STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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July 1983

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Alaska Report of Investigations 83-17

GEOLOGIC HAZARDS IN SOUTHEASTERN ALASKA: AN OVERVIEW

By
R.A. Combellick and W.E. Long

STATE OF ALASKA
Department of Natural Resources
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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ERRATA

Please make the following annotations to RI 83-17:

Page 1:

In first paragraph, first line, add: "a number of" after the second word. ("There are a number of geologic hazards....")

Page 3:

The next-to-last paragraph should not be a paragraph.

Page 11:

.In second paragraph, second line, read "beaches," not "benches."

.In fifth paragraph, item 2, line should read, "2. Areas that require corrective engineering measures...."

Page 15:

In next-to-last paragraph, fifth line, read "geologic", not "geothermal."

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INTRODUCTION

There are geologic hazards in southeastern Alaska that may affect development. The hazards include earthquakes, active faults, tsunamis, slope instability, snow avalanches, sediment erosion and deposition, and flooding.

A few studies have described general hazards in southeastern Alaska (Lemke and Yehle, 1972; Post and Mayo, 1971). Other studies have addressed engineering-geologic problems in small areas, primarily near communities (Miller, 1972; Yehle, 1974; Lemke, 1974; Lemke and Yehle, 1972). However, general availability of information on the geologic hazards in southeastern Alaska is inconsistent. Existing information can be supplemented with airphoto interpretations and geologic and soils maps; from them, preliminary assessments of potential hazards can be made. Such assessments would be adequate for preliminary planning, but detailed field investigations are still needed. Depending on the intended use of the area, site-specific field investigations may be necessary.

A geologic hazard is a geologic condition or process---either natural or man-made---that presents a potential danger to life or property. The presence of a geologic hazard does not necessarily preclude development. In most cases, a known geologic hazard can be mitigated through sound land-use practices and proper construction techniques. Appropriate mitigation measures will depend on the hazard, its distribution and extent, its probable severity, and the intended land use.

The brief narrative that follows describes significant geologic hazards in southeastern Alaska, their distribution, controlling factors, likelihood of occurrence, and probable severity. Possible hazards-mitigation measures are also presented.

EARTHQUAKES AND ACTIVE FAULTS

Southeastern Alaska is dissected by numerous faults juxtaposing diverse geologic terranes (Beikman, 1975). The area lies along the boundary between the Pacific and North American crustal plates, where there is a right-lateral displacement of 4 to 5 cm (1.5 to 2 in.) per yr (Page, 1969; Plafker and others, 1976). Although these observations suggest a potential for considerable active faulting throughout the area, nearly all the relative motion between the plates occurs along the Fairweather fault (Plafker and others, 1976). There is no geologic evidence to indicate that other faults in southeastern Alaska have been active since the end of the Tertiary period some 2 million yr ago (Grantz, 1967; Hudson and others, 1982b). Historic seismic activity has not been positively correlated with faults other than the Fairweather fault.

Faults and lineaments that show evidence of substantial displacement or that can be traced for considerable distances in southeastern Alaska are shown in figure 1.

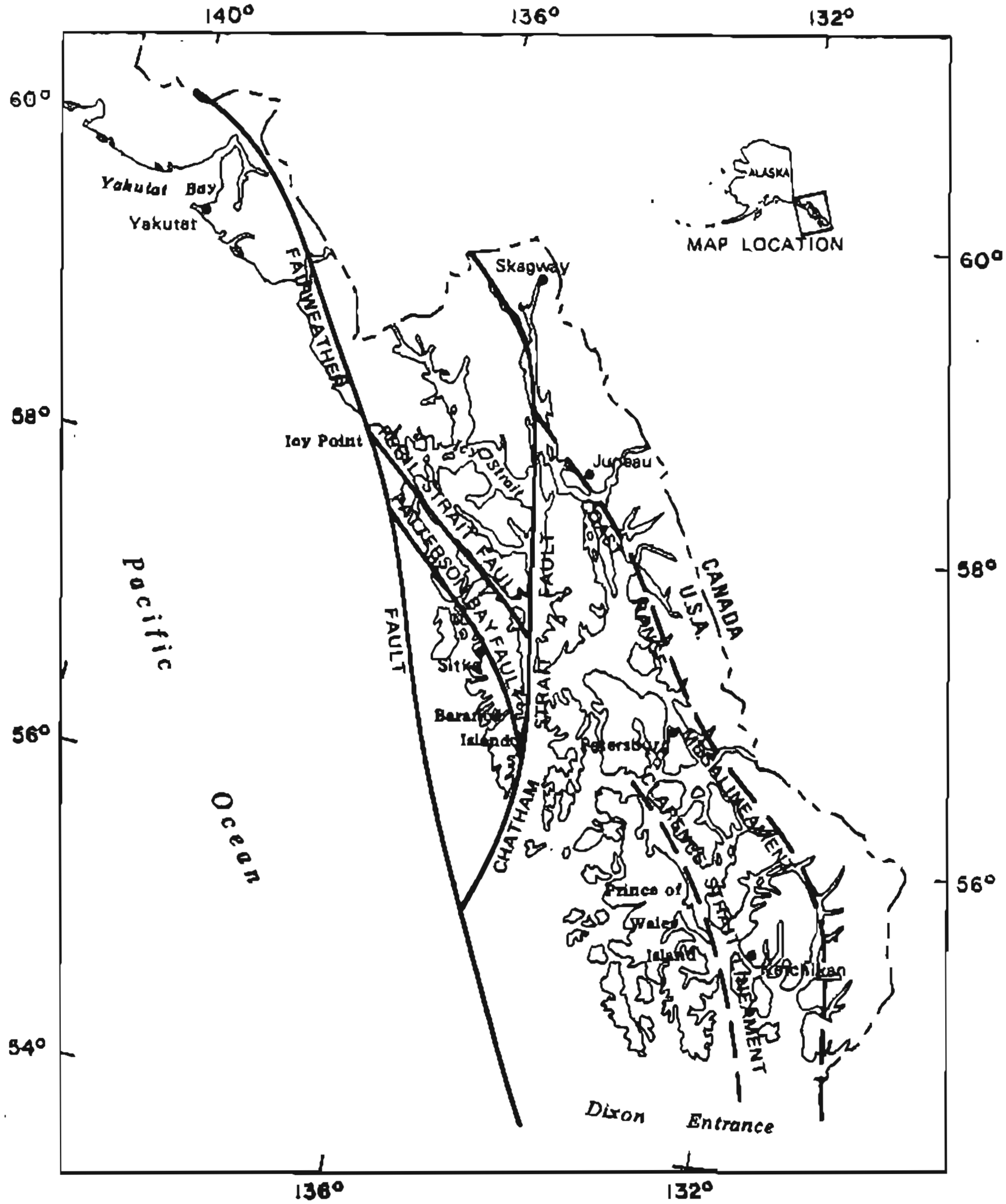

Figure 1. Major faults and lineaments of southeastern Alaska (adapted from Grantz, 1967, p. 9; and Brew and Ford, 1978, p. 1764).

There has been no significant displacement on the Chatham Strait fault for at least 2 million yr (Hudson and others, 1982b). The Peril Strait fault shows no evidence of displacement during the last 23 million yr, and the

Patterson Bay fault has not been active for at least 37 million yr (Grantz, 1967). The Coast Range megalineament is a topographic feature associated with an old structural discontinuity that shows no geologic evidence of displacement during the last 2 million yr and no historic seismic activity (Brew and Ford, 1978). The Clarence Strait lineament shows no conclusive evidence of displacement. If displacement occurred, it was probably during the Cretaceous period, at least 65 million yr ago (Grantz, 1967).

Substantial seismic activity continues along the Fairweather fault. Numerous surface displacements have occurred during historic time. In recent years, large earthquakes were centered along the fault near Prince of Wales Island (1949, magnitude 8.1), Baranof Island (1972, magnitude 7.3), Lituya Bay (1958, magnitude 7.9). The 1958 earthquake was associated with approximately 6.5 m (21 ft) right-lateral displacement and 1 m (3 ft) vertical displacement along the Fairweather fault near Lituya Bay (Tocher, 1960). The earthquake triggered a massive landslide at the head of Lituya Bay that generated a tsunami. This sea wave, which reached a height of 530 m (1,738 ft), killed two people and deforested much of the shoreline of Lituya Bay.

Potential hazards associated with the Fairweather fault include local surface displacement, strong ground shaking, and earthquake-induced ground failures. Landslides triggered by earthquakes may continue to generate destructive waves in Lituya Bay. Because the onshore portion of the Fairweather fault generally passes beneath glaciers or through national-park land, it is unlikely that structures would be placed close enough to the fault for ground displacement to be a hazard. Also, the potential for tsunami generation along the offshore portion of the fault is low because vertical displacements are minor compared to horizontal displacements. Waves produced during the 1949 offshore earthquake were barely distinguishable on mareograms, and measured only 0.2 m (0.7 ft) for the 1972 earthquake (Cox and Pararas-Carayannis, 1976).

Strong ground shaking and earthquake-induced ground failures are the primary hazards from displacements along the Fairweather fault. These hazards are greatest in areas adjacent to the Gulf of Alaska coastline in southeastern Alaska and decrease to the east and northeast. However, there is some potential for major ground shaking anywhere in southeastern Alaska.

Strong ground shaking may result in structural damage to inadequately designed buildings or personal injury from loose or improperly secured objects.

Earthquake-induced ground failures are most likely to occur in water-saturated, fine-grained sediments and in unstable debris and sediments on steep slopes. Failure of water-saturated sediments was a primary destructive effect of the 1964 Prince William Sound earthquake, causing lateral ground movements of many tens of meters in the Turnagain Heights subdivision in Anchorage. The destruction of the Valdez dock facilities was caused by failure of offshore unconsolidated sediments. In southeastern Alaska, water-saturated fine-grained sediments are present in the lower portions of flood plains and below sea level in protected embayments where streams deposit sediment faster than it is removed by wave or tidal action.

There is a high probability of destructive earthquakes occurring along the Fairweather fault in the foreseeable future. On the basis of slip rates and seismic moments, Lahr and others (1980) estimate average recurrence intervals of 12 yr for earthquakes of magnitude 6.6 or larger, 55 yr for earthquakes of magnitude 7.3 or larger, and 240 yr for earthquakes of magnitude 7.9 (the largest recorded along the fault). These estimates are only approximate and actual recurrence intervals may vary substantially. Woodward-Clyde Consultants (1982) estimated an average return period of 80 yr for magnitude 8 earthquakes, based on the historic earthquake record.

Although the Fairweather fault is the only probable source of large earthquakes in southeastern Alaska, a second source of earthquakes that could affect the northwestern part of the region is a zone of low-angle thrust faults extending from Yakutat Bay westward to Cape Suckling. This zone was the source of two major earthquakes (magnitudes 8.5 and 8.4) in September 1899 and a magnitude 7.7 earthquake in February 1979. The 1899 events produced several meters of uplift in the Yakutat Bay area (Tarr and Martin, 1912). Because of the length of time that has passed since the major 1899 events, and because the 1979 event did not fully relieve the stress that accumulated after 1899, this zone (called the Yakataga seismic gap) is expected to be the site of a great earthquake (magnitude 7.8) during the next 2 decades (McCann and others, 1980).

To mitigate the hazards of earthquakes and active faults:

1. Human-occupied structures or critical facilities (for example, power plants, dams, police and fire stations) should be designed and constructed to meet or exceed minimum specifications of the Uniform Building Code of 1982 or other accepted seismic design standards.

2. In areas of high earthquake hazard such as steep slopes or unconsolidated sediments, engineering-geology investigations should be done before construction to determine susceptibility of the site to earthquake-induced ground failure. Susceptible areas should be avoided or appropriate construction methods, such as pilings driven to underlying bedrock, should be used.

3. Permanent or critical structures should not be built on or adjacent to the Fairweather fault. In the unlikely event that a structure must be placed on or near the fault, the exact location of the fault should be determined and a setback of at least 15 m (50 ft) should be used in siting the structure.

VOLCANISM

There are no active volcanoes in southeastern Alaska. A few scattered volcanic vents along Lisianski Inlet on Chichagof Island, in western British Columbia, and in southern southeast Alaska were active in Quaternary time, but none show evidence of Holocene activity. Mount Edgecumbe, on Kruzof Island northwest of Sitka, is part of a small volcanic field active in Pleistocene and early Holocene time. Radiocarbon dates show that the most recent major eruption of Mount Edgecumbe was about 9,000 yr ago (Henning and others, 1976).

TSUNAMIS

Included in the category of tsunamis are seismic sea waves generated by distant and nearby earthquakes and large waves generated in a restricted body of water by a landslide, rockfall, or debris avalanche that may or may not be triggered by an earthquake. Only nine tsunamis over 1 m (3 ft) high have been recorded in southeastern Alaska since 1788 (Cox and Pararas-Carayannis, 1976). Although infrequent, the possibility of tsunamis in southeastern Alaska should be considered in long-range planning.

The hazard from distant tsunamis is greatest along the outer coast and along the outer portions of major entrances, such as Cross Sound, Chatham Strait, Sumner Strait, and Dixon Entrance. Protected areas further inland may experience no more than a gradual rising and falling of sea level out of phase with the tides. The impact of a distant tsunami depends on the direction of the source, size and character of the wave, configuration of the coastline, shape of the ocean floor, and stage of the tide. These variables make it difficult to determine the areas that may be damaged by distant tsunamis. A widely accepted standard (Office of Emergency Preparedness, 1972) defines the areas of greatest hazard from a distant tsunami as those within 1.6 km (1 mi) of the coast lower than 15 m (50 ft) above sea level. This standard must be applied cautiously because of the wide variations in factors that affect tsunami impact.

Qualitative estimates for severity of hazard from distant tsunamis have been made for a number of communities in southeast Alaska (Carte, 1981). A rating of high, moderate, or low was assigned based on maximum expected tsunami heights of 15, 10, and 6 m (50, 35, and 20 ft), respectively (table 1).

Local tsunamis are more hazardous than distant tsunamis, but they are also much harder to predict. In southeastern Alaska a local tsunami is more likely to be generated by a landslide or rockfall than by fault displacement during a local earthquake. Local tsunamis are more hazardous because of the potential for a landslide or submarine slump to displace large volumes of water and insufficient time for issuing warnings. Surges generated by landslides can exceed 30 m (100 ft). The 1958 surge in Lituya Bay, the largest ever recorded, reached a height of 530 m (1,738 ft) above the shorelines on a mountain opposite the slide.

Sheltered bodies of water, bounded by high, steep slopes of unstable sediment or rock, are most vulnerable to landslide-generated tsunamis. The hazard is greater along the outer coast, where ground shaking from earthquakes along the Fairweather fault is likely to be stronger. The standard adopted by the Office of Emergency Preparedness (1972) for tsunamis of local origin defines areas of potential danger as those within 1.6 km (1 mi) of a shoreline that are lower than 30 m (100 ft) above sea level. This definition is broad and, if strictly applied, would be conservative in some cases and inadequate in others (Lituya Bay, for example). Site-specific assessments can help to define tsunami hazard areas.

Table 1. Estimated hazard from distant tsunamis for selected communities in southeastern Alaska (from Carte, 1981, updated 1982). 'High' means a wave of 15 m (50 ft); water reaching up to 1.6 km (1 mi) inland is possible. 'Moderate' means a 10-m (35-ft) wave; water reaching up to 1.2 km (3/4 mi) inland is possible. 'Low' means a wave of 6 m (20 ft); water reaching up to 0.8 km (1/2 mi) inland is possible. All communities have a hazard from local tsunamis that could reach the community before a warning could be issued.

Site	Est. hazard	Site	Est. hazard
Angoon	moderate	Klawock	moderate
Annette	moderate	Lena Cove	low
Auke Bay	moderate	Metalkatla	moderate
Cape Pole	moderate	Mud Bay	low
Chatham	low	Myers Chucks	low
Craig	moderate	Pelican	high
Douglas	low	Petersburg	low
Edna Bay	moderate	Point Baker	moderate
Elfin Cove	high	Port Alexander	high
Gustavus	moderate	Saxman	low
Haines	low	St. John Harbor	low
Hamilton Bay	moderate	Shakan Bay	low
Hoonah	low	Sitka	high
Hydaburg	low	Skagway	low
Hyder	none	Tenakee Springs	low
Juneau	low	Thorne Bay	none
Kake	moderate	Ward Cove	low
Kasaan	low	Wrangell	low
Ketchikan	low	Yakutat	high

To mitigate the hazards of tsunamis:

1. Tsunami-hazard zones should be established in areas of proposed development based on the above standards or, preferably, on site-specific evaluations. Development in the zone should be restricted to docking and harbor facilities, open-space recreational areas, parking, and other low-density uses. Critical facilities, such as police and fire stations, hospitals, schools, and permanent housing, should be located outside the zone.

2. A tsunami warning system, including sirens and communications facilities, should be established. A permanent and reliable system for receiving messages from the Alaska Tsunami Warning Center should be installed in each coastal community or logging camp.

SLOPE INSTABILITY

Mass movements not related to earthquakes may also occur in southeastern Alaska. (Snow avalanches are treated separately in the next section). Under the general category of landslides, many different types of large-scale slope failures are common to southeastern Alaska, including debris flows, debris avalanches, rock slides, and rock falls. Landslide scars and deposits have only been mapped in and near some existing communities. A surficial geologic map of the Juneau area (Miller, 1975), for example, shows numerous debris-flow deposits, rockslides, and undifferentiated landslides, many of which lie in or near developed areas.

Most of the large-scale mass movements in southeastern Alaska are debris flows and debris avalanches. These involve mixtures of soil, rock, and forest debris with varying amounts of water (Swanston, 1969). Over 3,800 large-scale mass movements were counted within the Tongass National Forest (fig. 2). Generally, the debris flows and avalanches occur on slopes of 35° to 60° and involve shallow soils that are derived from weathered bedrock and colluvium. These soils contain a large proportion of large angular rock fragments and some organic debris, and are highly permeable. Underlying bedrock surfaces are often hard and glacially smoothed and steepened, offering little obstruction to downslope movement of the overlying soil and retarding the escape of water.

Debris flows and avalanches also occur in soil profiles developed on till (glacial deposits). Surface-water saturation of the weathered soil profile during heavy rains decreases its shear strength. The failure begins as a rotational movement (slump), with the underlying unweathered till providing the slip surface. The soil mass picks up speed in a downslope direction and develops into a debris flow or avalanche. Till slopes of 34° to 40° are most susceptible to failure, with the most common occurrence on slopes of about 37°. This corresponds with the internal angle of friction determined in the laboratory for these soils (Swanston, 1974).

Rockslides in southeastern Alaska are common on steep slopes underlain by fractured or weathered bedrock. Foliation planes of soft platy minerals in metamorphic rocks provide additional weak zones along which the rock can slide or break apart. Frost action and tree roots help to separate the rocks along these zones of weakness (Miller, 1972).

Nonearthquake-induced slope failures are usually triggered by water saturation from heavy rainfall or rapid snowmelt. Excess water increases the downslope driving force by adding weight to the soil and decreases the resisting forces by saturating the soil and lowering its shear strength. Shallow tills in southeastern Alaska become saturated during storms that produce rain exceeding 13 cm (5 in.) in 24 hr. Such storms occur in southeastern Alaska every 2 to 5 yr (Swanston, 1969).

Artificial factors also contribute to slope failures in southeastern Alaska. Common construction mistakes are undercutting the toe of a slide or overloading an unstable slope with man-made structures. Timber harvesting is also a leading contributor to slope failure. A correlation has been found between frequency of mass movements and timber harvesting (Bishop and Stevens, 1964). As tree roots decay, natural slope stabilization and water absorption are reduced; this appears to be a primary cause of slope failure in harvested areas. The frequency of debris avalanches increases 3 to 5 yr after cutting, which corresponds to the time required for the root systems to decay.

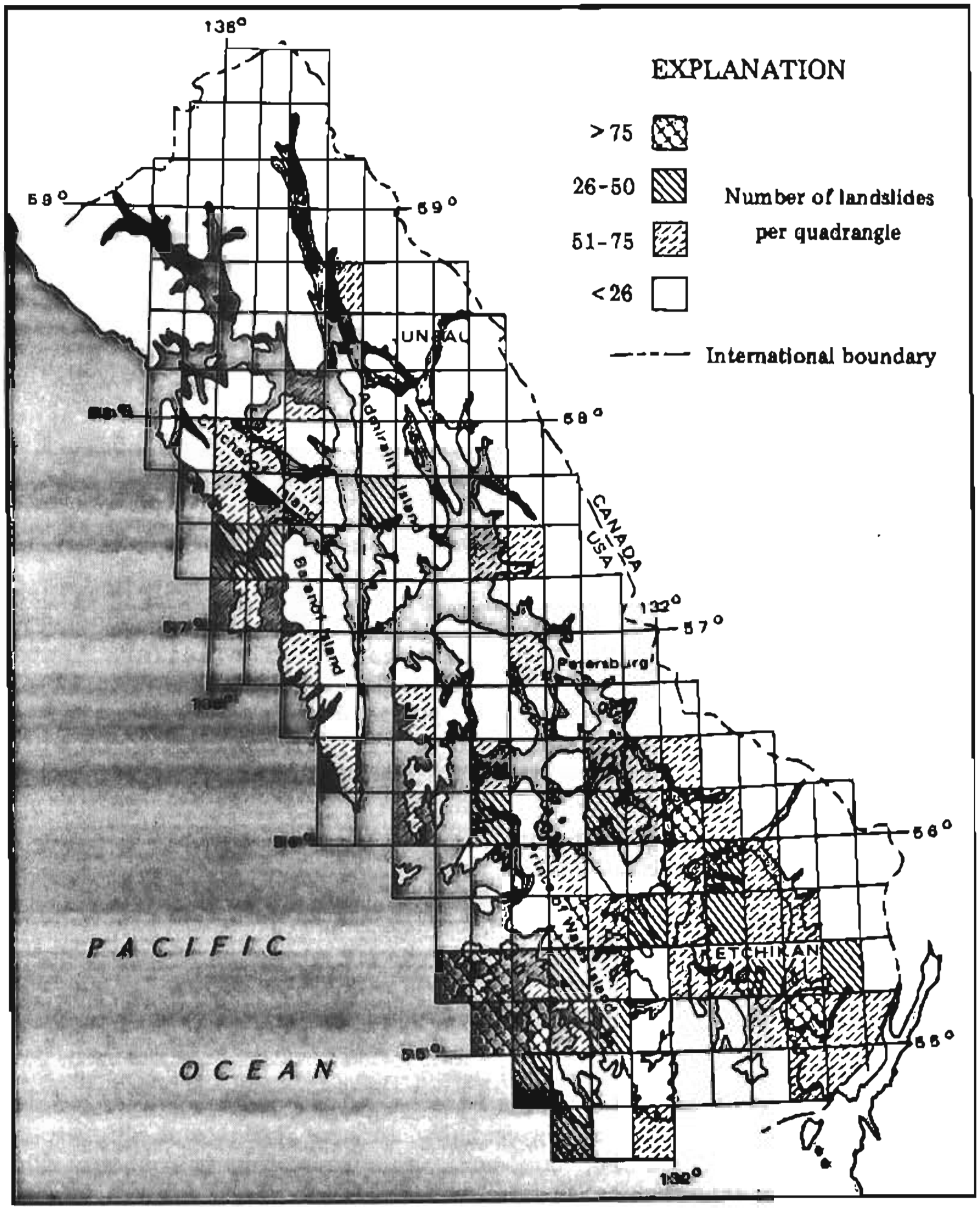

Figure 2. Landslide distribution in southeast Alaska, expressed as number per 15-minute map quadrangle (adapted from Swanston, 1974, p. 7).

The first step in locating unstable areas is to identify and map past slope failures. Areas adjacent to unstable slopes will probably also be unstable. However, many slopes that show little or no evidence of past slope failure may also be unstable. An anomalously heavy rainfall, artificial disturbance, or rapid snowmelt after a winter of heavy snow may be all that is needed to trigger numerous failures on a slope with no evidence of instability.

To mitigate the hazards of slope instability:

1. As part of land-use planning, areas of moderate to steep slopes should be examined for landslide potential by professional engineers or geologists.

2. Construction, excavation, or logging on, above, or below potentially unstable slopes should be preceded by field studies, including drilling or trenching, to determine appropriate grading and construction methods.

3. Use of areas on or below slopes that have potential for severe failure should be restricted to open space, recreational, mineral, and agricultural use. Activities that increase susceptibility to slope failures (such as logging) should be prohibited or restricted if slope failures pose a danger to life or property. Critical facilities, homes, and other buildings for human occupancy should not be located in areas susceptible to major slope failures.

SNOW AVALANCHES

Heavy snow precipitation, high terrain, and steep slopes combine to create high avalanche potential over much of southeastern Alaska. Condition of the snow pack differs considerably throughout the region because of differences in elevation, slope, precipitation, temperature, and vegetation.

In southeastern Alaska, the snowpack, which is generally warm and deep, is modified by strong, variable winds and occasional rainshowers during warmer periods. Slope orientation relative to storm paths, wind shadows, and cloud cover has a stronger effect on avalanche potential than direction of incoming solar radiation (Hackett and Santeford, 1980). Avalanches may favor one aspect during one season and a different aspect another season. Large avalanches tend to recur along established paths, although any areas of high, steep terrain can be hazardous because of the wide variability in conditions. An important factor in southeastern Alaska is the strength and variability of winds. Wind, which transports and deposits large volumes of snow, can create a hard crust, providing a sliding surface for snow deposited later.

The severity of hazard from avalanches depends on the nature of the human presence in an avalanche-prone area. Many snow slides and small avalanches occur at high elevations and may be dangerous only to the occasional skier. On the other hand, large, dense, flowing avalanches can reach impact pressures of several tons per square meter (Mears, 1976), travel large distances down a slope (often beyond the base of the slope), and destroy structures not specifically designed to withstand the impact pressures. On many steep slopes in southeastern Alaska, large avalanches incorporate other debris on reaching lower snow-free elevations, thereby substantially increasing potential impact pressures.

Avalanche-potential maps have not been prepared for most of southeastern Alaska at scales appropriate for land-use planning or site-specific evaluation. A preliminary small-scale avalanche potential map of Alaska divides southeastern Alaska into zones of high and moderate potential based primarily on differences in snowfall (Hackett and Santeford, 1980).

Generally, mainland areas have higher snowfalls---and therefore higher snow-avalanche potential---than the milder island and coastal areas. At a scale of 1:63,360, Davidson and Hackett (1980) prepared a generalized map of provisional snow-avalanche potential for the Juneau B-2 Quadrangle based on elevation, slope, known and suspected avalanche activity, climatic conditions, and regional snowpack characteristics. Other than several large-scale studies of the Juneau vicinity (Daniel and others, 1972), detailed information on snow-avalanche potential is not available for most of southeastern Alaska.

Avalanche potential can be assessed by identifying and mapping avalanche scars and moderate to steep slopes above treeline. Although this technique may overlook adjacent areas having avalanche potential, it will identify those areas most susceptible to avalanche activity. In general, any moderate to steep slope in southeastern Alaska (greater than about 30°) that rises to elevations above 300 m (1,000 ft) above sea level (and land downslope from such areas) should be suspected as having avalanche potential. Detailed field investigations should be done in such areas prior to development.

To mitigate the hazards of snow avalanches:

1. Prohibit building of permanent structures in areas of moderate to high avalanche potential and restrict those areas to low-density or transitory uses such as summer recreation, parking, and habitat preserves.

2. Where structures must be built in areas of avalanche potential, install snow-supporting fences in the starting zones and deflecting or protection structures in the runout zones. These approaches are quite expensive.

3. Before removing vegetation (such as by loggers), determine its effect on avalanche potential, particularly if the area is upslope from existing or proposed structures.

4. Develop avalanche warning systems for any frequently used areas of moderate to high avalanche potential.

5. Artificial triggering of avalanches with explosives or artillery should not be considered an acceptable mitigation technique in developed areas.

SEDIMENT EROSION AND DEPOSITION

Riverbank, soil, and coastal erosion all occur in southeastern Alaska to varying degrees. The problem is localized and must be examined on a site-specific basis. Because the two major rivers in southeastern Alaska, the Alsek and the Stikine, pass through national-park and wilderness areas, riverbank erosion is not an extensive or persistent problem for development. Substantial erosion can occur during floods; therefore, flood zones are also subject to erosion problems.

Soil erosion occurs primarily in timber-harvest areas, but also affects areas downslope and downstream where large volumes of eroded sediment may be deposited. Under natural conditions, areas of dense forest cover are eroded very little, but can be subject to severe erosion if trees are removed. Where vegetation is removed, erosion may begin as sheetwash and gully erosion, and then develop into debris flows. Tree cutting increases runoff because it reduces the amount of water intercepted by the canopies or absorbed by the roots through transpiration.

Most coastlines in southeastern Alaska are dominated by steep slopes and cliffs with no significant benches and can be classified as erosional or neutral. Site-specific information on erosion rates is available for a few communities, but no regional evaluation of coastal erosion has been made. The severity of coastal erosion can only be determined by long-term surveys or by comparison of aerial photographs and large-scale maps over several decades. The latter are not available for much of southeastern Alaska for periods long enough to determine rates of coastline change.

Sediment deposition is primarily a problem in channels and harbors. Sediments are deposited near the mouths of streams or in areas where wave-generated longshore currents transport sediment from areas of high wave-energy to areas of low wave-energy. For example, sediment from the Mendenhall river near Juneau continues to build a delta southward across Gastineau Channel, creating a serious navigational hazard. Only small boats are now able to use that portion of the channel, and many run aground each year. Though strong tidal currents remove much of the sediment deposited by the river, the channel may be closed off completely if not periodically dredged. The Chilkat River has the highest sediment yield per square kilometer of drainage area of any river in Alaska (8.4 million metric tons) and is depositing an extensive fan and delta as its mouth in Lynn Canal (AEIDC, 1975).

To mitigate hazards from sediment erosion and deposition:

1. Potential problems of erosion or deposition should be taken into consideration prior to any development along a stream or coastline, or prior to opening an area of timber harvesting. Site-specific studies based on expected erosion rates should be performed to establish setback distances on coastlines or riverbanks.

2. Corrective engineering measures such as jetties, seawalls, or revetments should be avoided. Although such measures may correct an erosion problem in one area, they may contribute to erosion or deposition in another; moreover, they are often only temporarily effective.

REGIONAL UPLIFT

Although rapid land uplift associated with major earthquakes (as occurred during the 1899 earthquake at Yakutat Bay) can be a potentially serious geologic hazard, gradual regional uplift is not. However, because this process is taking place in southeastern Alaska and can be significant over long periods, it should be considered in long-range planning. Regional uplift is important to consider when selecting sites for community and coastal facilities.

Tide-station data and changes in elevation of tidal bench marks have been used to calculate average uplift rates in southeastern Alaska for more than

40 yr (fig. 3). Because maximum uplift is occurring at Glacier Bay, it is assumed to be an isostatic rebound effect from deglaciation over the past several thousand years. However, significant emergence has been recorded in areas not recently glaciated, such as Admiralty Island, and cannot be attributed to ice unloading. Hudson and others (1982a) interpret this uplift as a "transient bulge of tectonic origin," probably related to buildup of strain along the Fairweather fault.

From 1939 to 1959, total uplift ranged from zero at Ketchikan to over 70 cm (27.6 in.) in Glacier Bay, a rate of 3.5 cm (1.4 in.) per yr (Hicks and Shofnos, 1965). From 1959 to 1980, maximum uplift of approximately 60 cm (23.6 in.) was recorded in the northern Glacier Bay and Chilkat Peninsula areas, an average rate of 3 cm (1.2 in.) per yr (Hudson and others, 1982a). Assuming maximum uplift continues at a rate of up to approximately 3 cm per yr, coastal areas in northern southeastern Alaska should expect up to 150 cm (5 ft) of emergence over the next 50 yr. The effects of this rate of uplift should be considered in long-range community planning and in selecting sites for new coastal facilities. New harbor sites, for example, should be deep enough to accommodate emergence over their expected lifetimes.

FLOOD HAZARDS

General Climatic and Geographic Setting

Flooding occurs on all rivers in southeastern Alaska and therefore any flood-plain area is subject to flood hazard. High precipitation and glacial outburst are the most common causes for floods.

The geography of southeastern Alaska is dominated by rugged coastal-range mountains with valleys of high relief. The streams are typically steep, short, and fast flowing. A few large rivers originate in Canada and cut through the mountains. Stream basins often contain large, glacier-covered areas.

The climate of southeastern Alaska is dominantly marine with high precipitation and relatively mild temperatures. Mean annual precipitation reaches 250 in. in some areas. Much of the precipitation is snow due to the high elevation of the coastal mountain ranges. The snow accumulation causes extensive glacierization of the mountains. Southeastern Alaska contains more glaciers than any other Alaskan area, with extensive ice fields and active valley glaciers.

Stream valleys usually can contain normal high and low flows, but conditions occasionally cause more water to flow than the channels can contain.

Flood Causes

High, intense precipitation is the primary cause of southeastern Alaska flooding. Meteorological records indicate that most intense storms occur during the fall (late August to early November). A particularly dangerous condition of the region for flooding is that of an early heavy snowfall

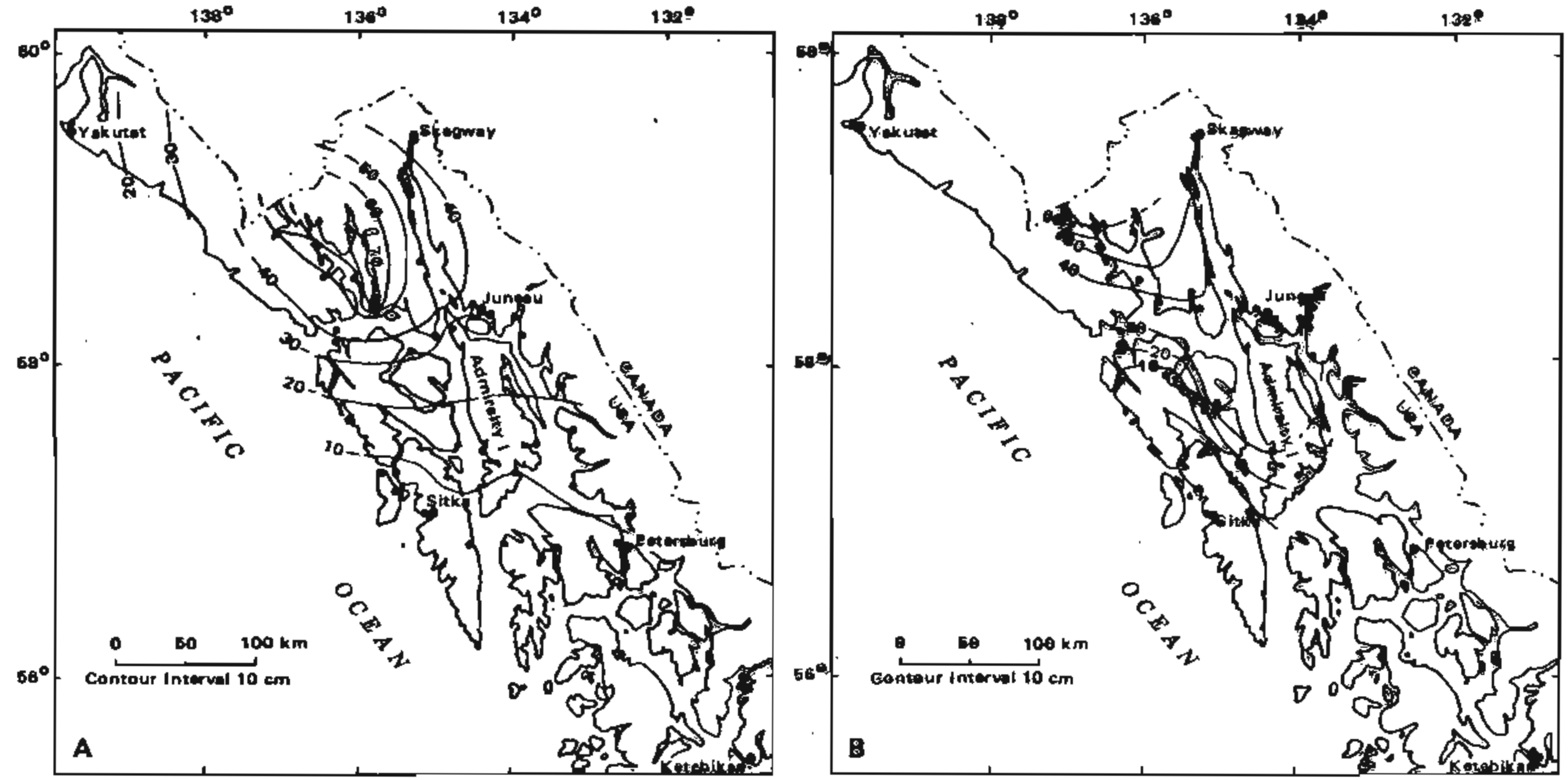

Figure 3. Contoured total uplift in southeastern Alaska over two 20-yr periods based on sea-level observations at numbered station locations: a) stations and uplift data for period 1939 to 1959, modified from Hicks and Shofnos (1965); b) stations and uplift for period 1959 to 1980 for observations in 1979 and 1980 (Hudson and others, 1982a, p. 134).

followed by warmer temperatures and large amounts of rain. The combination of high precipitation and melting snow causes unusually large volumes of water to flow, resulting in floods. Another major cause of flooding in some drainages is glacial outburst, or the sudden release of glacially dammed water.

Duration of Floods

Floods are typically of short duration but of high discharge. The glaciers of the area probably contribute to high mean flow during summer periods, but would tend to moderate storm precipitation runoff because much of the water becomes part of the glacier's ice mass.

The steep terrain and absence of soil on the slopes result in rapid runoff of precipitation. Therefore, intense storm precipitation rapidly reaches the stream systems.

Historic Floods of Southeastern Alaska

Most communities in southeastern Alaska have a history of floods; however, scientific data on flooding are limited. The Mendenhall River and Lemon Creek in the Juneau area flooded in 1927, 1943, and 1961. The Skagway River flooded in 1901, 1919, 1927, 1936, 1943, 1944, 1949, and 1967. All these floods occurred during September and October. The 1943 flood was the 'flood of record' and had a unit runoff of 2.63 cu m/sec/sq km (241 cu ft/sec/sq mi.)---a very high unit runoff. Dikes constructed by the U.S. Corps of Engineers protect the City of Skagway from 50-yr or smaller floods. Skagway is an exception; most southeastern Alaskan communities do not have flood protection for developed areas on flood plains.

Carlanna Creek in the Ketchikan area flooded in 1973, causing damage valued at more than $2 million. This flood was caused by heavy rains and the failure of a 25-yr old dam.

The pattern of flooding throughout southeastern Alaska shows that rivers flood during the fall from heavy precipitation. Flooding is often accentuated by unusual local factors such as ice jams, logjams, or breached dams. Dams of natural or man-made origin may breach. The Taku River was dammed by a landslide and subsequent breaching caused flooding below the dam. In the case of the Carlanna flood, a man-made structure failed.

Outburst Floods

Floods caused by the rapid release of glacially dammed water can occur at any time of the year, but particularly during the summer months. Fifty-three glacier-dammed lakes are listed in the AEIDC Alaska regional profiles, southeast region (1975). Valleys below these impounded water bodies are apt to be flooded when glacial ice dams fail. Glacial outburst floods can be more destructive than even the most extreme precipitation-caused flood. Areas subject to outburst flooding in southeastern Alaska have been mapped by Post and Mayo (1971).

Flood Studies and Reports

Detailed flood hazard studies have only been conducted for a few southeastern communities. The U.S. Corps of Engineers has published 'Flood Plain Information reports' for nine streams: Mendenhall River, Lemon Creek, Eagle River, Herbert River, Salmon River, Ketchikan Creek, Carlanna Creek, Whipple Creek, and Hoadley Creek. Also, Flood Insurance Studies have been published by the U.S. Corps of Engineers for Haines, Hoonah, Juneau, Kake, Ketchikan, Metlakatla, Petersburg, Sitka, Skagway, and Wrangell. These studies roughly outline potential 100-yr flood areas on the flood plain.

Summary of Flood Hazards

River valleys with their flood plains and terraces make up most of the relatively flat land in southeastern Alaska. Therefore, flood-plain areas are used for many cultural activities in the region. However, flood plains also are subject to flooding. Any land-use analysis should include a detailed evaluation of the local flood plains.

Floods also relate to other hazards such as erosion and deposition. Erosion of banks and resulting damage to structures adjacent to river channels can be an expensive or dangerous result of flooding. Also, when stream courses shift, the resulting sediment deposition is a hazard to structures and other developments affected by sediment inundation.

Streams of glacial origin have more sediment to carry than the stream can transport. Therefore, channels of glacial streams take on a braided pattern because of shifting channels. New channels often are cut into older parts of the flood plain and begin to deposit sediment.

SUMMARY AND CONCLUSIONS

Future development in southeastern Alaska must take into consideration potential geologic hazards due to earthquakes, active faulting, tsunamis, slope instability, snow avalanches, erosion, deposition, and flooding. The most recent volcanic activity in southeastern Alaska was at least 9,000 yr ago; thus, volcanoes are not considered a hazard. Regional uplift is also not a serious hazard, although it is occurring in northern southeastern Alaska at rates that warrant consideration in long-range planning for coastal communities.

The severity of hazards to people and property in developing areas depends on the intended land use and the likelihood of occurrence and intensity of the process described above. The presence of one or more of the hazards does not necessarily preclude development in an area. Potentially harmful effects of geothermal hazards can be mitigated through sound land-use management and proper construction, excavation, and timber-harvesting practices.

Because of the lack of detailed information needed for assessment of site-specific effects over much of southeastern Alaska, only generalizations about the regional distribution, occurrence, and severity of the hazards are possible at this time. Development should be preceded by site-specific studies, particularly if the regional information indicates the possibility of a hazard.

ACKNOWLEDGMENTS

This report was prepared in cooperation with the Division of Research and Development, Alaska Department of Natural Resources, for use in the state National Forest Land Selection Project and by the general public. Review comments and suggestions by G.D. March, J.E. Decker, and R.D. Reger are appreciated.

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