquakes. Large earthquakes, like those that commonly occur in Alaska are reported according to the moment-magnitude scale because the standard Richter scale does not adequately represent the energy released by these large events.

Intensity is usually reported using the Modified Mercalli Intensity Scale. This scale has 12 categories ranging from not felt to total destruction. Different values can be recorded at different locations for the same event depending on local circumstances such as distance from the epicenter or building construction practices. Soil conditions are a major factor in determining an earthquake's intensity, as unconsolidated fill areas will have more damage than an area with shallow bedrock.

Surface faulting is the differential movement of the two sides of a fault. There are three general types of faulting. Strike-slip faults are where each side of the fault moves horizontally. Normal faults have one side dropping down relative to the other side. Thrust (reverse) faults have one side moving up and over the fault relative to the other side.

Earthquake-induced ground failure is often the result of liquefaction, which occurs when soil (usually sand and course silt with high water content) loses strength as a result of the shaking and acts like a viscous fluid. Liquefaction causes three types of ground failures: lateral spreads, flow failures, and loss of bearing strength. In the 1964 earthquake, over 200 bridges were destroyed or damaged due to lateral spreads. Flow failures damaged the port facilities in Seward, Valdez and Whittier. Similar ground failures can result from loss of strength in saturated clay soils, as occurred in several major landslides that were responsible for most of the earthquake damage in Anchorage in 1964. Other types of earthquake-induced ground failures includes slumps and debris slides on steep slopes.



Three types of faults. Image courtesy of USGS.

Relationship of the Mercalli Scale to the Richter Scale

Scale		
Mercalli	**Richter**	Description
I	0-4.3	Not felt.
II		Felt by persons at rest, on upper floors, or favorably placed.
III		Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	4.3-4.8	Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing cars rock. Windows, dishes, door rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.
V		Felt outdoors; direction estimated. Sleepers awakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI	4.8-6.2	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken visibly, or heard to rustle.
VII		Difficult to stand. Noticed by drivers. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, also unbraced parapets and architectural ornaments. Some cracks in masonry C. Waves on ponds, water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII	6.2-7.3	Steering of cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX		General panic. Masonry D destroyed; masonry C heavily damage, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas, sand and mud ejected, earthquake fountains, sand craters.
X		Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	7.3-8.9	Rails bent greatly. Underground pipelines completely out of service.
XII		Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

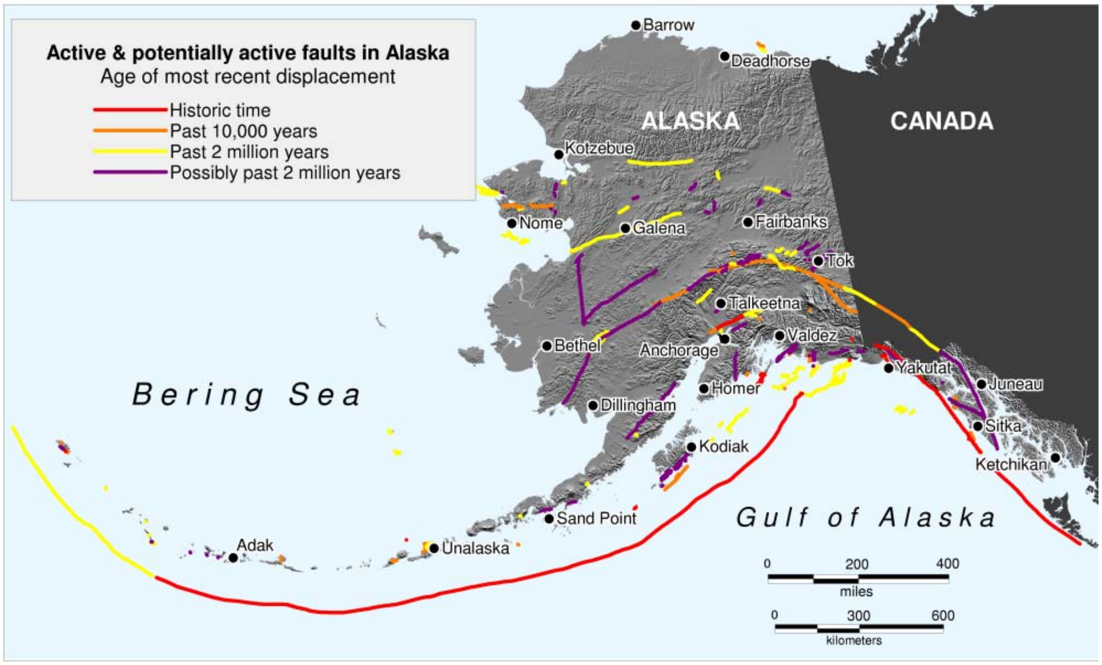
Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Tsunamis will be discussed in Annex G.



Seismic History in Alaska

Approximately 75% of Alaska's detected earthquakes occur in, Alaska Peninsula, Aleutian, Cook Inlet and Anchorage areas. About 15% occur in South-east Alaska and the remaining 10% occur in the Interior. The greatest earthquake in North American history occurred in the Alaska-Aleutian seismic zone. That quake was a magnitude 9.2, lasting between four and five minutes and was felt over a 7,000,000 square mile area. It caused a significant amount of ground deformation as well as triggering landslides and tsunamis resulting in major damage throughout the region. The megathrust zone where the North Pacific Plate plunges beneath the North American Plate still has the potential to generate earthquakes up to magnitude 9.

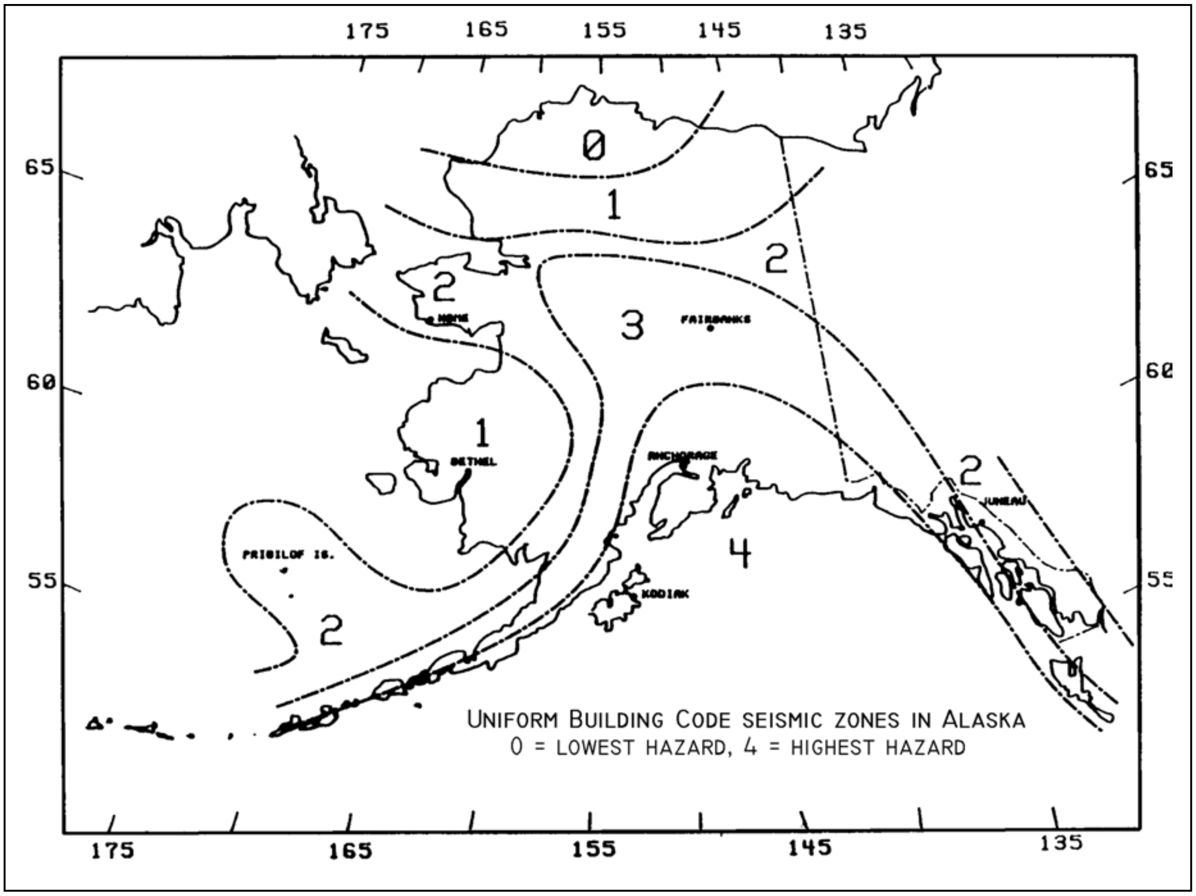
Within 25 miles of Anchorage, there are at least three suspected active faults with the potential to create magnitude 7.5 earthquakes. One of them, the Castle Mountain Fault, produced a magnitude 5.7 earthquake near Sutton in 1984 and may have generated a magnitude 6.9 earthquake that shook Anchorage in 1933. This area is of concern, as a great deal of subdivision development has and continues to occur along the fault.

One of the more memorable events in the Aleutian Islands lengthy seismic history is a magnitude 9.1 earthquake that occurred in 1957 in the Andreanoff Islands. The same area experienced magnitude 7.9 events in 1986 and 1996. In addition, the Aleutian Islands experienced a magnitude 8.7 earthquake in 1965.

Earthquakes have affected other parts of the State. In the past 90 years, the Fairbanks area has experienced three magnitude 7 earthquakes within 50 miles of the community. Southeast Alaska also has earthquakes from the Queen

Charlotte-Fairweather fault including a magnitude 8.1 earthquake in 1949 and the magnitude 7.9 event in 1958 that triggered the giant landslide-generated wave in Lituya Bay. Areas at greatest risk from earthquakes along this fault zone are communities along the outer coast of South-east Alaska.

A lack of large earthquakes along a portion of an active plate margin can be cause for concern. This may indicate the development of a seismic gap, which is an area where there has not been a major earthquake for a much longer time than in adjacent areas. There may be higher likelihood of a strong earthquake in these areas in the future because of strain buildup. The Yakataga seismic gap is one such area because it has not had a major earthquake in more than 100 years. Another suspected seismic gap, the Shumagin gap, shows recent evidence of slipping aseismically, so it appears to pose less potential for a major earthquake than previously thought.



UNIFORM BUILDING CODE SEISMIC ZONES IN ALASKA
0 = LOWEST HAZARD, 4 = HIGHEST HAZARD

Existing Earthquake Programs and Strategies

Outreach

- The "Quake Cottage" is an earthquake simulator operated through a partnership between ADES and the Municipality of Anchorage, Office of Emergency Management and is being used in earthquake outreach activities. It is taken to schools, businesses, and special events to educate people about what can be done to non-structurally mitigate a structure and for general disaster preparedness awareness.

- The Earthquake Resistant Model Home was developed by FEMA and the State of Washington to show structural mitigation and other bracing options for either retrofit applications or during new construction. ADES takes this model on the road to fairs, home shows and other functions to demonstrate earthquake mitigation options.

- The Alaska Earthquake Information Center (AEIC) is a project between the USGS and the University of Alaska Fairbanks Geophysical Institute (UAF/GI) to collect and analyze seismic data as well as disseminate information about earthquakes in Alaska.

- Inclusion of earthquake-hazard mitigation language in many local coastal district plans and enforceable policies.

- Identification, mapping, and evaluation of geologic hazards by DNR/DGGS.

- Cooperative program between UAF/GI and DNR/DGGS to develop seismic site-response and soil class maps for Anchorage, funded by the Alaska Science and Technology Foundation.

- Adoption of seismic provisions of the Uniform Building Code by some municipalities (Anchorage and possibly Fairbanks)

- Developing earthquake-hazard related zoning ordinances by the Municipality of Anchorage.

- Activities of the Anchorage Geotechnical Advisory Commission to review municipal seismic policies and advise the mayor and municipal assembly on earthquake-related issues.

- Policies and standards implemented by DOT&PF for earthquake-resistant design and construction of State roads and facilities.

- The Alaska Coastal Management Program (at 6 AAC 80.050) requires State agencies and coastal districts to identify known geophysical hazard areas. The appropriate State or local authority may not approve development in geophysical hazard areas until siting, design, and construction measures for minimizing property damage and protecting against loss of life is provided.

Earthquake Hazard Mitigation Successes

Relocation of Valdez, AK

After the 1964 earthquake, the City of Valdez was relocated a few miles west of its original site. The new town site was located on stable alluvial fan deposits and bedrock. These soils withstand earthquake ground shaking better than the saturated silty sands at the former site. The new location had the added benefit of helping protect it from tsunami inundation. This was the first time in US history that a community had been completely rebuilt in a new location after an earthquake.

Reconstruction of Seward, AK

The 1964 earthquake also heavily impacted the City of Seward. The waterfront failed as a result of ground motion destroying the city dock and the Alaska Railroad yard and buildings, Afterwards, the rail facilities were not reconstructed and the city dock was relocated. In addition, the high-risk areas near the waterfront were converted to park space and camping facilities.

"The Next Big Earthquake"

Following a highly successful model from the San Francisco area after the 1989 Loma Prieta earthquake, Peter Haeussler of USGS produced a similar earthquake hazard education document for Alaska residents in the mid-1990s. The publication, "The Next Big Earthquake in Southern Alaska May Come Sooner Than You Think" is a 25-page photo-illustrated primer on earthquake hazards and risk in Alaska. Working with funding and in-kind support from USGS, DNR/DGGS, ADES, and the Anchorage Daily News, thousands of these inserts were distributed free-of-charge within the newspaper and as stand alone outreach products for years thereafter. This pamphlet serves as an accessible, timeless, and informative resource for the public and hazard education professionals alike.

Anchorage

The Municipality of Anchorage adopted building code amendments in 1986 and 1992. The land use guidelines correlate the level of geotechnical investigation with ground failure susceptibility zone.


Monument in Earthquake Park.

Anchorage also established Earthquake Park to serve as open space in perpetuity. This prevents development in an area that had a significant number of landslides during the 1964 earthquake. Monuments and interpretive signs educating people about the earthquake were installed within the park.

Unfortunately, examples of unsuccessful mitigation efforts can also be found. After the 1964 earthquake, Anchorage provided incentives for people to move to a less hazardous area. However, the local government failed to take title of the hazard prone land being vacated. Subsequently, redevelopment in the earthquake hazard area is reoccurring. The new construction must meet the highest seismic building code standards (Zone 5 through local amendments to the Uniform Building Code).

Short Term Goals

High Priority

1. ***Establish a Seismic Safety Committee within the State Emergency Response Commission (SERC).***
   This committee would assist the SERC in planning for a seismic event and guide the development of seismic hazard mitigation policies.
   Lead: SERC
   Support: ADES, DNR/DGGS, UAF/GI, WC&ATWC, USGS, AVO, NWS, AEIC, Anchorage Geotechnical Commission
   Timeline: Immediate

Long Term Goals

Medium Priority

1. ***Develop incentives and programs to seismically update/retrofit structures and critical facilities.***
   Create seismic retrofit legislation to provide minimum standards for structural seismic resistance to reduce the risk of life loss or injury and damage to existing structures. Some agencies are working towards this. As an example, DOT&PF is undertaking a seismic retrofit program for State owned bridges.
   Lead: ADES
   Support: DOT&PF, Anchorage Geotechnical Commission, USGS, AEIC, DNR/DGGS
   Timeline: 10 years

2. ***Encourage all communities to adopt or update to the current IBC for single family, duplex, and tri-plex residential construction, and provide sufficient resources and incentives to ensure compliance.***
   Establishing minimum seismic standards for new construction will reduce structural damage in communities and make recovery efforts easier and less costly.
   Lead: Fire Marshall’s Office

Support: ADES, DCED, Anchorage Geotechnical Commission, USGS, AEIC, DNR/DGGS
Timeline: 10 years

3. ***Encourage school mitigation efforts.***
This measure will increase help to protect children and retain a school's functionality as an emergency shelter. It can take seven days or longer for outside assistance to arrive. The SB125 initiative requires all schools to have all-hazard plan. Mitigation is a vital element of the planning process.
Lead: ADES
Support: ADES, ARC, AEIC, DEED, AST, local communities and community groups
Timeline: on-going

4. ***Encourage non-structural mitigation and preparedness activities.***
Encourage activities at the household level because it can take up to seven days for assistance to reach everyone.
Lead: ADES
Support: ARC, AEIC, USGS, Media representatives, local jurisdictions
Timeline: on-going

5. ***Place earthquake / seismic sensor instruments at critical highway transportation choke points. Develop contingency plans to reestablish transportation after roads or bridges have been damaged.***
This includes identifying of material sources, workforce, and equipment availability.
Lead: DOT&PF, Advanced National Seismic Safety Committee
Support: ADES, UAF/State Seismologist, USGS, DNR/DGGS,
Timeline: 10 years

Low Priority

6. ***Conduct state-wide earthquake drills.***
Statewide earthquake drills will educate people on what to do when an earthquakes occur and reinforce interagency and individual expectations.
Lead: ADES
Support: DEED, ARC, Department of the Interior,
Timeline: 5 years

7. ***Encourage the development of earthquake structural performance standards and incorporate earthquake overlay zones in community zoning ordinances.***
Encourage the development of siting requirements based on soil type, slope, and other considerations. Before this can happen, information about where the various risks are located must be developed.
Lead: State Fire Marshal's Office

Support: ADES, DNR/DGGS, UAF/GI, Anchorage Geotechnical Commission, USGS
Timeline: on-going

8. ***Promote incorporation of new methods to improve building performance.***
   New materials and construction techniques might be more effective or feasible than what is currently available.
   Lead: Fire Marshal's Office
   Support: ADES, AEIC, Anchorage Geotechnical Commission
   Timeline: on-going

9. ***Promote development of large-scale earthquake-hazard maps of urban areas.***
   Seismic hazard area maps need to be created or updated. Many areas lack seismic hazard maps or have experienced significant growth making the existing maps obsolete. The maps should depict site amplification, liquefaction susceptibility, and ground failure at a minimum scale of 1 inch = 1 mile.
   Lead: DNR/DGGS
   Support: ADES, AEIC, USGS, FEMA
   Timeline: on-going

10. ***Develop incentives and programs to incorporate mitigation into new construction.***
    Incentives can include property tax reductions, transferable development rights, density bonuses, or waiver of impact fees.
    Lead: Legislature
    Support: ADES, Governor's Office, DCED
    Timeline: 10 years

11. ***Establish a Board of Registration for geologists.***
    This board would track the registration of professionals performing geotechnical evaluations and recommendations. The board will adopt standards of experience and education for geologists who prepare reports required by State or local laws for siting and designing facilities.
    Lead: DNR/DGGS
    Support: ADES, Governor's Office
    Timeline: to be determined

ANNEX G - TSUNAMIS & SEICHES

Hazard Analysis/Characterization

Tsunamis are traveling gravity waves in water, generated by a sudden vertical displacement of the water surface. They are typically generated by an uplift or drop in the ocean floor, seismic activity, volcanic activity, meteor impact, or landslides (above or under sea in origin).

Most tsunamis are small and are only detected by instruments. Tsunami damage is a direct result of three factors: inundation (extent the water goes over the land), wave impact on structures and coastal erosion.

Types of Tsunamis

Tele-tsunami

Tele-tsunami is the term for a tsunami observed at places 1,000 kilometers from their source. In many cases, tele-tsunamis can allow for sufficient warning time and evacuation. No part of Alaska is expected to have significant damage due to a tele-tsunami. There is a slight risk in the western Aleutians and some parts of South-east Alaska.

Most tele-tsunamis that have reached Alaska have not caused damage. In fact, most tele-tsunamis have had their largest recorded amplitude (in Alaska) at Massacre Bay, Attu Island. The amplitude is usually under 1 foot.

Magnitude	***Height (ft)***
-2 to –1	<1.0 to 2.5
-1 to 0	2.5 to 4.9
0 to 1	4.9 to 9.9
1 to 2	9.9 to 19.7
2 to 3	19.7 to 34.2
3 to 4	34.2 to 79.0
4 to 5	79 to >105.0

Tsunami Magnitude and Height relationships.

Only one tele-tsunami has caused damage in Alaska; the 1960 Chilean tsunami. Damage occurred to pilings at MacLeod Harbor, Montague Island and on Cape Pole, Kosciusko Island where a log boom broke free.

Volcanic tsunamis

There has been at least 1 confirmed volcanically triggered tsunami in Alaska. In 1883, a debris flow from the Saint Augustine volcano triggered a tsunami that inundated Port Graham with waves 30 feet high. Other volcanic events may have caused tsunamis but there is not enough evidence to report that conclusively. Many volcanoes have the potential to generate tsunamis.

Seismically-generated local tsunamis
Most seismically-generated local tsunamis have occurred along the Aleutian Arc. Other locations include the back arc area in the Bering Sea and the eastern boundary of the Aleutian Arc plate. They generally reach land 20 to 45 minutes after starting.

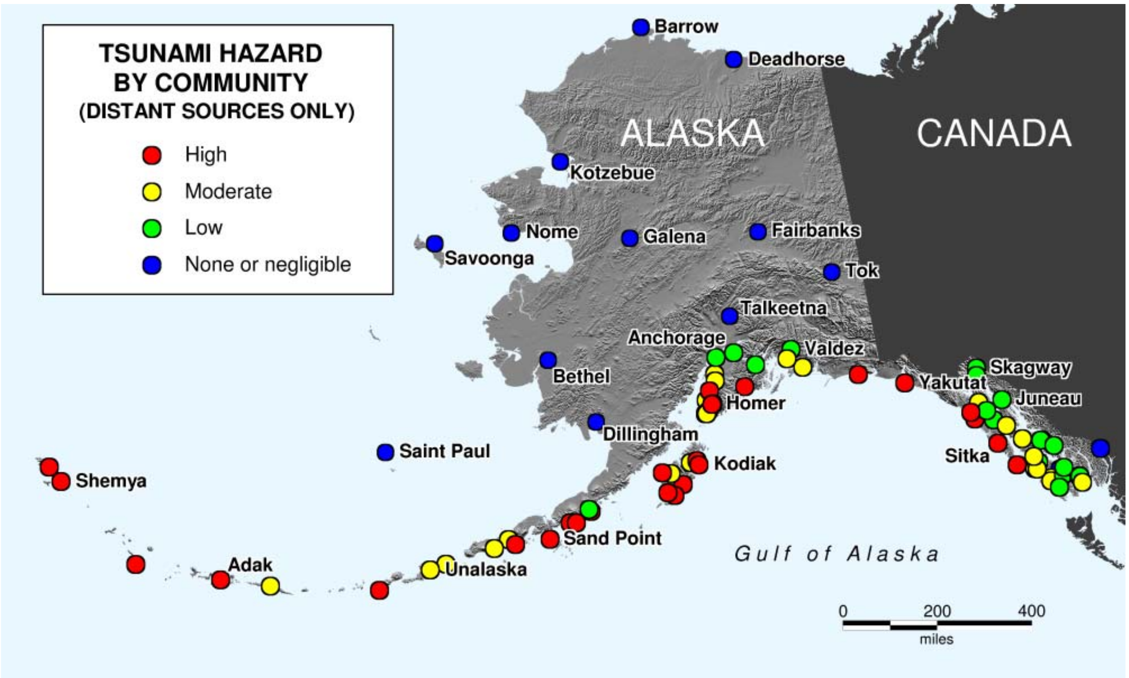
Landslide-generated tsunamis
Submarine and subaerial landslides can generate large tsunamis. Subaerial landslides have more kinetic energy associated with them so they trigger larger tsunamis. An earthquake usually, but not always, triggers this type of landslide and they are usually confined to the bay or lake of origin. One earthquake can trigger multiple landslides and landslide-generated tsunamis. Low tide is a factor for submarine landslides because low tide leaves part of the water-saturated sediments exposed without the support of the water. Loading on the delta from added weight such as trains or a warehouse or added fill can add to an area's instability.

These events usually occur in the heavily glaciated areas of Prince William Sound and the part of South-east Alaska.

Landslide –generated tsunamis are responsible for most of the tsunami deaths in Alaska because they allow virtually no warning time.

Tsunamis generated by landslides in lakes occur more in Alaska than any other part of the U.S. They are associated with the collapse of deltas in glacial lakes having great depths. They may also be associated with delta deposits from rapidly flowing streams and rivers carrying glacial debris.

A seiche is a wave that oscillates in partially or totally enclosed bodies of water. They can last from a few minutes to a few hours as a result of an earthquake, underwater landslide, atmospheric disturbance or avalanche. The resulting effect is similar to bathtub water sloshing repeatedly from side to side. The reverberating water continually causes damage until the activity subsides. The factors for effective warning are similar to a local tsunami, in that the onset of the first wave can be a few minutes, giving virtually no time for warning.



The portion of Alaska bordering the North Pacific Ocean can be hit by tsunamis generated by landslides, underwater landslides, crustal plate movement, or volcanic activity. The Aleutian Islands could get a tsunami generated by remote source earthquakes. The Gulf of Alaska could receive a tsunami from several possible sources. The Alaska coastline facing the Bering Sea has a very low tsunami threat. Evidence exists of a volcanically induced tsunami in Bristol Bay about 3,500 years ago.

Historical Tsunamis

1964 Earthquake Tsunami

The 1964 earthquake triggered several tsunamis, one major tectonic tsunami and about 20 local submarine and subaerial landslide tsunamis. The major tsunami hit between 20 and 45 minutes after the earthquake. The locally generated tsunamis struck between two and five minutes after being created and caused most of the deaths and damage. Tsunamis caused more than 90% of the deaths – 106 Alaskans and 16 Californian and Oregonian residents were killed.

While there was tsunami damage throughout the area, the effects were significant in Kodiak, Seward, Whittier and Valdez.

Tsunami damage in Kodiak.

The Kodiak area experienced ten observed tsunamis. The main electrical power unit was knocked out and the water pipe system was destroyed. In addition, the dock pier, generators, roads, houses, runways, warehouses and other facilities were damaged or totally destroyed. In total, the damages amounted to $31.3 million, 80% of the city's industrial base was destroyed, and 600 people were made homeless out of a population of 2,658. Very few fatalities occurred; only six people were reported missing and presumed dead because most sought high ground after the earthquake,

In Seward, the shaking of the earthquake caused the Seward Waterfront to collapse, generating a 30-foot local tsunami. The local tsunami destroyed most of the facilities near the waterfront, including a fuel tank farm, which started the first of many fires. Smaller tsunamis then spread the burning oil floating on the water's surface and started another fire at the Texaco Petroleum tank farm further inland.

The combined slump and tsunami caused the dock to collapse and a number of boats to sink (30 fishing boats and 40 pleasure craft) within the small boat harbor. The railroad yards were heavily damaged, as were freight cars in the marshalling yards. A 120-ton locomotive was moved 100 feet and a 75-ton locomotive was carried 300 feet.

Seward rail yard.

About 25 minutes after the earthquake, the tectonically generated tsunami arrived. This wave spread a wall of flaming oil into Seward, destroying and setting fire to a large section of the town. Overall, the tsunami caused about 95% of Seward's industrial base to be lost, 15% of the town's residential properties to be totally destroyed or very heavily damaged, 12 fatalities, 200 injuries and approximately $14 million in damage.

In Whittier, a series of at least eight tsunamis struck the town. Tsunamis destroyed two saw mills; the Union Oil Company tank farm, wharf and buildings; the Alaska Railroad depot; the railroad ramp handling towers at the army pier, and several houses, as well as causing damage to the small boat harbor. The tsunamis were responsible for 13 deaths and approximately $10 million in damages.

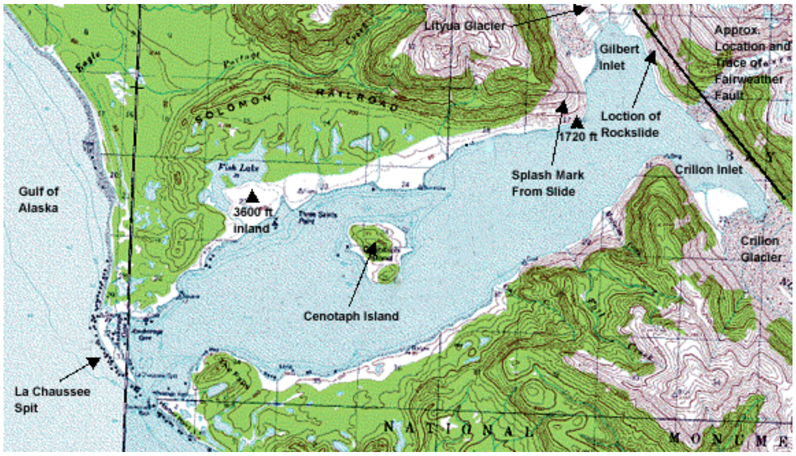
In Valdez, part of the waterfront slumped into the bay triggering, a locally generated tsunami. There was massive damage to the waterfront, storage, warehousing and railroad facilities. Half of the downtown business district was totally destroyed. The resulting fires burned at the waterfront for two weeks. Almost the entire town's fishing fleet, 68 out of 70 boats, were destroyed. Luckily, they were empty

Tsunami caused fire in Valdez.

when the tsunami struck. The dock area was not as fortunate. Prior to the tsunami, 28 people had gathered to watch a freighter unload. All were swept away. Shifting cargo in the freighter’s hold caused additional fatalities.

In nearby Shoup Bay, waves reached over 220 feet high. These were the highest recorded waves associated with the event.

1958 Lituya Bay Tsunami



In July 1958, in Lituya Bay (Glacier Bay National Park), a large earthquake started a giant landslide that ran into the head of the bay and generated a tsunami. The wave washed up a mountainside on the opposite side of the bay to a height of more than 1,720 feet. Two fishing vessels anchored in the bay sank, killing two people and a third boat was washed over the La Chaussee Spit. The earthquake actually triggered at least eight separate local tsunamis. Three fatalities were associated with the tsunami occurring in Yakutat Bay. Lituya Bay is a known tsunami prone area as there have been three other fatal landslide generated tsunamis.


Scotch Cap lighthouse.
Image courtesy USCG.

1946 Unimak Island Tsunami


The site of the Scotch Cap lighthouse after the tsunami. Image courtesy the USCG.

On April 1, 1946, a magnitude 7.3 earthquake occurred near Unimak Island. The resulting tsunami was approximately 100 feet high and was strong enough to knock the Scotch Cap lighthouse, a reinforced concrete structure, off its foundation. All five people in the lighthouse died. The tsunami caused about $250,000 in damages in Alaska but the effects were widespread. Relatively minor damage was reported in Washington and Oregon as well as French Polynesia and Chile, while California was more affected, with $10,000 in damages and one death. Hawaii was heavily impacted with $26 million in damages and 159 fatalities. This event renewed interest in tsunami research.

1994 Skagway Tsunami

The 1994 Skagway tsunami was a landslide-generated tsunami and was responsible for one fatality and over $25 million in damages. The triggering mechanism for the landslide is not known definitively. It is believed that the 23,350 tons of construction equipment and fill material on the railroad dock may have overloaded the sediments on which the dock was built, causing it to fail during the evening's low tide. It is also possible that the area failed as part of a larger underwater landslide.

Existing Tsunami Programs and Strategies

Deep-ocean Assessment and Reporting of Tsunamis (DART)

The DART project is a component of the larger U.S. National Tsunami Hazard Mitigation Program (NTHMP). The NTHMP is a comprehensive, joint Federal/State effort to reduce the loss of life and property due to tsunami inundation of U.S. coastlines. Cooperating U.S. agencies include NOAA, FEMA , USGS, and the Emergency Management agencies of the five Pacific States: Alaska, California, Hawaii, Oregon and Washington.

The DART project is an ongoing effort to develop and implement a capability for the early detection and real-time reporting of tsunamis in the open ocean. Project goals are to:

1. Reduce the loss of life and property in U.S. coastal communities
2. Eliminate false alarms and the high economic cost of unnecessary evacuations

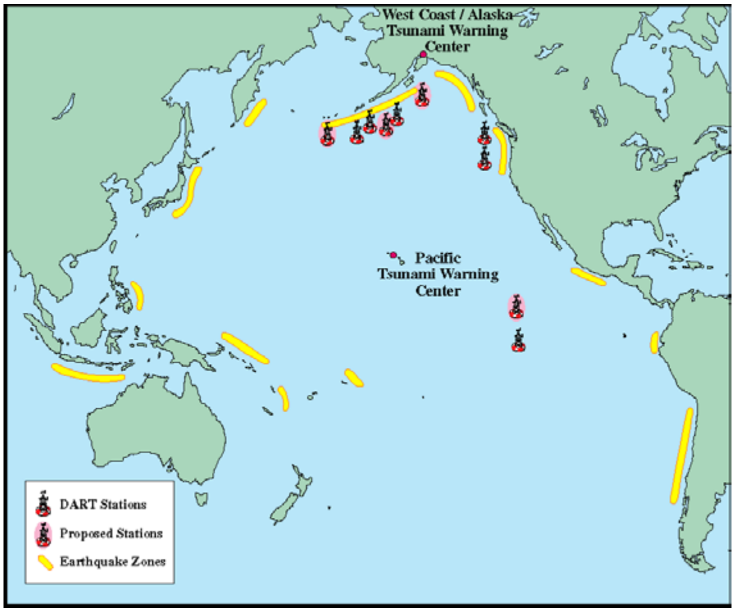


Image courtesy of NOAA.

DART stations are sited in regions with a history of generating destructive tsunamis to ensure early detection of tsunamis and to acquire data critical to real-time forecasts. Buoys shown on the accompanying map represent an operational array scheduled for completion in 2003.

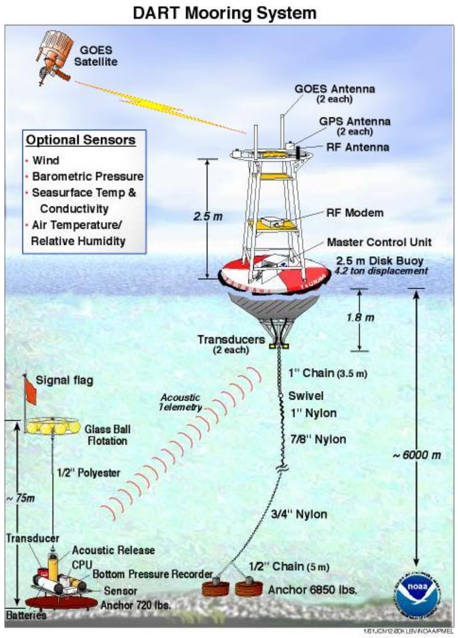


Image courtesy of NOAA.

A DART system consists of a seafloor bottom pressure recording system (BPR) capable of detecting tsunamis as small as one centimeter, and a moored surface buoy for real-time communication. An acoustic link is used to transmit data from the BPR on the seafloor to the surface buoy. The data are then relayed via a GOES satellite link to ground stations, which demodulate the signals for immediate dissemination to NOAA's Tsunami Warning Centers and the Pacific Marine Environmental Laboratory (PMEL).

TsunamiReady Communities

The TsunamiReady Community program promotes tsunami hazard preparedness as an active collaboration among Federal, State and local emergency management agencies, the public, and the NWS tsunami warning system. This collaboration supports better and more consistent tsunami awareness and mitigation efforts among communities at risk. The main goal is improvement of public safety during tsunami emergencies. Before a community can be declared tsunami ready, it must meet the following criteria.

Criteria	**Population**			
	<2500	2500-14,999	15,000-40,000	>40,000
Criterion 1: Communications and Coordination Center				
24 hr Warning Point (WP)	X	X	X	X
Emergency Operations Center		X	X	X
Criterion 2: Tsunami Warning Reception				
Number of ways EOC/WP can receive NWS tsunami messages. (NWR receiver with tone alert. NWR-SAME is preferred. Required for recognition only if within range of transmitter)	3	4	4	4
Criterion 3: Warning Dissemination				
Number of ways EOC/WP can disseminate warnings to public	1	2	3	4
NWR-SAME receivers in public facilities	X	X	X	X
For county/borough warning points, county/borough communication network that insures information flow among communities	X	X	X	X
Criterion 4: Awareness				

Criteria	**Population**			
	<2500	2500-14,999	15,000-40,000	>40,000
Number of annual tsunami awareness programs	1	2	3	4
Designate/establish tsunami shelter in safe zone	X	X	X	X
Designate tsunami evacuation areas and evacuation routes, and install evacuation route signs	X	X	X	X
Provide written, locality specific, tsunami hazard response material to public	X	X	X	X
Schools: establish tsunami hazard curriculum, practice evacuations, and train staff	X	X	X	X
Criterion 5: Administrative				
Develop formal tsunami hazard operations plan	X	X	X	X
Annual meeting/discussion between local emergency manager & NWS	X	X	X	X
Visits by NWS official to community at least every other year	X	X	X	X

Seward is the first community in Alaska to complete all requirements of the West Coast & Alaska Tsunami Warning Center (WC&ATWC), NWS and ADES Community TsunamiReady Program,

Tsunami Inundation Mapping Program

As part of a larger federal program, Alaska is generating tsunami inundation maps for communities along the Gulf of Alaska. Detailed maps of future flooding (inundation) are needed for delineation of evacuation routes and long-term planning in vulnerable coastal communities. In addition, these maps require maintenance and upgrades as better data becomes available and coastal changes occur. Inundation maps for Kodiak City, USCG station, and Women's Bay have been completed. The next communities in priority are Seward followed by Sitka. However, neither of these communities have accurate digitized, bathymetric data available. Therefore Homer and Seldovia are now being mapped.

West Coast/Alaska Tsunami Warning Center

The WC&ATWC was established in Palmer, Alaska in 1967 as a direct result of the earthquake that occurred in Prince William Sound on March 27, 1964. This earthquake alerted State and Federal officials to the need for a facility to provide timely and effective tsunami warnings and information for the coastal areas of Alaska.


The new home of the WC&ATWC facility (under construction).

In 1982, the WC&ATWC's area of responsibility (AOR) was enlarged to include issuing tsunami warnings to California, Oregon, Washington, and British Columbia, for potential tsunamigenic earthquakes occurring in their coastal areas. In 1996, the responsibility was again expanded to include all Pacific-wide tsunamigenic sources which could affect the California, Oregon, Washington, British Columbia and Alaska coasts.

Tsunami warnings are of two types: regional warnings for tsunamis produced in or near the AOR and warnings for tsunamis generated outside the AOR. Regional warnings are issued within 15 minutes of earthquake origin time and are based solely on seismic data. Warnings are issued for any coastal earthquake in the WC&ATWC's AOR over magnitude 7. Warnings outside the WC&ATWC's AOR are issued after coordination with the Pacific Tsunami Warning Center in Ewa Beach, Hawaii. The warnings are based on seismic data, along with historical tsunami records and recorded tsunami amplitudes from tide gauges.

In addition to tsunami warning messages, the WC&ATWC also issues information messages for earthquakes that may be felt strongly by local citizens but are not large enough to generate a tsunami. Each year, the WC&ATWC staff responds to more than 250 alarms averaging approximately five each week. The messages are important in preventing needless evacuations since citizens near coastal areas are taught to move to higher ground when severe earthquake shaking occurs. Other messages issued by the WC&ATWC include seismic data exchanges among other centers, and tsunami information messages for large earthquakes outside the AOR that are not potentially dangerous to the AOR.

Tsunami Warning and Environmental Observatory for Alaska (TWEAK)

TWEAK is a recently established program to collect tsunami information and biological and oceanographic data. Its efforts are focused on the following areas:

- Tsunami Research
- Water Quality
- Ocean Productivity
- Weather Prediction
- Education/Outreach

Tsunami Hazard Mitigation Successes

Installation of Tsunami Warning Signs

Tsunami warning signs were installed in Sitka, Sand Point, Seward and Homer. In addition, the Alaska Department of Parks and Recreation installed signs in Shoup Bay, a remote area frequented by hikers and kayakers and inundated by a 170-foot wave in 1964.

Short Term Goals

Low Priority

1. ***Encourage all coastal communities with a tsunami threat to participate in the ADES Tsunami Sign Program.***
   Participating in the Tsunami Sign Program requires communities to complete a Tsunami Hazard Plan (or annex to existing Emergency Operations or Comprehensive Plans), identify a Tsunami Evacuation Route and agree to place tsunami awareness signs in their community.
   Lead: ADES
   Support: NOAA, DOT&PF, DEC, local jurisdictions
   Timeline: on-going

Long Term Goals

Medium Priority

1. ***Expedite development of tsunami inundation maps for vulnerable coastal communities.***
   Without inundation maps, communities must rely on historical or estimated information for land use and evacuation route planning. Inundation maps will provide more accurate information allowing for more accurate community decisions.
   Lead: ADES
   Support: UAF/GI, DNR/DGGS, NOAA/PMEL/TIME, NOS, local jurisdictions
   Timeline: on-going

2. ***Encourage all coastal communities with a tsunami threat to participate in the NWS/WC&ATWC TsunamiReady Program.***
   The TsunamiReady Program requires communities to complete extensive requirements for a TsunamiReady Community Certification (see program description above).
   Lead: WC&ATWC
   Support: ADES, NOAA, DOT&PF, local jurisdictions
   Timeline: on-going

Low Priority

1. ***Encourage communities to incorporate tsunami risk areas in land use planning and zoning.***
   Land use planning and zoning can help limit tsunami damage by minimizing, reducing or preventing development in tsunami risk areas. This can be done in many ways including: encouraging the elevation of buildings, siting structures on the high part of their lots, using the lower floors of high rise structures as non occupied spaces, encourage the development of site planning regulations requiring streets and structures to be perpendicular to

potential waves creating a path of least resistance for the water and reducing debris impact. These measures are targeted to reduce non-coastal dependent development. Water based facilities like ferry terminals and shipping docks should be built to withstand tsunami wave forces.

Lead: DCED
Support: ADES, AEIC, Anchorage Geotechnical Commission, local jurisdictions
Timeline: on-going

2. ***Encourage use of blocking structures such as walls, berms, etc. which would restrict wave activity and may redirect water safely.***
   While avoiding tsunami risk areas is preferable, it is not always possible as some areas have already been developed and some facilities are dependent on being on the coastline. Using these structures could allow survival of threatened facilities.
   Lead: Local Governments
   Support: ADES, AEIC, Anchorage Geotechnical Commission
   Timeline: on-going

3. ***Encourage federal flood insurance programs to cover tsunami damage.***
   Lead: ADES
   Support: DCED, FEMA, local jurisdictions
   Timeline: on-going

4. ***Encourage development and adoption of coastal zone building codes as tsunamis and sea storms are not considered in either the International or Uniform Building Codes.***
   Using appropriate coastal zone building construction methods can help resist tsunami damage. For example, using coastal zone specific engineered foundations can aid with resisting erosion and scour.
   Lead: ADES
   Support: DCED, FEMA, AEIC, Anchorage Geotechnical Commission, Local Governments, Governor’s Office
   Timeline: on-going

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ANNEX H - WEATHER (FUTURE ADDITION)

Hazard Analysis/Characterization

Existing Weather Programs and Strategies

Weather Hazard Mitigation Successes

Short Term Goals

Long Term Goals

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ANNEX I - LANDSLIDES (FUTURE ADDITION)

Hazard Analysis/Characterization

Existing Landslide Programs and Strategies

Landslide Hazard Mitigation Successes

Short Term Goals

Long Term Goals

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ANNEX J - EROSION (FUTURE ADDITION)

Hazard Analysis/Characterization

Existing Erosion Programs and Strategies

Erosion Hazard Mitigation Successes

Short Term Goals

Long Term Goals

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ANNEX K - DROUGHT (FUTURE ADDITION)

Hazard Analysis/Characterization

Existing Drought Programs and Strategies

Drought Hazard Mitigation Successes

Short Term Goals

Long Term Goals

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ANNEX L - TECHNOLOGICAL (FUTURE ADDITION)

Hazard Analysis/Characterization

Existing Technological Programs and Strategies

Technological Hazard Mitigation Successes

Short Term Goals

Long Term Goals

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ANNEX M - ECONOMIC (FUTURE ADDITION)

Hazard Analysis/Characterization

Existing Economic Programs and Strategies

Economic Hazard Mitigation Successes

Short Term Goals

Long Term Goals

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