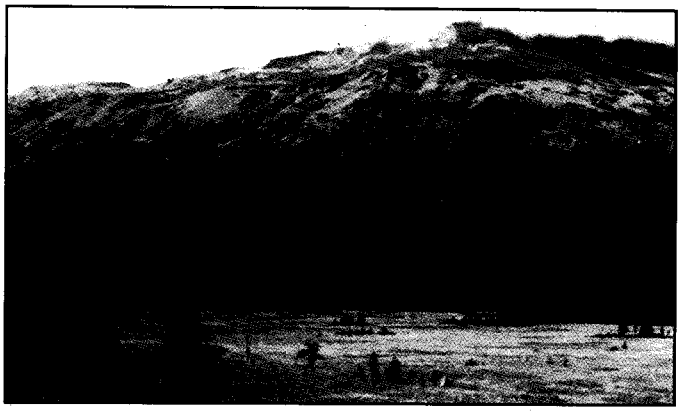
Chapter 3
Natural Environment

GIRDWOOD WAS A RESTING POINT ALONG THE IDITAROD TRAIL WHICH RAN FROM SEWARD TO VARIOUS POINTS IN THE ALASKAN INTERIOR, AND EVENTUALLY REACHING TO NOME. A DOG TEAM IS RESTING IN GIRDWOOD DURING THE WINTER OF 1916–1917.



Moose Meadows.

The Girdwood valley provides an outstanding physical setting for a mountain resort community. As beautiful as it is, however, much of the land area is fragile, hazardous or marginal for development purposes. Such land area as steep alpine slopes, wetland meadows and marshes, deep green forests, braided streams and rock outcroppings combine to provide both unexcelled natural beauty and ideal recreational areas for the attraction and enjoyment of local residents, as well as visitors.

A fundamental objective of the **Girdwood Area Plan** is to create a mountain resort community design that regards the natural environment as its central rationale for form. The location and intensity of uses must take into consideration the constraints and assets that are presented simultaneously by the various physical features. With that in mind, the following overview is presented to describe the primary natural features of Glacier Creek valley and how they came into being.

Landform and Geology

Girdwood lies within an extensive belt of Mesozoic marine deposits that were metamorphosed, uplifted and broken to form much of the present-day Chugach-Kenai-Kodiak Mountain system. The bedrock is composed chiefly of argillite, slate, and graywacke. The chief features of the mountain system's landforms seen today are the result of ice sculpting that occurred during the great glacial advances of the Pleistocene Ice Age.

Girdwood valley developed initially along a major structural trend in the bedrock that was later deepened and widened by glaciation. The valley is relatively short in length, being only about six miles long. It is nearly two miles wide at tidewater and gradually narrows as it progresses inland to the headwall. The lower portion of the valley is broad and flat with quickly steepening sidewalls along mountainsides that rise to about 3,000-3,500 feet elevation. The upper valley is narrower, with more hummocky terrain being wedged between mountains that rise higher to elevations of more than 6,000 feet at the headwall.

Unconsolidated sediments overlie the bedrock of the valley. Most of the unconsolidated material was originally transported to the area by glaciers, which at times nearly filled the valley. The distribution of various types of unconsolidated materials is complex because of repeated and interrelated effects of glacier ice, marine water of Turnagain Arm, and melt-water streams.

The original glacier deposits were poorly sorted mixtures of material ranging in size from clay particles to boulders. As the glacial ice receded and the waters of Turnagain Arm invaded the lower part of the valley, fine-grained materials were also deposited. Turnagain Arm water later withdrew and glacier melt-water streams then reworked the deposits. The washing action of the streams removed silt and clay from the existing deposits, leaving sand and gravel in the old stream channels.

The current major glacial melt-water stream is Glacier Creek, which heads at the termini of several glaciers on Goat Mountain. From its head, the creek flows southwest to tidewater. Two other major streams flow into Glacier Creek in the upper valley very close to one another. They are Crow Creek from the northwest, and Winner Creek from the southeast. In the area of the confluence of the three streams, the waters are rushing through narrow, deeply cut bedrock. This very scenic area is known locally as the "Four Corners" area.

Glacier Creek flowing through narrow, rock-walled gorge in the Four Corners Area.

Further downstream, a number of other melt-water creeks flow into Glacier Creek. The most significant is California Creek, which originates in a smaller side valley. Virgin Creek, which has its source in a small side valley at the lower eastern side of Girdwood valley, flows directly into Turnagain Arm.

The community of Girdwood and the resort have been built in the lower 2.5 miles of the valley. The area's landform, geology and soils have played significant roles in shaping the pattern of community development and will continue to do so in the future.

Soils

The most commonly found deposits of unconsolidated materials in Girdwood valley that form the basic soil units are alluvial, colluvial, morainal, glaciomarine and estuarine deposits. Alluvial deposits are chiefly composed of sand and gravel, with some layering of silt. They are found primarily on the lower terraces and floodplain of Glacier Creek and outwash fans of California, Alyeska, and Virgin Creeks. Alluvial soils are well drained and have adequate bearing strength to be considered generally suitable for building and road foundations.

Colluvial deposits are accumulations of mixed materials that are thickest along the bottom portions of the mountain slopes along the sides of the valley. Colluvium typically includes old landslide and rockfall debris, as well as material that has moved downslope on a slow but continual basis.

Colluvial materials are mixed, with a wide range of grain size. They are typically found on sloping terrain, with drainage ranging from fair to poor. Some colluvial areas west of the Alyeska Highway, near the mountain slope, contain numerous seeps. These soils may be suitable for building and road foundations. However, care must be taken to avoid drainage problems.

Morainal deposits consist of material that was laid down by direct glacial action. These include terminal (end), lateral (side), and ground moraines. They are chiefly found on the valley sides and in the upper valley just above the confluence of Glacier-Winner-Crow Creeks. The materials are in many ways similar to, as well as mixed with, colluvial materials.

Glaciomarine and estuarine deposits are poorly drained, fine-grained silt and clay materials found on some of the upland ridges, in natural depressions, and in the lower flat portion of the valley that is close to tidewater. Many are overlain with a mat of peat or muskeg and closely correspond to wetland areas. Materials that make up these soil units have a high water-holding capacity. Unless mixed with large amounts of other sand and gravel material, they are generally unsuitable for road and building foundations.

The soils in the Girdwood valley are distinguished from those of the Anchorage area in one notable way. They are much wetter. This distinction has to do with the climatic differences between the two areas.

Climate

The Girdwood valley has a maritime climate characterized by cool summers, relatively mild winters, and year-round precipitation. This is typical of southern coastal areas of Alaska where the ocean exerts a moderating influence. Compared with Anchorage, Girdwood experiences warmer winters, slightly cooler summers, and a great deal more precipitation.

Winters in the Girdwood area are characterized by periods of cold, stable weather followed by long periods of warm, inclement weather. These patterns result from the interaction of extremely cold, dense, high pressure systems that develop over interior Alaska, and relatively warm, moisture-laden, low pressure systems produced in the Gulf of Alaska. Periods of clear winter weather may last as long as a month when low sunlight angles cause a daily net radiation loss. During such periods, temperatures gradually decrease, sometimes reaching -20 degrees Fahrenheit or lower. Generally, these conditions remain unchanged until a very large, low pressure system moves the dense, cold air mass from the area.

January and February are normally the coldest months. Average winter temperatures in the lower valley between Turnagain Arm and Alyeska Resort typically range from 15 to 25 degrees Fahrenheit. Although very cold temperatures are sometimes experienced, periods of warm winter weather are also not uncommon, and January temperatures in excess of 50 degrees Fahrenheit have been recorded. At such times, snowmelt and accompanying precipitation can create extreme conditions of overland flow run-off. Typical summer temperatures are in the 60's, with July usually being the warmest month. Fall is the wettest time of year, while May and June are the driest.

Climate conditions vary within the valley. Temperatures are affected by altitude, especially during mid-winter. Limited available climate records indicate that while annual average

temperatures are similar (36.4 degrees Fahrenheit at the old train station versus 35.6 degrees Fahrenheit at the Alyeska Resort), average temperatures at Alyeska Resort in December and January are 4 degrees Fahrenheit and 3 degrees Fahrenheit colder respectively than those recorded for the old station. Also, total precipitation and snowfall are substantially higher in the upper valley because of differences in altitude.

Storms in Southcentral Alaska generally create an airflow from the southeast, producing heavy precipitation on the east side of the Chugach Mountains and light precipitation on the west. Girdwood averages 67 inches of precipitation annually, compared with 171 inches at Whittier and 27 inches at Anchorage. Similarly, the winter snowfall in Girdwood of 144 inches exceeds the 52 inches recorded for Anchorage.

Stormy periods consistently generate snow above the 2,000-foot level in the winter. Very wet snow and rain are common below 1,000 feet throughout the entire snow season, extending from November through April. Snow loads are high, a factor which must be considered in construction. On the other hand, since either rain or snow may occur at sea level, a shortage of snow at lower elevations sometimes results.

The micro-climate of the upper valley area at Glacier-Winner Creek is similar to Mount Alyeska's, with a few exceptions. The base elevation is 500-650 feet compared to an elevation of 300 feet at Alyeska. In addition, the Glacier-Winner Creek base is 2.5 miles farther away from the moderating influence of the marine waters of Turnagain Arm. Consequently, base temperatures at Glacier-Winner Creek should be slightly cooler than Alyeska, resulting in less rain and more snow. Miscellaneous snow depth measurements taken from 1981-1986 at both base sites showed the Glacier-Winner Creek base area to have approximately 55 percent greater snow depth, on average, than the Alyeska base.

Higher elevation snow depth comparisons between the two areas do not correlate with the differences in base snow depths. Miscellaneous snow depth measurements taken from 1981-1986, show Alyeska as having greater snow depths than Glacier-Winner Creek over a range of similar elevations above 1,000 feet. The lighter snowpack on the Glacier-Winner Creek upper slopes could be a result of a combination of factors, such as drier air at a greater distance from Turnagain Arm, terrain differences, exposure and wind.

There is only sketchy information available on wind direction and velocity in the Girdwood valley. Strong southeasterly winds usually accompany heavy snows. However, it is reported that the highest wind velocities experienced at Alyeska typically occur from the northeast and sweep across the upper mountain chairlifts. Resulting wind-related closures on Chairs 1, 2 and 4 average about seven days per year.

Climate has had a significant effect on the shaping and contouring of the Girdwood valley, as well as on its vegetative cover. It also influences the design of many basic facilities and structures in the community, and helps define available forms of recreation.

Hydrology

Water is a resource in great abundance in the Girdwood valley. Surface waters emanate from several different sources, while existing wells and available evidence from various hydrological investigations indicate that the valley holds large groundwater reserves in relatively shallow aquifers.

SURFACE WATER

Surface water in the Girdwood area is readily available in abundant quantities from Glacier Creek and its tributaries. The valley of Glacier Creek and its smaller related side valleys encompasses a drainage basin of approximately 62 square miles. More than 5 square miles, or about 8 percent, is covered with glacial ice. Perennial snowfields also exist on the high mountain slopes. Storage of water in glaciers and snowfields and the subsequent release of melt water regulate streamflow in the valley. Consequently, meltwater can maintain streamflows even during periods of hot dry summer weather.

The period of lowest streamflow is during late winter and early spring when glacial and snowmelt are at their lowest levels. The only current and anticipated withdrawal of any sizable amount of surface water is for snowmaking at the resort. However, snowmaking is typically undertaken in late fall to establish a snow base before the colder temperatures of winter bring plenty of natural snow.

GROUNDWATER

Groundwater aquifers are found in porous and permeable unconsolidated deposits that are water saturated. Such materials are found where stream action on the glacial deposits has produced clean, well-sorted sand and gravel. Therefore, good producing aquifers are found along both the current and former channels of Glacier Creek and its tributaries, as well as the fan-shaped deposits at the base of steep mountain slopes by California, Alyeska, and Virgin Creeks.

Groundwater supplies nearly all the water demands in the Girdwood area. All the high producing community wells are located in the alluvial deposits of Glacier, California, or Alyeska Creeks. About one fourth of Girdwood homes (all located on the west side of the valley), however, rely on private wells. Development in the new townsite area and areas on the east side of Glacier Creek utilize community wells.

The aquifer depths below ground level vary throughout the valley. However, they are all quite shallow, generally in the 40-80 feet range and very seldom going deeper than 100 feet. The community well serving the new Girdwood townsite has one of the highest reported yields in the valley. Yet, the water level is only about 10 feet below the land surface.

The highest producing wells in the valley belong to Anchorage Water and Wastewater Utility (AWWU). They have two wells tapped into the Glacier Creek aquifer a short distance northeast of the Girdwood airstrip. These two wells can produce flows of 1,000 and 600 gallons per minute respectively to the water system.

A short distance upstream from the AWWU wells, the Glacier Creek floodplain narrows from nearly 1,000 feet in width to less than 100 feet and the creek becomes constrained within a

bedrock gorge. Here, the alluvial deposits are narrowly confined and thin, and may not be adequate for any significant groundwater production. Thus, large sources of groundwater production in the upper valley may be more difficult to find than in the lower valley.

WATER QUALITY

The chemical quality of the groundwater in the area is excellent. The water is a moderately hard, calcium-bicarbonate type. Chemical analyses performed by the U.S. Geological Survey and Alaska Division of Water indicate the surface waters of Glacier and Winner Creeks are of similar chemical quality to the valley's groundwater, except for slightly lower levels of dissolved solids such as calcium and manganese.

Most of the sand, silt, clay and finer-sized particles found in stream channels are transported in suspension, giving the water a turbid appearance. The level of turbidity varies from stream to stream, with glacial-fed streams generally having a higher sediment load during periods of high flow. The local streams are more turbid during periods of fast flow (coinciding with periods of rapid snow and ice melt, and after heavy rains) than periods of low flow during the colder winter and early spring months.

The most serious potential impacts on water quality in the Girdwood valley are likely to be associated with further community development. Care will be required to avoid disturbance or contamination of important groundwater aquifers. Surface waters will need to be protected from additional sedimentation associated with construction and runoff from developed areas.

Wetlands

There are three basic wetland types within the Girdwood valley: intertidal wetlands, floodplain wetlands, and open patterned ground peat bogs. Both the intertidal and floodplain wetlands overlie mostly unconsolidated surficial soils. The open meadow bogs overlie peat deposits commonly found in low-relief depressions in the middle and upper valley on the larger river terraces.

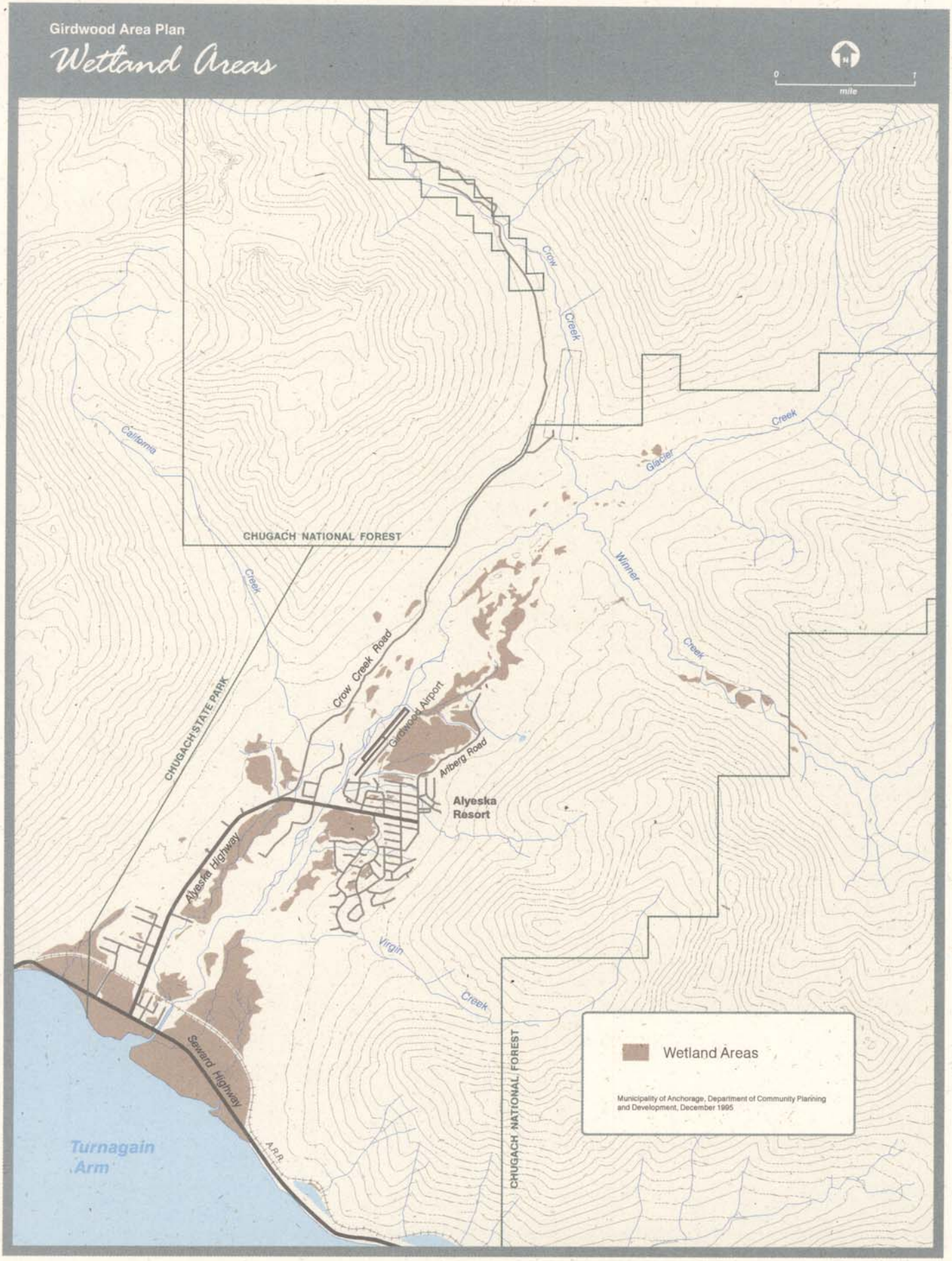
Intertidal wetland areas occur chiefly along the Seward Highway right-of-way and reach their inland extent in the vicinity of the Alaska Railroad right-of-way. The zone of intertidal influence extends further inland up the floodways of Glacier and Virgin Creeks and Tidewater Slough. Several areas of formally intertidal wetlands are evolving to more brackish to freshwater conditions where the Seward Highway has restricted the influence of high tides, mostly in the vicinity of the Seward Highway / Alyeska Highway intersection.

The intertidal wetlands are dominated by salt-tolerant sedges, grasses, and woody shrubs, and contain scattered shallow, silt-laden pools. These wetlands provide moderate- to high-value migratory bird habitat. Pockets of fairly productive breeding habitat can also be found in areas where slight elevation changes preclude summer tidal flooding. The key intertidal habitat sites include the large brackish pond south of the Alyeska Highway intersection, the mouth of Glacier Creek, and the loose conglomeration of pools and flooded meadows seaward of the railroad east of Glacier Creek.

Floodplain wetlands in the Girdwood valley occur in alluvium chiefly along the floodways of the major streams and tributaries and the larger ephemeral drainage courses. These habitats

Girdwood Area Plan

Wetland Areas



are dominated by deciduous thickets and interspersed with large black cottonwood trees. Occasional pools and beaver ponds are found mainly along the lower Glacier/California Creeks, below the Girdwood School, and also the lower portions of Moose Meadow and Virgin Creek. These wetlands provide valuable flood control, water quality, and fish habitat functions, especially in flatter sections where stream waters more regularly interact with adjacent wetlands. A series of floodplain wetlands also exist far up valley in shallow sections of the upper Winner Creek drainage.

The third major wetland type is referred to as open patterned ground and typically covers deeper peat soils away from the floodplains. The larger patterned bogs are concentrated on the east side of the valley floor and inland of the railroad. These bogs are nutrient poor and contain small islands of western hemlock interspersed among wet sedge/grass meadows. Small solifluction pools are often scattered across the meadows wherever micro relief allows local ice conditions to carve out depressions. Small tributaries of Glacier Creek wind through these open meadows often carving out deep incised channels which often provide anadromous fish habitat.

Unlike the patterned ground wetlands found in Anchorage, which typically include very complex and diverse plant communities, the patterned ground meadows in Glacier Creek valley include very simple plant assemblages and provide correspondingly moderate to low value wildlife habitat. The chief wetland functions of these areas appear to be for flood water attenuation, upper watershed water quality, and summer fish habitat. These patterned ground meadows become even less valuable for fish and wildlife habitat farther up valley, where higher elevations allow deeper snow accumulation and a shorter growing season. Therefore, the Winner Creek terraced meadows are simpler and of lower value than the Moose Meadows.

Vegetation

The Girdwood valley is located at the northern edge of the Pacific coastal rainforest zone. This is in contrast to the drier boreal or interior forest zone of most of Alaska.

The forest growth within the Girdwood valley consists of western hemlock, sitka spruce, and black cottonwood. They are typical for parts of coastal forests at this latitude and topographic conditions.

The most predominant species with the largest coverage is the western hemlock, followed by the sitka spruce. These large standing trees have created dense evergreen forests with soft forest floors of duff and moss. The black cottonwoods occupy the well-drained floodplain of Glacier Creek, as well as the alluvial fans of California and Virgin Creeks.

The forest extends up the mountainsides to about 1,500 feet elevation. Shrub/scrub growth occurs for a slightly higher distance, but is soon replaced with alpine tundra cover at the higher elevations.

The dominant forms of low shrub/scrub growth are alder, willow, and devil's club. Although they are found throughout the valley, they appear most prominently along small drainage ways on sloping terrain, or in more open areas.

Commercial logging operations took place in the Girdwood valley during the early years of this century, mainly to provide railroad ties. Today, the primary values of the valley's forest lie in its beauty and associated quiet. Together, these qualities provide the focus of human appreciation and interest.

The main natural threat to the forest is the spread of the spruce bark beetle and black-headed budworm. These pests have been spreading throughout the region and have been observed in the Turnagain Arm area. The rapidity of their spread is based upon the abundance of breeding material and favorable weather conditions.

Fish and Wildlife

The Girdwood valley and adjacent Chugach State Park and Chugach National Forest lands support a wide variety of fish and wildlife resources.

FISH

All five species of salmon, along with dolly varden and eulachon smelt (hooligan) migrate up Turnagain Arm to various streams. Those found in Glacier Creek and its tributaries are pink, chum, coho, and king salmon, as well as some steelhead and dolly varden. The anadromous salmon species have been observed as far up Glacier Creek as the four corners area in the upper valley.

Most fish spawning, however, occurs in the clearer running tributaries and/or their confluence with Glacier Creek. Fish generally avoid glacially fed, braided streams for spawning due to the uncertainty of the river channels. Significant fish milling areas are at the confluences of California and Moose Meadow Creeks with Glacier Creek.

The most significant fish spawning areas are located on California Creek between Alyeska Highway and Crow Creek Road (near the new Girdwood townsite area), and on the lower portion of Moose Meadow Creek. The small tributary/wetland complexes associated with Glacier, California, and Moose Meadow Creeks are the important fish rearing areas.

Little is known about the fishery resources of Virgin Creek, which flows directly into Turnagain Arm. As the stream reaches the lowlands, it enters an area flooded by beavers, which has made it difficult to access. On the opposite side of the valley, the upper portion of the Tidewater Slough is an important holding area for juvenile fish heading out to sea.

WILDLIFE

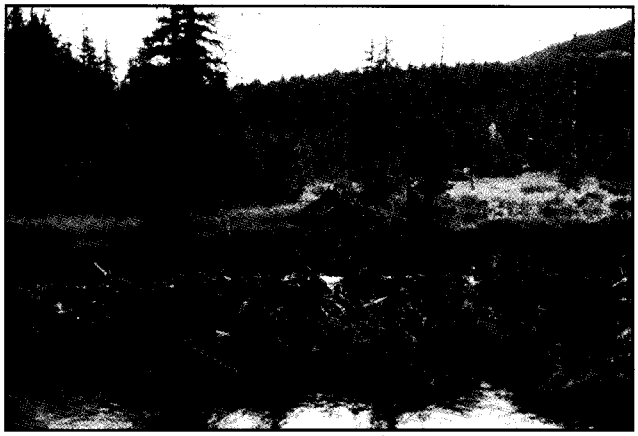
Because of its location between coastal and boreal ecosystems, the Girdwood valley and its surrounding environs support a high diversity of wildlife species. Large mammals that can be found throughout the area include moose, brown bear and black bear. Mountain goats exist in significant numbers on the higher slopes in the upper portion of the valley, while Dall sheep and wolf can be found in the adjacent Chugach State Park.

Recent aerial surveys performed by the Alaska Department of Fish & Game documented approximately 40 mountain goats and approximately 20 moose occupying the upper portion of the valley and surrounding mountains. The lowlands in the valley, and particularly riparian lands along Glacier Creek, are important moose overwintering habitat.

Furbearers commonly found in the valley are beaver, mink, river otter, and weasels. More rare are coyote, wolverine, and lynx. Smaller mammals include squirrel, porcupine, snowshoe hare, voles and shrews.

Marine mammals that can sometimes be seen offshore in Turnagain Arm are beluga and orca (or killer) whales. They come during the annual salmon runs. Other less common whale species, such as the minke whale, occasionally also venture up the Arm.

Many bird species are also present in the area. They include bald eagle, golden eagle, hawks, owls, ducks, geese, swans, ptarmigan, spruce grouse, raven, magpie, and a large variety of resident and seasonal passerines. The coastal wetlands and impounded ponds along the Seward Highway and railroad corridors are important feeding, staging, and nesting habitat for waterfowl, arctic terns, shorebirds, and raptors.



Beaver dam and lodge on Moose Meadows Creek.

Minerals

The two primary mineral resources of interest in the Girdwood valley area are gold and gravel. Girdwood was founded as a result of gold discoveries, particularly in the Crow Creek drainage. Today, most gold mining is recreational and confined to Crow Creek, although Winner Creek may also have some potential for recreational mining.

Nevertheless, there are a few federally recognized gold mining claims in the upper part of Crow Creek drainage that may have commercially recoverable subsurface lode deposits. Although there has been no lode mining activity there for more than half a century, the possibility of future lode mining should not be discounted. In addition, the Girdwood Mining Company has an active placer mining operation at the end of Crow Creek Road.

In the future, the mineral most in demand in the Girdwood area will be gravel. All new development in the area will require gravel for foundation support, be it a road, utility line, or structure. The only local source of gravel material currently in use comes from the Girdwood Mining Company as a by-product of its mining operation. Otherwise, the material must be imported, usually from Portage valley.

The most readily available source of gravel is from the alluvial deposits in and along Glacier Creek. However, previous extractions exceeded the recharge expected from streamflow. In addition, contractors extracting the gravel committed too many violations of environmental stipulations, causing reparable harm to the stream habitat and floodplain. Consequently, the mineral extraction was halted.

A Girdwood area gravel extraction study undertaken for the Heritage Land Bank a few years ago noted two potential sites on municipal land for retrievable amounts of gravel. One site is along Glacier Creek above the airport, and the other is in the Virgin Creek area.

The Heritage Land Bank followed up the report with a soils investigation effort in the alluvial fan of Virgin Creek, which indicated the presence of gravel in recoverable quantities. The

report covering this effort noted, however, that the gravel was discontinuous and interspersed in layers between finer sands, thus requiring separation and processing. The report also advised avoidance of a shallow groundwater table at the lower portion of the study area.

The only other known source of material is a state pit operated by the Department of Transportation & Public Facilities, located south of Virgin Creek next to the Alaska Railroad right-of-way. Its quantity is limited and will continue to be used for highway construction and maintenance purposes, thus precluding any community use.

Natural Hazards

There are a number of natural hazards in the Girdwood valley and on the surrounding slopes that are not unusual for a mountain setting with a high level of precipitation. These hazards can pose a significant threat to life and property, and as such, must be identified and taken into consideration.

FLOODING

The primary cause of flooding is the rapid runoff during heavy rains. The three heaviest floods on record in the Girdwood valley in this century all occurred as a result of heavy rainfall in summer or early fall. However, flooding can also occur as a result of rapid snowmelt during spring, which would be preceded by a sequence of supporting weather patterns.

The main source of flooding is Glacier Creek. Glacier Creek occupies a braided channel in the lower valley, producing a wide floodplain. Other areas prone to flooding are the smaller streams, California, Alyeska, and Virgin Creeks. In the upper valley, on the other hand, flooding is less of a threat. Here, the floodplain of Glacier Creek, as well as its tributaries Crow and Winner Creeks, is much narrower and more confined to the stream channel by steeply rising embankments.

An additional hazard during a flood is presented by floating logs and trees, which can cause jams, erode banks, and change the location of the stream channel. The floating debris can pile up, threaten bridge structures, and cause rapid shifts in the velocity and direction of water flow. There is evidence of channel changes and flood levels on the trees and vegetation in the valley, particularly along Glacier Creek.

Girdwood has not had a major flood in more than 25 years. The last one occurred in 1967, and brought flood waters to the steps of businesses in the new townsite.

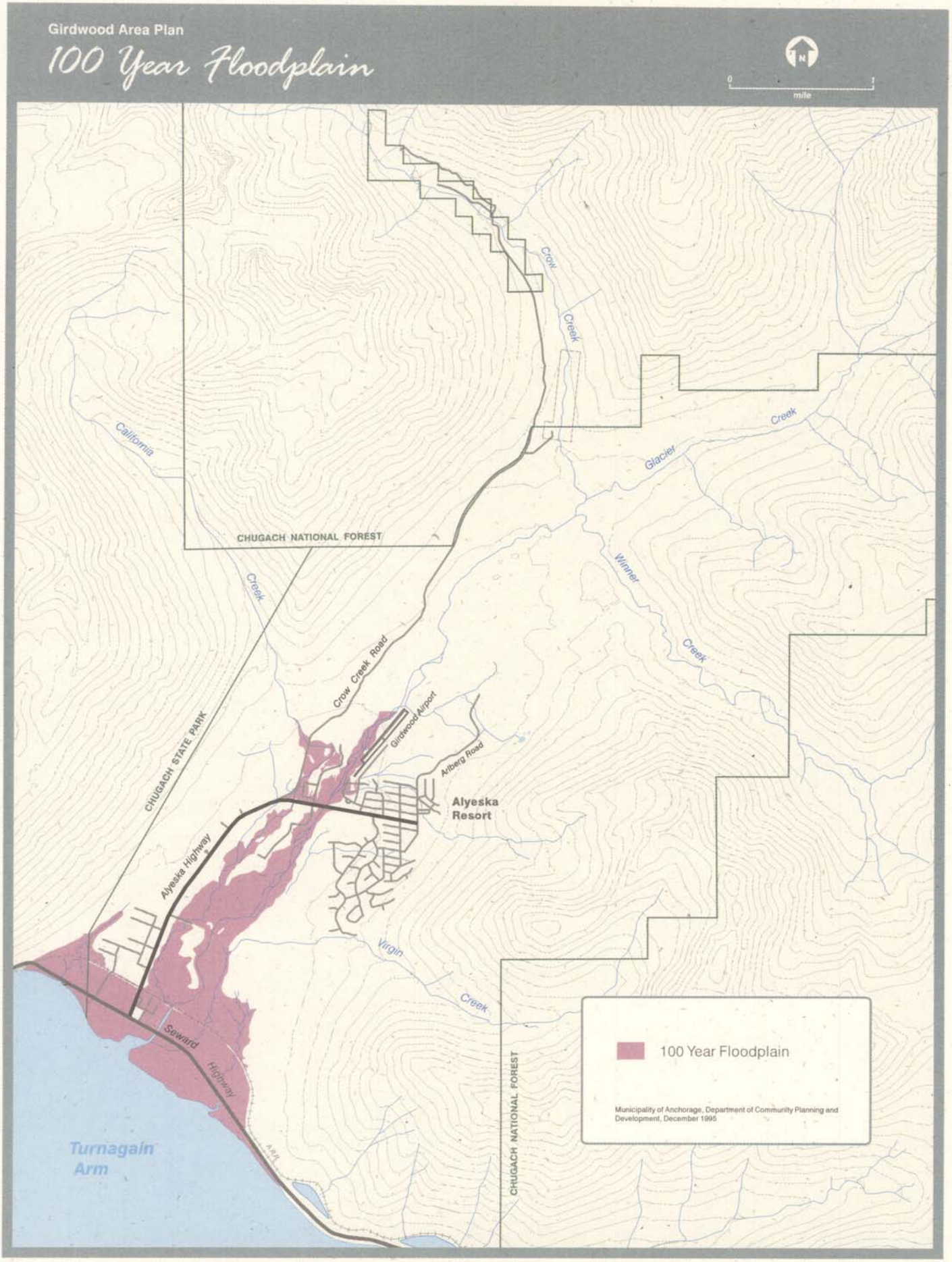
SNOW AVALANCHES

Like floods, avalanches are caused by a combination of terrain and weather. In the case of avalanches, a third factor is also present – the snowpack. Avalanches occur when a portion of an unstable snowpack on or atop a mountain slope releases and moves rapidly downslope. Many times, it may carry vegetative, rock or soil debris with it.

The most dangerous avalanches are slab avalanches. They pose the most risk to people and structures because they tend to fail across an extensive area, encompass a greater mass of material, and attain greater velocities and reach higher impact pressures.

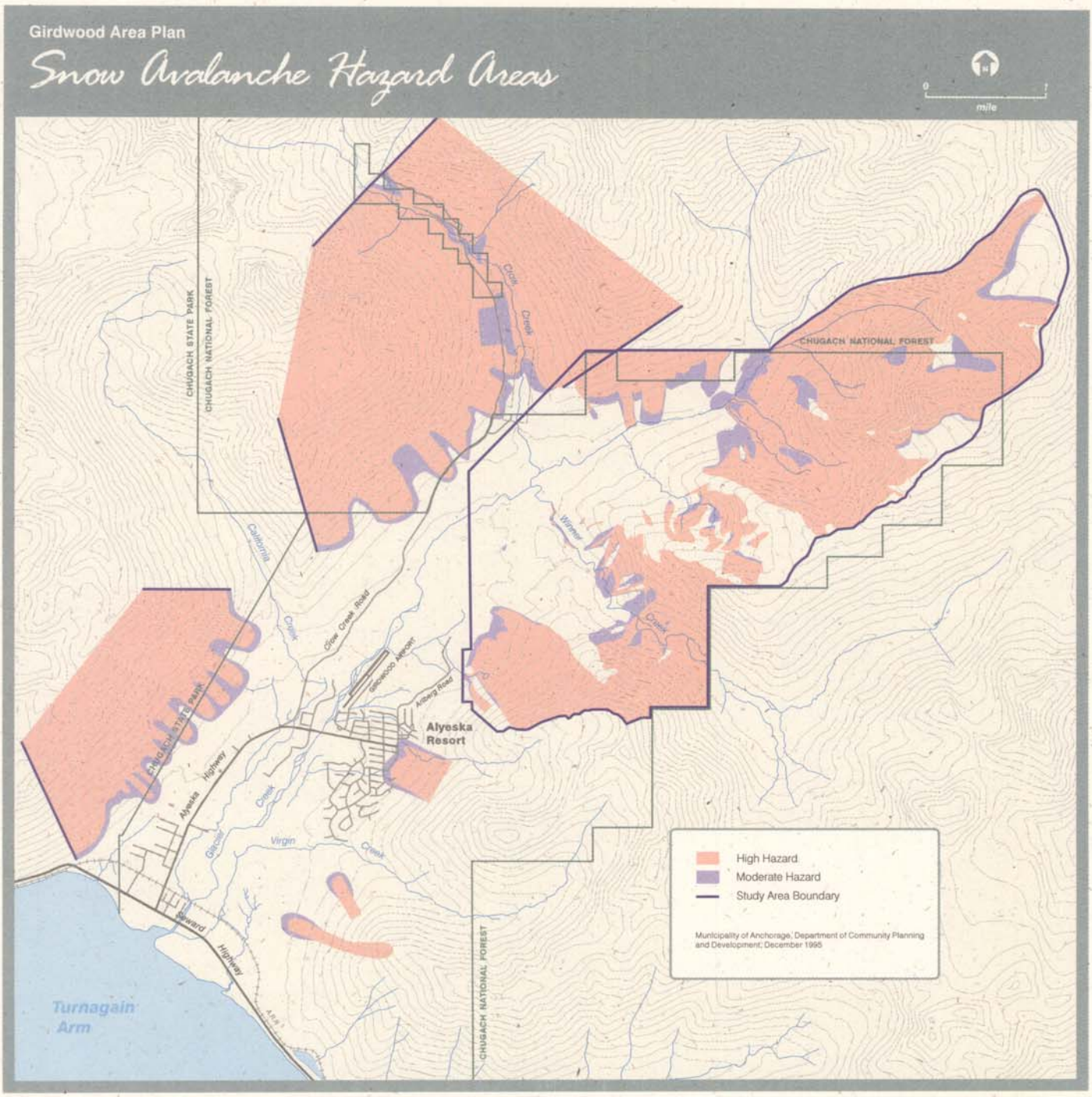
Girdwood Area Plan

100 Year Floodplain



Girdwood Area Plan

Snow Avalanche Hazard Areas



Evidence of snow avalanches are prominent on the mountain sides above the valley. Some avalanches have reached lower elevations at times, snapping large mature spruce trees like match sticks. A number of avalanches have occurred at Alyeska Resort, causing a variety of damage to the facilities.

The best form of avalanche defense is avoidance. Consequently, community development should remain outside known or potential avalanche areas.

MASS-WASTING

The principal mass-wasting processes in the Girdwood valley area are rock avalanches (rock slides), debris flows, and rock falls.

Rock avalanches are widespread throughout the region, initiating within steep rock outcrops in the glacially oversteepened terrain. Typically, failure is initiated as large volumes of rock, soil, snow, and ice in cliff areas fail catastrophically. These slope failures are commonly triggered by earthquake-induced ground vibrations.

An example of a major earthquake-induced rock avalanche which occurred in 1964 is located in Winner Creek valley. The debris from that event fell more than 4,000 feet vertically, while traveling horizontally 10,000 feet. The debris reaching the runout zone traveled approximately one-half mile over nearly flat terrain in the valley bottom.

Debris flows occur in small, steep drainage basins throughout the valley. Debris (usually consisting of mud, rocks, entrained vegetation) typically flows into steep channels which are already conveying large water discharges from snowmelt or rainstorms. The combination of water and material becomes a "slurry" and moves downslope. Areas of debris flow correspond closely to previously identified avalanche hazard areas.

Rockfall occurs within and below steep outcroppings of bedrock throughout the area. Typically, single rocks or a few rocks become detached and fall, bounce, and slide as individual events.

SEISMICALLY INDUCED GROUND FAILURE AND SUBSIDENCE

Earthquakes can trigger a number of natural hazards. In addition to snow avalanches and mass-wasting, earthquakes can also cause ground failure and subsidence in certain areas.

Seismic vibration which occurs during an earthquake may cause ground failure when certain conditions are present. Ground failure occurs when water-saturated material slides or drops to a lower lying area.

Subsidence can be a localized event if the seismic vibrations consolidate previously unconsolidated material resulting in further settlement of the material. Subsidence can also occur on a regional scale, such as occurred for the entire Turnagain Arm area during the 1964 earthquake.

Generally, the Girdwood valley has a moderate to moderately low susceptibility to seismically induced ground failure. Areas underlain with saturated fine-grained materials are more prone to ground failure and subsidence than courser, well-drained areas.

The lower portions of the valley near tidewater are more at risk from regional subsidence, as well as localized consolidation and settlement. In 1964, five feet of regional subsidence and an

additional three feet of local subsidence occurred at Girdwood. This was enough to put many lower lying areas in the old Girdwood townsite underwater during high tides and to force the relocation of settlement further up the valley.

Recent research indicates that certain coastal areas, like Girdwood's, appear to go through natural cycles of earthquake subsidence, post-earthquake restoration and subsequent subsidence over time.

Most of the natural features noted in this chapter were categorically mapped and then composited in order to formulate an image of the Girdwood valley in terms of its suitability, and sensitivity, to development. This was done to create a future community development pattern that will avoid sensitive areas, minimize development costs, and be safe from natural hazards.

A community development suitability map is included in Chapter 6 of this Plan. That map gives a general indication of which portions of the valley are most suitable for community development, which portions are not, and which portions would be with certain design and construction precautions specific to the area.