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MISCELLANEOUS PUBLICATION 129

SURVEY OF GEOLOGY, GEOLOGIC MATERIALS, AND GEOLOGIC HAZARDS IN PROPOSED ACCESS CORRIDORS, ALASKA

This booklet accompanies Miscellaneous Publications 45 through 122 and provides a detailed explanation of the rationale, methodology, and data presented on the maps. It is strongly suggested that this information be available to users of any of the maps in this series.

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Survey of Geology, Geologic Materials, and Geologic Hazards in Proposed Access Corridors in Alaska

Survey of Geology, Geologic Materials, and Geologic Hazards in Proposed Access Corridors in Alaska

by

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Introduction

Access to Alaska's mineral lands is a strategic issue for the mineral industry and the state and federal governments. During previous campaigns undertaken by the state of Alaska to choose statehood entitlement lands, many potential access corridors were identified and linked in a conceptual long-range transportation grid. This grid is the basis for much of the state's current transportation planning and is consulted when considering access to new mineral discoveries. In 1992, the Alaska Division of Geological & Geophysical Surveys (DGGS) compiled a series of 1:250,000-scale digital geologic maps for these transportation corridors from compilations of previously published and unpublished reports, and interpretations of aerial photographs and satellite imagery. The 10-mile-wide corridors straddling proposed access routes were compiled, by quadrangle, so that 1-mile-wide access corridors connecting strategically important centers of population, ports, pinch points, and resource-rich lands could ultimately be located to accommodate favorable terrain and avoid natural hazards and so that available geologic-materials resources could also be selected.

The corridor maps were used for planning during the State land selection process but were never formally released. By 1999 it became apparent that the digital map files were no longer useable because they were made for a plotter technology that was no longer supported. Thus, these maps were no longer available to policy makers, mineral explorationists, and engineers who have need of the information that they portray. In 2001, DGGS instituted a project to formally release the map products and data compiled during the previous study in order to provide public access to geologic, geologic-materials, and engineering-geologic information that can affect decisions about transportation options for mineral development and other diverse enterprises.

The goals of the 1992 DGGS corridor project were: (1) to prepare 1:250,000-scale maps of the geology, geologic materials, and geologic hazards for 10-mile-wide corridors containing proposed access routes and traversing 78 quadrangles (fig. 1); (2) to establish the quality of the data from which these maps were prepared; and (3) to document the results of the study. This report presents the results of those previous efforts, and provides a summary overview to accompany the re-

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drafted, single-quadrangle digital map suites. The user should note that the only changes made to the original 1992 products are to the digital data files and map cartography; none of the reference information has been updated to reflect subsequent mapping in the quadrangles traversed by the proposed access corridors.

RATIONALE

Geologic maps portray the general distribution of geologic units at the surface of the Earth. These maps are prepared by geologists during studies of exposed rocks and sediments or landforms that result from the presence or placement of rocks and sediments. Field and laboratory studies of materials comprising geologic units and landforms in Alaska demonstrate that each geologic unit or landform has a definite composition or range of composition wherever that feature is present (table 1) (Kreig and Reger, 1976, 1982). Thus, we derived a series of geologic-materials maps from geologic maps or by interpreting landforms (in 14 quadrangles where map information is inadequate)[5] (map a). Our geologic-materials maps are generalized. They do not attempt to show exact locations of specific materials but are intended to indicate general areas that deserve consideration for certain materials and to eliminate other general areas from consideration for these materials. Local variations are common, especially near unit boundaries. Precise economic evaluations of specific deposits as sources of construction materials will require detailed examination of each deposit, including areal extent, volume, grain-size variation, thickness of overburden, thermal state of the ground, and depth to water table as well as logistical factors and demand.

Data-quality maps (map b) present our best judgment of the reliability of available geologic information based on several factors, including the type and date of topographic maps used as the base upon which the data were initially plotted, the presence or absence of published or unpublished information, the type and date of the geologic report, who prepared the report (specialist vs. nonspecialist), the complexity of the area mapped, the amount of field verification, and (where we interpreted aerial photographs or satellite imagery to produce geologic and geologic-materials maps) the date and scale of the aerial photography and satellite imagery.

For the 64 quadrangles where geologic mapping is reliable[6], geologic-hazards maps were derived directly from geologic maps because (1) the processes that produced the geologic deposits also threaten property and human lives and activities or (2) conditions in the deposits are hazardous (table 2) (map c, sheet 1, *if applicable*). In the 14 quadrangles where geologic mapping is not reliable[7], derivative geologic-hazards maps were developed from geologic-materials maps and contain complex hazards units, including several combined hazardous processes (table 3) (map c, sheet 1, *if applicable*).

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[5] Landforms were interpreted for Baird Mountains, Bradfield Canal, Dillingham, Iditarod, Juneau, Lake Clark, Lime Hills, Naknek, Noatak, Ruby, Sagavanirktok, Sleetmute, Taku River, and Taylor Mountains quadrangles because geologic maps were not available.

[6] During project reliable geologic mapping did not exist for the Baird Mountains, Bradfield Canal, Dillingham, Iditarod, Juneau, Lake Clark, Lime Hills, Naknek, Noatak, Ruby, Sagavanirktok, Sleetmute, Taku River, and Taylor Mountains quadrangles.

[7] Ibid.

Non-derivative (additional) geologic-hazards maps,which illustrate areas of significant potential for snow avalanches and drainages that are subject to stream icings and outburst floods, were developed from an interpretation of 1:250,000-scale topographic maps or from information published in the technical literature (map c, sheet 2). Source slopes for snow avalanches are inferred from slope angles, which are reflected in the spacing of contours on 1:250,000-scale topographic maps. We use an inclination of 30° (58 percent) as a lower threshold for slopes of moderate to high potential for producing snow avalanches because this is generally the shallowest slope for initiating dry-snow and slab avalanches (Perla and Martinelli, 1976). However, wet-snow avalanches are initiated on slopes as gentle as 15° (27 percent) and factors (like surface roughness, wind drifting, temperature gradients, snow metamorphism, water content, and snow creep) that affect the failure of snow packs are complex (Perla and Martinelli, 1975). Similarly, runout distances, directions, and effects vary considerably and are difficult to predict without detailed studies of past avalanche paths (Martinelli, 1974; Burrows and Burrows, 1976; Mears, 1976).

Although they are the source data for many of the aforementioned maps, the geologic maps are discussed last because they are not available for all 78 quadrangles that this report summarizes. Geologic maps for the 64 quadrangles where geologic mapping is reliable portray simplified geology compiled from published sources (map d, *if applicable*). Age distinctions were eliminated and geologic units combined based on similar lithologic character, which could then be used to derive the construction-materials and geologic-hazards maps.

METHODOLOGY

After centerlines of proposed access routes were located through most of Alaska, corridor limits were established at 5 miles on either side of the centerlines (fig. 2). Geologic information on these corridors was assembled, reviewed, and compiled from published and unpublished reports, aerial photographs, and satellite imagery.

In quadrangles where the published or unpublished information is reliable, maps of surficial and bedrock geology were traced and then digitized into the DGGS geographic information system (GIS), where the data could be stored, retrieved, manipulated, and printed (fig. 2). Then geologic-materials and geologic-hazards maps were derived from the geologic maps and printed.

Where the published or unpublished information is unreliable or nonexistent, maps of surficial geology and unconsolidated geologic materials were produced by interpreting 1,097 false-color, infrared aerial photographs (Baird Mountains, Barter Island, Bettles, Bradfield Canal, Dillingham, Holy Cross, Hughes, Iditarod, Juneau, Lake Clark, Lime Hills, Melozitna, Naknek, Noatak, Ruby, Sagavanirktok, Sleetmute, Taku River, and Taylor Mountains quadrangles)(app. 1), and one scene of 1:250,000-scale, enhanced and rectified satellite imagery (scene 10756-21121 dated 8-18-74) was interpreted to prepare a geologic-materials map of the Port Moller Quadrangle (fig. 2).

Geologic-hazards maps were prepared only for 10-mile-wide corridors, except that active fault zones are delineated throughout the 1:250,000-scale quadrangles traversed by the corridors, and streams that are susceptible to outburst floods are identified outside the corridor in the Cordova Quadrangle. Sources of information needed to prepare geologic-hazards maps include (1) geologic and geologic-materials maps previously developed during this study, (2) 1:60,000-scale false-color, infrared aerial photographs, (3) supplemental technical literature, and (4) 1:250,000-scale topographic maps (fig. 3).

Data Presentation and Discussion

The primary products of the DGGS Corridor Evaluation Project are the 376 1:250,000-scale geologic-materials, data-quality, derivative geologic-hazards, non-derivative (additional) geologic-hazards, and geologic maps that accompany this report.

Geologic and Geologic-materials Maps

A total of 190 sources of technical information were consulted during our extensive compilation of data on corridor geology and geologic materials. These references are alphabetically listed by quadrangle in appendix 2.

Geologic-hazards Maps

A total of 83 sources of information on geologic hazards were consulted during our research. In addition to identifying potentially active faults and drainages affected by thick stream icings and outburst floods on non-derivative (additional) hazards maps, we established 13 classes of geologic hazards on derivative-hazards maps (table 3). In general, our main concerns in lowland areas are natural hazards related to a lack or loss of bearing (shear) strength (saturated, organic-rich swamp deposits and thawing of ice-rich permafrost) and flooding. In highlands, mass movements are locally a serious concern. Based on topography, we identified terrain where there generally is moderate to high potential for snow avalanches, including probable runout zones. Local, unevaluated factors affecting other forms of mass movement (rock avalanches, landslides, and debris flows) include textures of sediments, bedrock structures, and water content. Faulting and associated earthquakes produce sudden displacements by shaking and impacts and by widespread liquefaction of foundations soils in both lowlands and highlands.

Permafrost

Permafrost is rock or soil, or both, that has natural temperatures that are consistently less than 0°C for 2 years or more (Péwé, 1982). This perennially frozen ground seriously affects many human activities in Alaska, especially the construction and maintenance of roads, railroads, airfields, bridges, buildings, dams, sewers, oil and gas pipelines, and communication and utility systems. Fundamental problems include: (1) thawing of ice-rich foundation materials beneath roads, airfields, and agricultural fields; (2) ground subsidence under heated structures; (3) intensification of frost action due to impeded drainage; and (4) freezing of buried sewer, water, and oil lines (Péwé, 1982).

In mountainous terrain, which is typically complex and rugged, great differences in elevation, materials, snowfall, vegetation cover, soil moisture, and insolation (solar radiation received at the ground surface) result in considerable variation in the temperature, ice content, thickness, and distribution of permafrost. In uplands with less relief and in lowlands, temperature, thickness, and distribution of permafrost are less variable.

Local permafrost distribution is extremely complex because it depends on complicated microclimatic factors, including aspect, slope angle, temperature at the ground surface, material type, and ground insulation. Therefore, for the purposes of this report, we only identify the general distribution of permafrost in each 1:250,000-scale quadrangle through which 10-mile-wide corridors pass. Six zones of general distribution include (1) continuous, (2) transitional from continuous to discontinuous, (3) discontinuous, (4) transitional from discontinuous to sporadic, (5) sporadic, and (6) no permafrost (table 4).

Among the quadrangles crossed by the 10-mile-wide corridors that we evaluated, only 11 quadrangles (14.1 percent) do not include at least some perennially frozen ground (table 5).

Floods

Low-relief, planar surfaces (floodplains) bordering streams are normally inundated, at least in part, each year by floods during spring melting of seasonal snow cover and during sustained or heavy rainfall. However, special conditions exist in Alaska that periodically produce exceptional flooding.

Sudden drainage of the waters impounded in mountain valleys blocked by glaciers produces brief floods characterized by stream stages well above normal flood levels (Post and Mayo, 1971). These outburst floods or jökulhlaups are not necessarily annual events, although they occur annually in some drainages. Impounded waters break out of their basins when they overflow low thresholds on the ice dam and cut rapidly down through the ice or when waters percolating under the glacier buoy it up enough to start subglacial drainage. Outburst floods are particularly hazardous during middle to late winter when stream channels are choked by seasonal ice and ice-jam flooding exacerbates the problem. In Alaska, significant outburst floods are limited to mountainous areas from the Alaska Range south (Post and Mayo, 1971). During our survey, we located 34 drainages that are susceptible to outburst flooding in 10 of 78 quadrangles (12.8 percent) traversed by 10-mile-wide corridors containing proposed access routes (table 6). In our study we take the conservative approach that outbursts from glacier-blocked lakes in headwater reaches affect the entire drainage, although bank storage in downstream reaches generally attenuates the abrupt rise in stream-stage level normally associated with jökulhlaups.

Each winter, braided streams and shallow reaches of other streams freeze to the bottom, producing exceptionally thick stream icings (naleds) by the freezing of successive thin sheets of overflow water forced by hydraulic stress up through contraction cracks in the seasonal ice cover (Sloan and others, 1976). Similar seasonal-icing sheets develop on slopes below springs. The gradual buildup of seasonal-ice sheets slowly inundates facilities and other property sited above the normal high-water level of nearby streams (Nelson, 1978; Péwé, 1982). Seasonal icings are widely distributed in Alaska but are more common in the northern half of the state (Sloan and others, 1976; Harden and others, 1977; Dean, 1984a, b). During our survey, we located 193 streams and numerous additional unnamed tributaries subject to seasonal icings in 55 of 78 quadrangles (70.5 percent) traversed by 10-mile-wide corridors (table 7).

Snow avalanches

Snow avalanches are sliding and turbulently flowing masses of snow, air, water, and debris that are capable of destroying people, structures, and property because of their spontaneity and the considerable forces that they generate (Mellor, 1968). In our brief reconnaissance, we have identified areas that we believe have moderate to high potential for snow avalanches, regardless of type, including estimated runout zones in 38 of 78 quadrangles (48.7 percent).

Faults

Faults are breaks in the Earth's crust along which significant movement has occurred. Sudden displacements along faults generate earthquakes that can be hazardous to people, structures, and property because of falling objects, slope failures, ground shaking and cracking, and liquefaction effects (Hansen, 1966). Hazards of infrequent, strong earthquakes (like the March 27, 1964 Prince William Sound earthquake) are regional in scale, but consideration of potential regional effects during future earthquakes is beyond the scope of our study.

Realizing that the Aleutian megathrust, which is not a surface fault, is the most extensive and dangerous source of future earthquakes in Alaska (Plafker, 1969), for the purposes of our evaluation of proposed access routes, we focus on more local influences of faulting by identifying and mapping surface faults in those quadrangles traversed by the 10-mile-wide corridors being evaluated (app. 3). Faults are not evaluated in quadrangles not crossed by corridors, even though these structural breaks may generate significant earthquakes there. Depending on when the last movement occurred along them, surface faults are designated as definitely active, probably active, or possibly active (table 8); inactive faults are not considered to have engineering significance. Where adequate data are available, we identify fault segments with different levels of activity. However, where data are not sufficiently detailed to separate segments, we take a conservative approach that the most active fault segment is the best measure of potential future displacements along the entire fault.

Data-quality Maps

Each source of map information on geology and geologic materials was evaluated for data quality (app. 4). Five classes of data quality range from very good to poor (table 9).

Acknowledgments

The concept of identifying and evaluating access corridors through most of Alaska for the purposes of land selection was first championed by Jerry Brossia, State Pipeline Coordinator, who got the ball rolling in Department of Natural Resources. Richard "OD" Odsather, State Pipeline Coordinator's Office, became our very capable project leader in July 1991 and soon organized the Corridor Selection Steering Committee, of which our team was a small part. OD personally spent much time, thought, and effort in the complicated process of locating routes for us to evaluate. During this process, the knowledgeable counsel of Edwin "Rocky" Rhoads was invaluable. Both Jerry and OD supported us with enthusiasm, timely arm-twisting, and vital funds when we needed them the most.

Our evaluation team received considerable timely help with digitizing from Nori Bowman, Kathy Campbell, and John Roe. Richard Clement and Gail March helped immeasurably with training and supervision of everyone working with the new DGGS geographic information system.

Florence R. Weber kindly loaned us her personal copies of USGS reports that we could not locate in local libraries.

Robin Smith, intern in the Engineering Geology Section, DGGS, updated the 362 corridor coverages, and underlaid quadrangle topography base maps to create the finished product in 2002.

Without the generosity and support of all these folks, our products would have been inferior and our deadlines not met.

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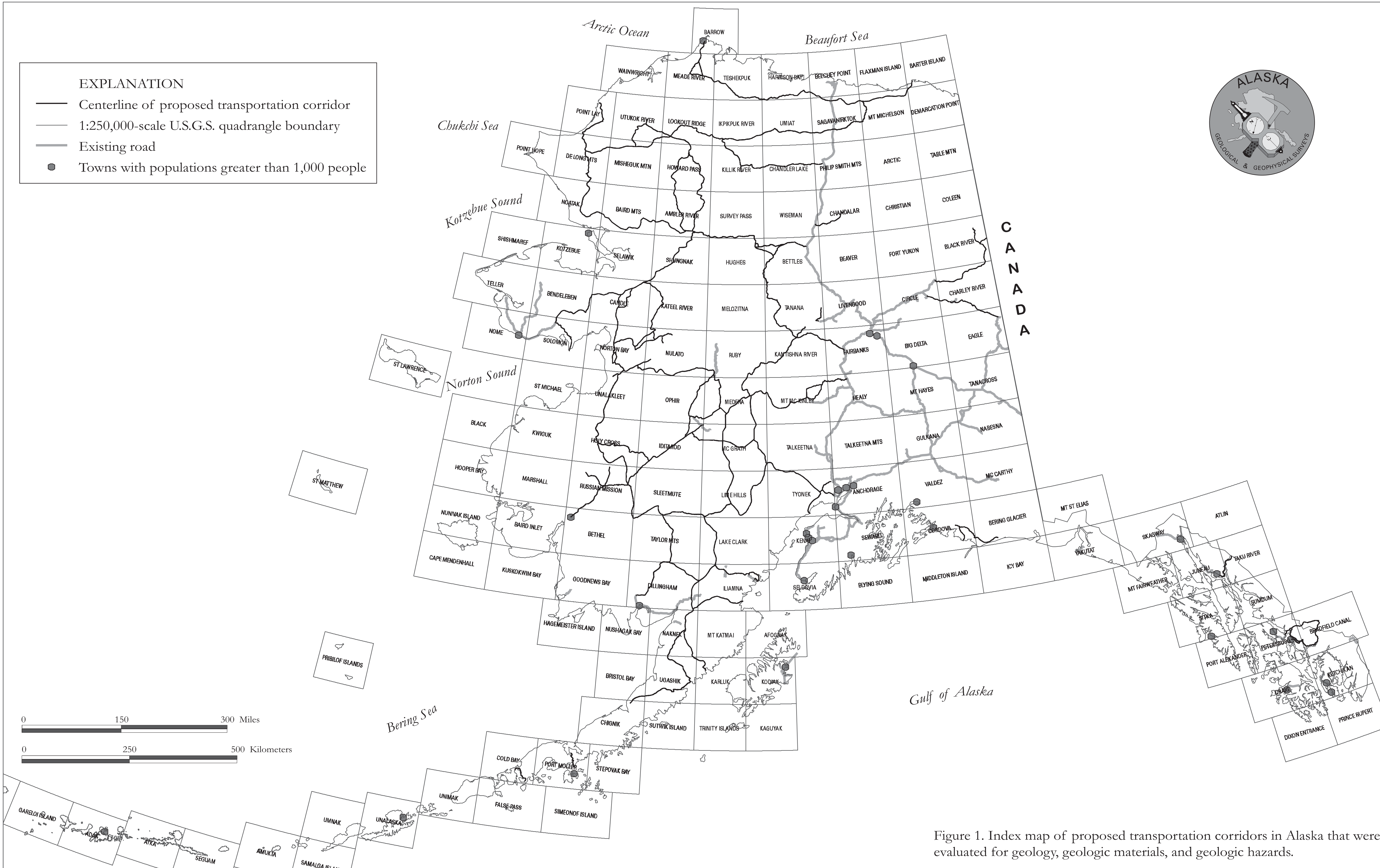
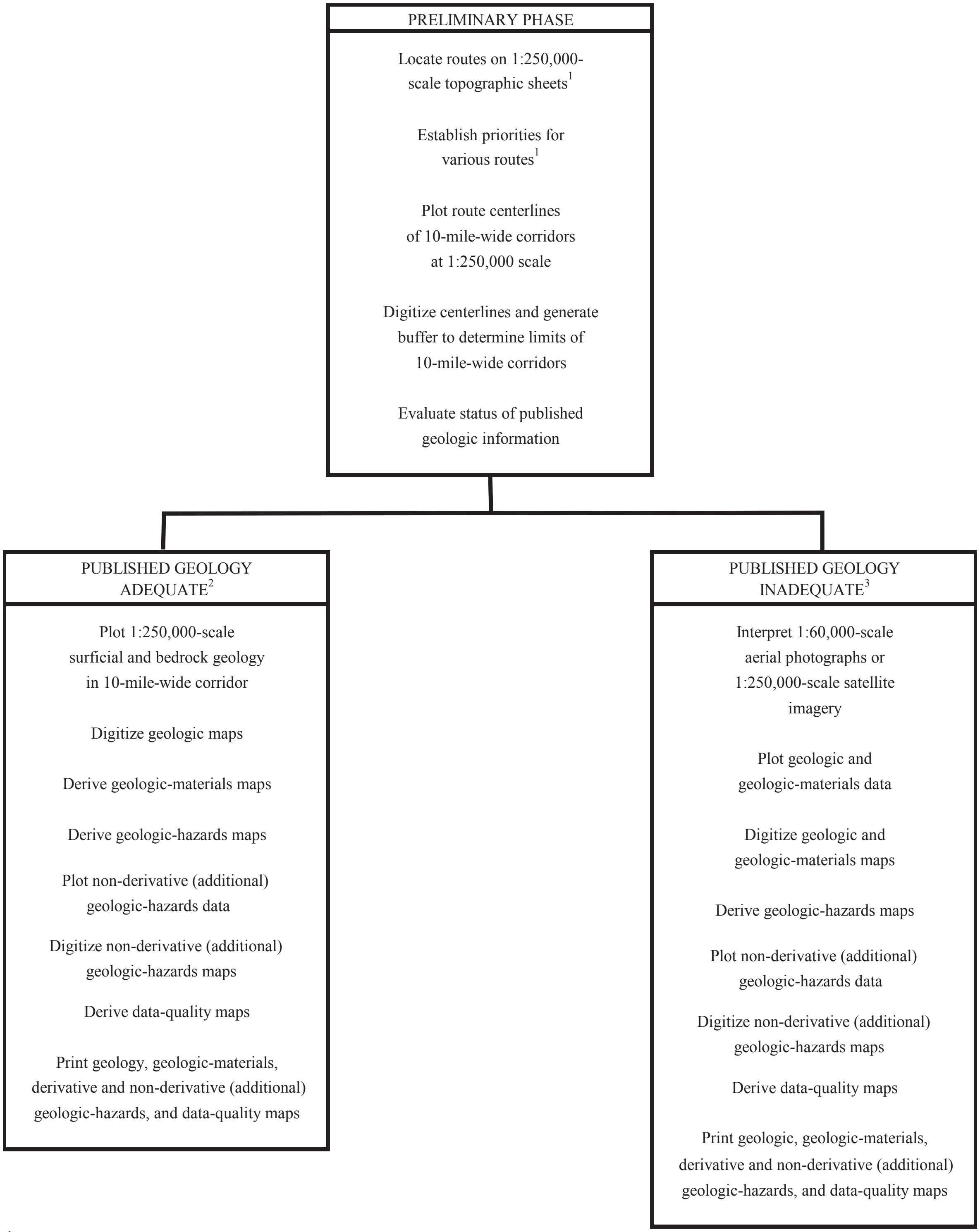


Figure 1. Index map of proposed transportation corridors in Alaska that were evaluated for geology, geologic materials, and geologic hazards.



[1]Non-DGGS responsibility
[2]For 64 quadrangles
[3]For 14 quadrangles

Figure 2. *Work plan for geologic evaluation of proposed access routes in Alaska.*

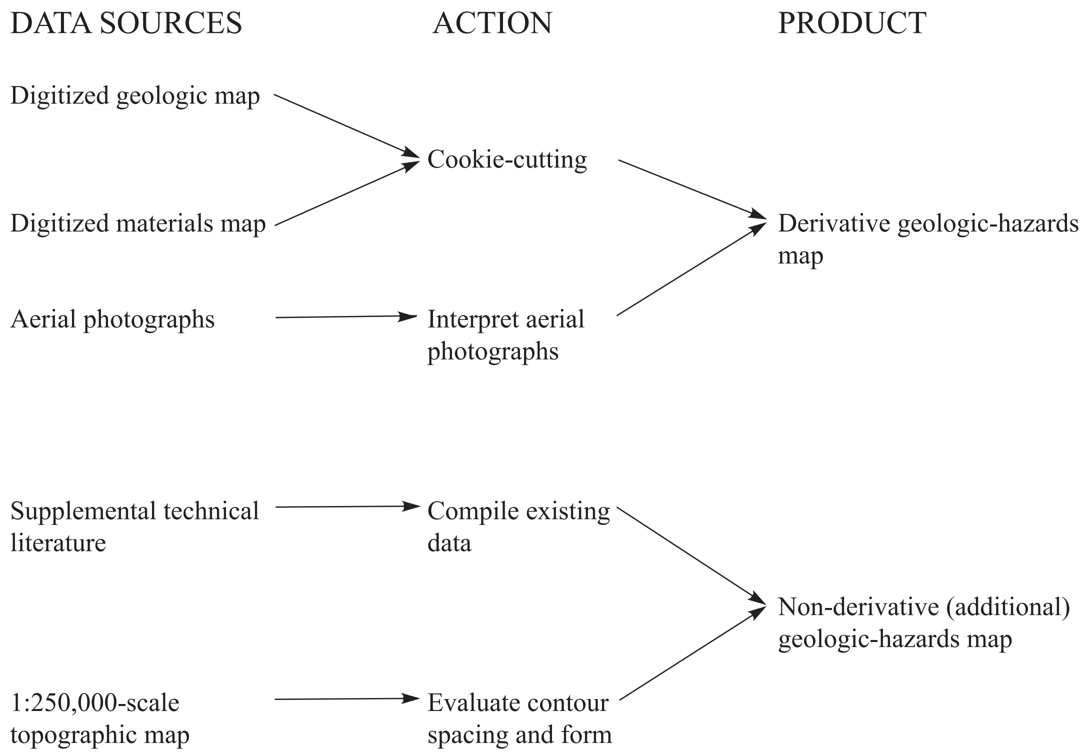


Figure 3. *Derivation of geologic-hazards maps during evaluation of proposed access routes in Alaska.*

Table 1. *Relations between materials classes, dominant landforms, and geologic units in geologic evaluation of proposed 10-mile-wide corridors*

Materials unit	Composition	Primary products	Component landforms	Geologic unit
GS	Chiefly (estimated > 80%) clean sand and gravel Rare oversized material Includes GW and GP (Unified Soil Classification)	Crushed aggregates Miscellaneous clean fills	Active floodplains Inactive floodplains Abandoned floodplains Outwash plain, fan, valley train Large abandoned meltwater channel Stream terrace Esker, kame, kame terrace Complex ice stagnation topography Granular delta and fandelta Beach, spit bar Tailings mound or ridge	Alluvium (Qa, Qsm) Alluvium (Qa, Qsm) Alluvium (Qa, Qsm) Outwash/inwash (Qo) Alluvium (Qa, Qsm) Terrace alluvium (Qat, Qsm) Ice stagnation deposits (Qis) Ice stagnation deposits (Qis) Fan-delta deposits (Qld) Lake/marine beach deposits (Qlb, Qmb) Placer-mine tailings (Qmt)
SA	Chiefly (estimated 80%) sand Includes SW and SP (Unified Soil Classification)	Unclassified fine fills	Eolian sand dune, sheet, dune complex Retransported sand fan, apron, sheet	Eolian sand (Qes) Undifferentiated eolian sand and silt (Qe) Reworked eolian deposits (Qer)

Table 1. *(cont'd.)*

Materials unit	Composition	Primary products	Component landforms	Geologic unit
SM	Chiefly fine materials Estimated > 80% sand, silt, and clay Includes SM, SC, ML, MH, CL, and CH (Unified Soil Classification)	Unclassified fine fills	Fine-grained delta, fandelta Retransported loess fan, apron, sheet Loess blanket Lake plain, basin Glaciolacustrine plain Tidal flat, elevated tidal flat	Deltaic, lagoonal deposits (Qml) Undifferentiated eolian sand and silt (Qe) Reworked eolian deposits (Qer) Loess (Qel) Undifferentiated lacustrine deposits (Ql) Undifferentiated lacustrine deposits (Ql) Estuarine deposits (Qme)
OR	Chiefly organic materials Estimated >50% peat, organic sand, or organic silt Includes Pt (Unified Soil Classification)	Unclassified fine fills	Thaw-lake basin Swamp	Thaw-lake deposits (Qtl) Swamp deposits (Qs)
BV	Medium-jointed, fine-grained igneous rocks and their metamorphic equivalents May be deeply weathered	Riprap, drain rock Crushed rock Unclassified fills	Volcanic flow rock outcrop Welded tuff outcrop Greenstone outcrop	Volcanic rocks (Biv) Volcanic rocks (Biv) Greenstone (Bmg)

Table 1. *(cont'd.)*

Materials unit	Composition	Primary products	Component landforms	Geologic unit
BC	Medium-jointed, fine- to coarse-grained sedimentary Carbonate rocks and their metamorphic equivalents May be deeply weathered	Dimension stone Ornamental stone Crushed rock Cement	Limestone outcrop Dolostone outcrop Travertine outcrop Marble outcrop	Limestone (Bsl) Dolostone (Bsl, Bmm) Limestone (Bsl) Marble (Bmm)
BM	Medium-jointed, fine- to medium-grained quartzose sedimentary rocks and their metamorphic equivalents May be deeply weathered	Riprap, drain rock Crushed rock Unclassified fills	Quartzose sandstone, conglomerate outcrop Quartzite outcrop	Sandstone (Bsa), conglomerate (Bsc) Quartzite (Bmq)
BO	All other lithologies May be deeply weathered	Unclassified fills	Outcrops of all bedrock classes not included in above groups	Chert (Bsch), Shale (Bsh), Siltstone (Bsi), Schist, serpentine, phyllite, fine-grained gneiss (Bms)
BU	Undifferentiated, unknown bedrock May be deeply weathered	Unclassified fills	Undifferentiated bedrock	Undifferentiated igneous rock (Biu), Undifferentiated sedimentary rock (Bsu), Undifferentiated metamorphic rock (Bmm), Undifferentiated, unknown rock (Bu)

Table 2. *Genetic relations of geologic deposits and hazardous processes*

SURFICIAL DEPOSIT	TYPE OF GEOLOGIC HAZARD				
	Rapid mass movements[1]	Significant liquefaction potential[2]	Significant ground-ice content[3]	Seasonal flooding[4]	Snow avalanching[5]
Undifferentiated alluvium (Qa)	-	X	-	X	-
Alluvial-fan deposits (Qaf)	X	-	-	X	X
Terrace alluvium (Qat)	-	-	X (SM only)	-	-
Placer-mine tailings (Qmt)	-	-	-	-	-
Fine-grained alluvium (Qsm)	-	X	X	X	-
Undifferentiated colluvium (Qc)	-	-	X	-	-
Debris-flow deposits (Qcd)	X	-	-	-	-
Landslide deposits (Qcl)	X	-	-	-	X
Solifluction deposits (Qcs)	-	-	X	-	-
Talus (Qct)	X	-	X	-	X
Rock-glacier deposits (Qrg)	X	-	X	-	X
Undifferentiated eolian sand and silt (Qe)	-	-	X	-	-
Loess (Qel)	-	-	X	-	-
Reworked eolian deposits (Qer)	-	X	X	-	-
Dune sand (Qes)	-	-	-	-	-

[1] Includes landslides, avalanches, and debris flows. Significant potential for displacements and impacts.
[2] Where fine grained (sand and silt), saturated, and thawed, there is significant potential for loss of shear strength during conditions of dynamic loading (shaking).
[3] Where perennially frozen, contains significant pervasive or massive ice, or both. During and after melting, susceptible to excessive and differential settlements and loss of shear strength.
[4] Includes seasonal stream icings.
[5] Includes slushflows during periods of rapid spring melting in Brooks Range and on Seward Peninsula.

Table 2. *(cont'd).*

SURFICIAL DEPOSIT	TYPE OF GEOLOGIC HAZARD				
	Rapid mass movements[1]	Significant liquefaction potential[2]	Significant ground-ice content[3]	Seasonal flooding[4]	Snow avalanching[5]
Undifferentiated lacustrine deposits (Ql)	-	X	X	-	-
Lake-beach deposits (Qlb)	-	-	-	-	-
Fan-delta deposits (Qld)	-	X	X	-	-
Thaw-lake deposits (Qtl)	-	X	X	X	-
Marine-beach deposits (Qmb)	-	-	-	-	-
Estuarine deposits (Qme)	-	X	X	X	-
Deltaic and lagoonal deposits (Qml)	-	X	X	X	-
Undifferentiated drift (Qd)	-	-	X	-	-
Outwash/inwash (Qo)	-	-	-	X	-
Ice-stagnation deposits (Qis)	-	-	-	-	-
Swamp deposits (Qs)	-	-	X	X	-
Undifferentiated surficial deposits (Qu)	?	?	?	?	?
Glacial ice (Ice)	X	-	-	-	X

Table 3. *Genetic relations of geologic-materials classes and hazardous processes*

MATERIALS CLASS	TYPE OF GEOLOGIC HAZARD				
	Rapid mass movements[1]	Significant liquefaction potential[2]	Significant ground-ice content[3]	Seasonal flooding[4]	Snow avalanching[5]
Chiefly sand and gravel (GS)	-	X	X	X	-
Mixed coarse and fine material (GM)	X	X	X	X	X
Chiefly sand (SA)	-	-	-	-	-
Chiefly fine materials (SM)	-	X	X	X	-
Chiefly organic material (OR)	-	X	X	X	-
Coarse-jointed, coarse-grained igneous lithologies (BG)[6]	-	-	-	-	-
Medium-jointed, fine-grained igneous lithologies (BV)[6]	-	-	-	-	-
Medium-jointed, fine- to coarse-grained sedimentary carbonate rocks and their metamorphic equivalents (BC)[6]	-	-	-	-	-

[1] Includes landslides, avalanches, and debris flows. Significant potential for displacements and impacts.

[2] Where fine grained (sand and silt), saturated, and thawed, there is significant potential for loss of shear strength during conditions of dynamic loading (shaking).

[3] Where perennially frozen, contains significant pervasive or massive ice, or both. During and after melting, susceptible to excessive and differential settlements and loss of shear strength.

[4] Includes seasonal stream icings.

[5] Includes slushflows during periods of rapid spring melting in Brooks Range and on Seward Peninsula.

[6] Steep bedrock outcrops are susceptible to snow avalanching, However, this hazard is related to the topography, which was identified during this study by a study of topographic maps. Landslides in bedrock are mapped as slope failures, not bedrock.

Table 3. *(cont'd.)*

MATERIALS CLASS	TYPE OF GEOLOGIC HAZARD				
	Rapid mass movements	Significant liquefaction potential	Significant ground-ice content	Seasonal flooding	Snow avalanching
All other lithologies (BO) [6]	-	-	-	-	-
Undifferentiated, unknown bedrock (BU) [6]	-	-	-	-	-
Glacial ice (ICE)	X	-	-	-	X

Table 4. *Zones of permafrost identified during corridor evaluation*

Zone	Explanation
Continuous	Perennially frozen ground present beneath > 90 percent of landscape. (Ferrians, 1965; Kreig and Reger, 1982)
Transitional from Continuous to Discontinuous	Both continuous and discontinuous permafrost are present. (Ferrians, 1965)
Discontinuous	Perennially frozen ground present beneath 50 to 90 percent of landscape (Kreig and Reger, 1982). Generally absent close to large water bodies. (Ferrians, 1965)
Transitional from Discontinuous to Sporadic	Both discontinuous and sporadic permafrost are present. (Ferrians, 1965)
Sporadic	Perennially frozen ground present beneath < 50 percent of landscape; generally present as isolated, relict masses at considerable depth or as local, thin lenses near ground surface where peat is thick enough to provide adequate insulation. (Kreig and Reger, 1982)
No permafrost	Perennially frozen ground is not present even in favorable locations. (Ferrians, 1965)

Table 5. *Distribution of permafrost zones by quadrangle crossed by proposed 10-mile-wide corridors in Alaska (after Ferrians, 1965)*

Permafrost Zone	Quadrangles Included	Percent of all Quadrangles
Continuous	Barrow, Barter Island, Beechey Pont, Chandler Lake, DeLong Mountains, Demarcation Point, Flaxman Island, Harrison Bay, Howard Pass, Ikpikpuk River, Killik River, Lookout Ridge, Meade River, Misheguk Mountain, Mount Michelson, Philip Smith Mountains, Sagavanirktok, Teshekpuk, Umiat, Utukok River (n=20)	25.6
Transitional from Continuous to Discontinuous	Ambler River, Baird Mountains, Bettles, Chandalar, Hughes, Noatak, Selawik, Shungnak, Survey Pass, Wiseman (n=10)	12.8
Discontinuous	Bendeleben, Black River, Candle, Charley River, Circle, Healy, Holy Cross, Kateel River, Livengood, Melozitna, Norton Bay, Nulato, Ruby, Solomon, Tanana, Unalakleet (n=15)	19.2
Sporadic	Dillingham, Iliamna, Naknek (n=3)	3.8
No permafrost	Bradfield Canal, Chignik, Cold Bay, Juneau, Karluk, Mount Katmai, Petersburg, Port Moller, Taku River, Ugashik, Yakutat (n=11)	14.1
	Total:	99.9

Table 6. *Distribution of stream drainages subject to periodic outburst floods in 10-mile-wide corridors containing proposed access routes (Post and Mayo, 1971)*

Quadrangle	Drainage affected by outburst flooding
Bering Glacier	Campbell River, Edwardes River, Kiklukh River, Nichawak River, Seal River, Tashalich River, Tsirat River, Tsiu River
Bradfield Canal	Stikine River
Cordova	Bering River, Campbell River, Copper River, Edwardes River, Gadil River, Martin River, Nichawak River, Oaklee River, Sheep Creek
Healy	Nenana River
Juneau	Stream draining North Fork Norris Glacier
Lime Hills	South Fork Kuskokwim River, Swift River
Mount McKinley	Foraker River, Herron River, McKinley River
Taku River	Taku River
Tyonek	Beluga River, Hayes River, Skwentna River, Susitna River, Yentna River

Table 7. *Distribution of stream drainages subject to seasonal icings (naleds) in proposed 10-mile-wide corridors containing proposed access routes (Dean, 1984a). Numerous small, unnamed streams are not listed.*

Quadrangle	Stream affected by seasonal icings[dsp1]
Ambler River	Agnes Creek, Akiak Creek, Akillik River, Ambler River, Cross Creek, Cutler River, Hunt River, Ipnelivik River, Kogoluktuk River, Miluet Creek, Naniratkohort Creek, Nekakte Creek, Noatak River, Nushralutak Creek, Redstone River, Tunukuchiak Creek
Baird Mountains	Squirrel River, Tutuksuk River
Barter Island	Okpilak River
Bendeleben	Boston Creek, Fish River, Lava Creek, Nutmoyuk Creek, Ophir Creek, Telephone Creek, Virginia Creek, Windy Creek
Bethel	Aniak River, Kipchuk River
Bettles	West Fork Henshaw (Sozhekla) Creek
Black River	Grayling Fork Black River, Salmon Fork Black River
Candle	Brush Creek, Connolly Creek, Little Kalusuk Creek, North Fork Buckland River, West Fork Buckland River
Chandalar	Crooked Creek, Slate Creek, South Fork Koyukuk River
Chandler Lake	Anaktuvuk River, Chandler River, Cobblestone Creek, Confusion Creek, Desolation Creek, Kanayut River, May Creek, Nanushuk River, Siksikpuk River
Charley River	Charley River, Webber Creek
Chignik	Barbara Creek, Birthday Creek, Plenty Bear Creek, Reindeer Creek
Cold Bay	Joshua Green River
Cordova	Copper River
De Long Mountains	Wulik River
Demarcation Point	Okpilak River
Dillingham	Alagnak River, Kokwok River, Kvichak River, Stuyahok River, unnamed tributaries to Kaskanak Creek, unnamed tributaries to Mulchatna River
Flaxman Island	Hulahula River
Healy	Nenana River, Savage River, Sushana River, Teklanika River
Holy Cross	Beaver Creek
Howard Pass	Colville River, Nigu River, Rough Mountain Creek
Hughes	Unnamed stream
Iditarod	Unnamed north tributary to Bonanza Creek
Iliamna	Dunuletak Creek, Iliamna River, Koktuli River, Paint River

Table 7. *(cont'd).*

Quadrangle	Stream affected by seasonal icings[dsp1]
Kantishna River	Unnamed tributaries to Cosna River, unnamed tributaries to Titna River
Karluk	Unnamed tributary to Kejulik River
Kateel River	Kateel River
Killik River	Killik River, Kurupa River, Okpikruak River, Oolamnagavik River, Travelair Creek
Lime Hills	Big River, Hartman River, North Fork Big River, Ptarmigan Creek, South Fork Kuskokwim River, Stony River, Styx River
Livengood	Hutlinana Creek
McGrath	Big River, Jones River, South Fork Kuskokwim River, Tatina River, Windy Fork Kuskokwim River
Medfra	Black Creek, Brown's Fork Susulatna River, Dennis Creek, East Fork Kuskokwim River, Eden Creek, Granite Creek, Hardscrabble Creek, North Fork Jones Creek, Shepherd Creek, Silver Creek, South Fork Sulatna River, Timber Creek, Tonzona River, unnamed tributaries to Susulatna River.
Mount McKinley	Bearpaw River, Birch Creek, Clearwater Fork Toklat River, East Fort Toklat River, Fish Creek, Foraker River, Herron River, McKinley Creek, Moonlight Creek, Shisnona River, Slippery Creek, Stony Creek, Toklat River
Mount Michelson	Canning River, Hulahula River, Itkilyariak Creek, Katakturuk River, March Creek, Sadlerochit River, Tamayariak River
Naknek	King Salmon River, Naknek River
Noatak	Agashashok River, Evaingiknuk Creek, Kiyak Creek, Noatak River
Norton Bay	Anakeksik Creek, Egavik Creek, North River, Nulato River, Shaktoolik River, Unalakleet River, Ungalik River
Nulato	Arvesta Creek, Gisasa River, Little Mud River, Nulato River, West Fork Little Mud River
Philip Smith Mountains	Unnamed tributary to Itkillik River
Port Moller	Unnamed streams
Ruby	Unnamed tributaries to Sulukna River, unnamed tributaries to Telsitna River
Russian Mission	Aniak River, Buckstock River, Kipchuk River, Mission Creek, Salmon River, Timber Creek
Sagavanirktok	Kavik River, Sagavanirktok River, Shaviovik River, Toolik River
Selawik	Unnamed tributary to Tagagawik River
Shungnak	Black River, Cosmos Creek, Ingruksukruk Creek, Wesley Creek
Sleetmute	Buckstock River, Timber Creek
Solomon	Eagle Creek, Kachauik River, Niukluk River, Richter Creek, Yuonglik River
Survey Pass	Malamute Fork Alatna River
Tanana	Big Denver Creek, Dagislakhna Creek, Hutlinana Creek, Nethkahati Creek, Slokhenjikh Creek, Tenmile Creek
Teshekpuk	Ikpikpuk River

Table 7. *(cont'd).*

Quadrangle	Stream affected by seasonal icings[dsp1]
Tyonek	Hayes River, Skwentna River
Umiat	Anaktuvuk River, Itkillik River, Kuparuk River, Nanushuk River
Unalakleet	North River, Swift River, unnamed tributaries of Unalakleet River
Utukok River	Utukok River
Wiseman	Middle Fork Koyukuk River

Table 8. *Criteria of classes of fault activity used in geologic evaluation of proposed access corridors in Alaska (modified from Howard and others, 1978)*

Class	Criteria
Definitely active	Movement demonstrated during last 10,000 years
Probably active	Possible evidence of displacement during last 10,000 years
Possibly active	Possible evidence of displacement during last 500,000 years

Table 9. *Criteria for data-quality classes used during geologic evaluation of proposed access corridors in Alaska*

Class	Criteria
Very good	One or more 1:63,360- or larger scale geologic maps available; verified by numerous detailed field observations, multiple laboratory tests, or both; interpretation of 1:65,000- or larger scale aerial photographs has considerable field verification.
Good	A 1:63,360- or larger scale geologic map available; partially verified by field studies, a few laboratory tests, or both; interpretation of 1:65,000- or larger scale aerial photographs has limited or spotty field verification.
Moderate	A 1:250,000- or 1:125,000-scale geologic map available; known to be generally reliable because of limited field observations, a few laboratory tests, or both; interpretation of 1:65,000- or larger scale aerial photographs is not verified by field observations.
Fair	A reconnaissance-series 1:250,000-scale geologic map available but has not been reliably verified by field observations, laboratory tests, or both; interpretation of 1:250,000-scale satellite imagery or topographic maps are composite and identification of individual landforms is not possible.
Poor	Only 1:1,000,000-scale geologic map available; only some obvious composite landforms can be identified on 1:63,360-scale or larger topographic maps.

APPENDIX 1

IDENTIFICATION OF 1:60,000-SCALE FALSE-COLOR INFRARED AERIAL PHOTOGRAPHS OF ALK 60 CIR SERIES INTERPRETED TO PREPARE GEOLOGIC, MATERIALS, AND HAZARDS MAPS DURING THIS INVESTIGATION

PRIMARY QUADRANGLE[1]	DATE OF PHOTOGRAPHY	ACCESSION OR ROLL NUMBER	FRAME NUMBERS
Baird Mountains	July 5, 1978	Roll 15	69 – 77
"	"	"	83 – 94
"	"	"	107 – 125
"	July 14, 1978	Roll 29	225 – 232
"	July 14, 1979	2788	2888 – 2891
"	"	"	2903 – 2910
"	"	"	2927 – 2931
"	July 5, 1978	2626	6075 – 6085
Barter Island	July 13, 1979	2786	2391 – 2394
"	"	"	2515 – 2521
Bettles (Hughes, Melozitna)	June 27, 1978	Roll 9	303 – 308
(Hughes)	"	"	370 – 376
(Hughes)	July 25, 1981	2998	1641 – 1658
(Hughes)	"	"	1670 – 1680
(Hughes)	"	"	1777 – 1783
(Hughes)	August 2, 1981	3004	1905 – 1911
Bettles	"	"	2000 – 2006
(Hughes)	July 14, 1979	2788	2552 – 2557
(Hughes)	"	"	2659 – 2664
(Hughes)	August 1, 1979	2794	3549 – 3556
(Hughes)	"	"	3562 – 3572
Bettles	"	"	3620 – 3633
"	"	"	3646 – 3653
Bradfield Canal	August 11, 1979	2804	4365 – 4368
"	August 12, 1979	2806	4640 – 4647
"	"	"	4703 – 4716
"	"	"	4726 – 4730
"	"	"	4784 – 4790
"	"	"	4847 – 4851
"	August 14, 1979	2811	5054 – 5057

[1] Parts of corridors in quadrangles inside parentheses are also covered by photographs listed, but represent less land area than primary quadrangle.

PRIMARY QUADRANGLE[1]	DATE OF PHOTOGRAPHY	ACCESSION OR ROLL NUMBER	FRAME NUMBERS
Dillingham	August 15, 1984	3391	76 – 82
"	"	"	150 – 156
"	August 4 1982	3110	180 – 184
"	"	"	198 – 204
"	"	"	245 – 249
"	"	"	283 – 287
"	August 20, 1982	3122	1775 – 1780
"	August 19, 1983	3271	5604 – 5610
"	"	"	5614 – 5623
"	"	"	5665 – 5669
"	"	"	5677 – 5682
"	July 17, 1980	2907	5794 – 5798
"	"	"	5808 – 5813
"	"	"	5832 – 5836
"	August 8, 1984	3376	6622 – 6627
"	"	"	6661 – 6668
Holy Cross	July 17, 1980	Roll 17	42 – 46
"	July 21, 1980	Roll 14	60 – 77
"	July 17, 1980	Roll 7	95 – 101
"	July 21, 1980	Roll 14	118 – 136
"	July 17, 1980	2907	5620 – 5623
"	July 19, 1980	2911	6257 – 6268
"	July 23, 1980	2917	7173 – 7177
"	"	"	7220 – 7239
"	July 24, 1980	2919	7514 – 7529
"	"	"	7571 – 7583
			2
Hughes	July 12, 1979	2784	1672 – 1684
"	August 2, 1981	3004	1970 – 1991
Iditarod	July 21, 1980	Roll 14	40 – 49
"	"	"	137 –142
"	"	"	147 – 154
"	July 17, 1980	Roll 7	157 – 166
"	July 21, 1980	Roll 14	221 – 227
(Holy Cross)	"	"	194 – 211
Iditarod	"	"	296 – 301
"	August 21, 1982	3124	2091 – 2098
(Sleetmute)	July 19, 1980	2911	6246 – 6254
Juneau	August 11, 1979	2804	4257 – 4260

PRIMARY QUADRANGLE[1]	DATE OF PHOTOGRAPHY	ACCESSION OR ROLL NUMBER	FRAME NUMBERS
"	"	"	4322 – 4325
"	"	Roll 11	384 – 387
Lake Clark	August 3, 1982	3109	13 – 16
"	August 13, 1984	3385	100 – 104
"	June 20, 1978	2616	4704 – 4710
"	"	"	4753 – 4756
"	"	"	4852 – 4857
"	August 26, 1978	2667	7569 – 7572
"	"	"	7741 – 7745
"	"	"	7795 – 7799
Lime Hills	August 13, 1984	3385	79 – 92
"	"	"	125 – 129
"	"	"	134 – 137
"	July 21, 1980	Roll 14	345 – 349
"	July 20, 1980	2913	6611 – 6626
(Lake Clark)	August 25, 1978	2664	7353 – 7358
Lime Hills	August 26, 1978	2667	7806 – 7813
"	"	"	7828 – 7832
"	"	"	7835 – 7841
"	"	"	7842 – 7846
"	"	"	7850 – 7855
Melozitna	June 27, 1978	Roll 9	183 – 191
"	"	"	208 – 213
"	"	"	281 – 287
Naknek	August 15, 1984	3391	287 – 292
"	"	"	315 – 320
"	"	"	428 – 432
"	"	"	441 – 446
(Dillingham)	August 20, 1982	3122	1775 – 1780
Naknek	"	"	1796 – 1800
"	"	"	1888 – 1894
"	August 27, 1983	3281	6667 – 6671
"	"	"	6715 – 6721
Noatak	July 14, 1979	2788	2772 – 2777
"	"	"	2793 – 2797
"	"	"	2864 – 2868
"	"	"	2878 – 2888
"	"	"	2931 – 2941

PRIMARY QUADRANGLE[1]	DATE OF PHOTOGRAPHY	ACCESSION OR ROLL NUMBER	FRAME NUMBERS
"	"	"	2946 – 2951
"	July 3, 1978	2624	5868 – 5872
Ruby	July 23, 1980	Roll 15	23 – 28
"	"	"	42 – 49
"	"	"	136 – 141
"	"	"	153 – 159
"	"	"	190 – 196
"	"	"	209 – 216
"	"	"	326 – 331
Sagavanirktok	June 28, 1978	2622	5604 – 5613
"	"	"	5632 – 5640
"	July 13, 1979	2786	2359 – 2369
"	"	"	2417 – 2429
"	July 8,1978	Roll 19	294 – 303
"	"	"	307 – 316
Sleetmute	August 13, 1984	3385	70 – 78
Sleetmute	August 5, 1982	3112	313 – 326
Sleetmute	"	"	355 – 357
"	"	"	370 – 376
"	"	"	379 – 388
"	"	"	393 – 401
"	June 20, 1978	2616	4647 – 4649
"	July 11, 1980	2911	6285 – 6290
"	July 20, 1980	2913	6689 – 6690
Taku River	August 11, 1979	2804	4403 – 4407
"	August 12, 1979	2806	4890 – 4896
Taylor Mountains	July 20, 1980	Roll 10	13 – 17
"	August 13, 1984	3385	14 – 18
"	"	"	50 – 54
(Dillingham)	August 15, 1984	3391	87 – 97
Taylor Mountains	July 20, 1980	Roll 10	222 – 224
"	"	"	250 – 254
(Sleetmute)	August 5, 1982	3112	327 – 349
Taylor Mountains	June 20, 1978	2616	4868 – 4869
"	August 18, 1983	3269	4870 – 4875
"	"	"	4917 – 4915
"	"	"	4919 – 4925
"	"	"	4944 – 4948

APPENDIX 2

LISTING BY QUADRANGLE OF TECHNICAL REFERENCES USED DURING EVALUATION OF GEOLOGY, CONSTRUCTION MATERIALS, AND NATURAL HAZARDS IN PROPOSED ACCESS CORRIDORS IN ALASKA

Ambler River

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Anchorage

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Detterman, R.L., Plafker, George, Hudson, Travis, Tysdal, R.G., and Pavoni, Nazario, 1974, Surface geology and Holocene breaks along the Susitna segment of the Castle Mountain fault, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-618, scale 1:24,000, 1 sheet.

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Lahr, J.C., Page, R.A., Stephens, C.D., and Fogleman, K.A., 1986, Sutton, Alaska, earthquake of 1984: Evidence for activity on the Talkeetna segment of the Castle Mountain fault system: Bulletin of the Seismological Society of America, v. 76, no. 4, p. 967-983.

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Page, Robert, and Lahr, John, 1971, Measurements for fault slip on the Denali, Fairweather, and Castle Mountain faults, Alaska: Journal of Geophysical Research, v.76, no. 35, p. 8534-8543.

Reger, R.D., 1978, Reconnaissance geology of the new capital site and vicinity, Anchorage Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Open-file Report 113A, scale 1:63,360, 1 sheet.

______1981a, Geologic and materials maps of the Anchorage C-8 SW Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Geologic Report 68, scale 1:25,000, 2 sheets.

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Richardson and Glenn Highways between Fairbanks and Anchorage, Alaska: Alaska Division of Geological & Geophysical Surveys Guidebook 1, p. 185-263, scale 1:250,000, 1 sheet.

Baird Mountains

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Barrow

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Barter Island

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Bendeleben

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APPENDIX 3

TECHNICAL REFERENCES USED TO ASSESS ACTIVITY OF FAULTS IN QUADRANGLES TRAVERSED BY 10-MILE-WIDE PROPOSED CORRIDORS IN ALASKA

Quadrangle	Fault	Reference[1]
Anchorage	Border Ranges-Knik	Burns and others (1991) Magoon and others (1976) Reger and Updike (1983)
	Castle Mountain-Caribou	Bruhn (1979) Detterman and others (1974, 1975, 1976) Grantz (1961) Lahr and Page (1986) Lahr and others (1985, 1986) Magoon and others (1976) Page and Lahr (1971) Reger (1981c) Reger and Updike (1983)
Bendeleben	Bendeleben	Hudson and Plafker (1978) Kaufman (1985, 1986) Till and others (1986)
	Kigluaik	Hudson and Plafker (1978) Kaufman (1985, 1986) Till and others (1986)
	Windy Creek	Kaufman (1985, 1986) Till and others (1986)
Bethel	Milk Creek-Holitna	Hoare and Coonrad (1959a) Plafker and others (1977)
Bettles	Kanuti	Brogan and others (1975) Patton and Miller (1973)
	Kobuk-Alatna Hills	Hamilton (1984) Patton (1973) Patton and Miller (1973)
Charley River	Tintina	Dover and Miyaoka (1988) Patton (1973)

[1] Complete reference citations are given in Appendix 2.

Quadrangle	Fault	Reference
Circle	Tintina	Foster and others (1983) Patton (1973) Weber and Foster (1982) Yeend (1989)
Cordova	Etches	Nelson and others (1985) Winkler and Plafker (1981)
	Ragged Mountain	Kachadoorian (1960) Nelson and others (1985) Tysdal and others (1976) Winkler and Plafker (1981)
	Rude River	Winkler and Plafker (1981)
Eagle	Tintina	Foster (1976) Patton (1973)
Fairbanks	Minto	Péwé and others (1966) Puplan (1988) Reger (1987a)
	(liquefaction)	Combellick (1984)
Healy	Healy	Thorson (1979)
	Healy Creek	Brogan and others (1975) Wahrhaftig (1970a)
Hughes	Kobuk-Alatna Hills	Hamilton (1984) Patton (1973) Patton and Miller (1966)
Iditarod	Iditarod-Nixon Fork	Bundtzen and Laird (1982, 1983A) Bundtzen and others (1988, 1992) Cady and others (1955) Miller and Bundtzen (1988, 1994)
Iliamna	Bruin Bay	Magoon and others (1976)
Juneau	Chatham Strait	Plafker and others (1978)

Quadrangle	Fault	Reference
Kateel River	Huslia	Brogan and others (1975) Patton (1966)
	Shoestring Dune	Brogan and others (1975) Patton (1966) Weber and Péwé (1970)
Lake Clark	Lake Clark	Magoon and others (1976) Nelson and others (1983)
Lime Hills	Denali-Farewell	DGGS (unpub. data) Gilbert (1981)
McGrath	Denali-Farewell	Blodgett and Gilbert (1983) Bundtzen and others (1982) DGGS (unpub. data) Fernald (1960) Gilbert (1981) Gilbert and others (1990) Plafker and others (1977)
	Iditarod-Nixon Fork	Miller and Bundtzen (1988)
Medfra	Iditarod-Nixon Fork	Fernald (1960) Miller and Bundtzen (1988) Patton and others (1980)
Melozitna	Huslia	Patton and others (1978)
	Kaltag	
Mount Katmai	Bruin Bay	Magoon and others (1976)
Mount McKinley	Denali	Plafker and others (1977) Reed (1961)
Norton Bay	Kaltag	Cass (1959a) Patton (1973) Patton and Hoare (1968)
Nulato	Kaltag	Cass (1959b) Patton (1973) Patton and Hoare (1968) Weber and Péwé (1970)

Quadrangle	Fault	Reference
Ruby	Kaltag	Patton (1973) Patton and Hoare (1968)
Russian Mission	Iditarod-Nixon Fork	Cady and others (1955) Hoare and Coonrad (1959b) Miller and Bundtzen (1988)
Selawik	Kobuk-Alatna Hills	Hamilton (1984) Patton (1973) Patton and Miller (1968)
Shungnak	Kobuk-Alatna Hills	Brogan and others (1975) Hamilton (1984) Patton (1973) Patton and others (1968)
Sleetmute	Atsaksovluk	Cady and others (1955)
	Boss Creek	Cady and others (1955) Miller and others (1989) Waythomas (oral commun., 1992)
	Chuilnuk Mountains	Cady and others (1955) Waythomas (oral commun., 1992)
	Farewell-Holitna	Decker and others (1984) Miller and others (1989) Plafker and others (1977) Robinson and others (1984) Waythomas (1990) Waythomas (oral commun., 1992)
	Holokuk	Cady and others (1955) Waythomas (oral commun., 1992)
	Iditarod-Nixon Fork	Cady and others (1955) Miller and Bundtzen (1988) Miller and others (1989) Patton (1973)
Solomon	Crater Creek	Kaufman (1985, 1986) Till and others (1986)

Quadrangle	Fault	Reference
Talkeetna	Chelatna Lake	Nelson and Reed (1978) Reed and Nelson (1980)
	Denali	Plafker and others (1977) Reed and Nelson (1980)
	Moose Creek	Nelson and Reed (1978) Reed and Nelson (1980
	Pingston Creek	Nelson and Reed (1978) Reed and Nelson (1980)
Tanana	Kaltag	Brogan and others (1975) Chapman and others (1982)
Taylor Mountains	Atsaksovluk	Cady and others (1955)
	Boss	Cady and others (1955)
	Holitna	Cady and others (1955) Plafker and others (1977)
Tyonek	Bruin Bay	Detterman and others (1975, 1976) Hackett (1977) Magoon and others (1976)
	Castle Mountain	Detterman and others (1974, 1976) Hackett (1977) Magoon and others (1976) Reger and Updike (1983) Schmoll and others (1981)
	Lake Clark	Detterman and others (1976) Hackett (1977) Magoon and others (1976) Schmoll and others (1981)
Unalakleet	Kaltag	Fisher (1982) Patton (1973) Patton and Hoare (1968) Patton and Moll (1985)

APPENDIX 4

QUALITY OF MAP DATA IN TECHNICAL REFERENCES USED DURING GEOLOGIC EVALUATION OF PROPOSED ACCESS CORRIDORS IN ALASKA

Quadrangle	Reference[1]	Data Quality	
		Bedrock Geology	Surficial Geology
Ambler River	Hamilton (1984) Pessel and Brosgé (1977)	- 3	3 -
Anchorage	Reger (1978, 1981a, b)	- - -	5 5 5
Baird Mountains	Karl and others (1990) Patton and Miller (1968) Pinney (1992 photointerpretation)	3 3 -	- 2 3
Barrow	Williams and Carter (1984)	-	3
Barter Island	Pinney (1992 photointerpretation)	-	3
Beechey Point	Hickmott (1986) Rawlinson (1986a, b, c)	5 5 - 5	5 5 5 5
Bendeleben	Kaufman (1986) Till and others (1986)	- 3	3 -
Bering Glacier	Miller (1961, 1971)	3 3	3 3
Bethel	Hoare and Coonrad (1959)	2	2
Bettles	Patton and Miller (1973) Reger (1992 photointerpretation)	3 -	- 3
Black River	Brabb (1970)	2	2
Bradfield Canal	Gehrels and Berg (1984) Pinney (1992 photointpretation)	1 -	- 3

[1] Complete reference citations are given in Appendix 2.

Quadrangle	Reference	Data Quality Bedrock Geology	 Surficial Geology
Candle	Patton (1967)	3	2
Chandalar	Brosgé and Reiser (1964) Hamilton (1978)	3 -	- 3
Chandler Lake	Hamilton (1979) Kelley (1990)	- 3	3 -
Charley River	Dover and Miyaoka (1988)	3	3
Chignik	Detterman and others (1981a, b)	3 -	- 3
Circle	Foster and others (1983)	3	3
Cold Bay	DuBois and others (1989) McLean and others (1978) Waldron (1961)	3 3 3	- 2 2
Cordova	Kachadoorian (1960) Winkler and Plafker (1981)	- 3	5 2
DeLong Mountains	Ellersieck and others (1990) Mayfield and others (1990) Mull (unpub. data) Sable and others (1984) Sable and Mangus (1984)	5 5 3 5 5	3 3 2 4 4
Demarcation Point	Reiser and others (1980)	-	3
Dillingham	Beikman (1974) Mertie (1938) Reger (1992 photointerpretation)	1 2 -	- - 3
Eagle	Foster (1976)	3	3
Fairbanks	Péwé and others (1966)	3 - 4 -	3 4 4 4

Quadrangle	Reference	Data Quality	
		Bedrock Geology	Surficial Geology
Flaxman Island	Carter and others (1986)	-	3
Harrison Bay	Carter and Galloway (1985) Rawlinson (1990)	3 5	3 5
Healy	Csejtey and others (1986) Gilbert and Bundtzen (1976) Wahrhaftig (1970a, b)	3 4 5 5	3 - 5 5
Holy Cross	Beikman (1974) Livingston (1983) Livingston (1992 photointerpretation)	1 - -	- 5 3
Howard Pass	Hamilton (1984) Mull (unpub. data)	- 3	3 -
Hughes	Patton and Miller (1966) Reger (1992 photointerpretation)	3 -	2 3
Iditarod	Bundtzen and Laird (1982, 1983) Bundtzen and others (1988, 1992) Miller and Bundtzen (1994) Reger (1992 photointerpretation)	5 5 5 5 3 -	5 5 5 5 - 3
Ikpikpuk River	Carter and Galloway (1988)	2	3
Iliamna	Detterman and Reed (1973, 1980)	- 3	3 -
Juneau	Beikman (1975) Pinney (1992 photointerpretation)	1 -	- 3
Kantishna River	Chapman and others (1975a, b) Collins (1985)	3 3 -	3 3 2
Karluk	Detterman and others (1987)	3	3
Kateel River	Patton (1966)	3	2

Quadrangle	Reference	Data Quality Bedrock Geology	 Surficial Geology
Killik River	Chapman and others (1964)	3	-
	Hamilton (1980)	-	3
Lake Clark	Nelson and others (1983)	3	-
	Reger (1992 photointerpretation)	-	3
Lime Hills	Capps (1930)	2	-
	DGGS (unpub. data)	3	-
	Gilbert (1981)	5	5
	Gilbert and others (1990)	5	5
	Reger (1992 photointerpretation)	-	3
	Reger (1992 satellite-imagery interpretation)	-	2
	Weber (1961)	3	3
Livengood	Chapman and others (1971)	3	2
Lookout Ridge	Yeend (1983)	2	3
McGrath	Blodgett and Gilbert (1983)	5	-
	Bundtzen and others (1982)	5	5
	Bundtzen and Laird (1983)	5	5
	DGGS (unpub. data)	3	2
	Fernald (1960)	-	2
	Gilbert (1981)	5	5
	Gilbert and others (1988, 1990)	5	5
	Kline and others (1986)	5	5
	Reed and Elliott (1970)	5	5
	Weber (1961)	2	-
		-	3
Meade River	Williams (1983)	3	3
Medfra	Fernald (1960)	2	3
	Patton and others (1980)	2	2
Melozitna	Patton and others (1978)	3	2
	Reger (1992 photointerpretation)	-	3
Misheguk Mountain	Sable and Mangus (1984)	5	5
	Sable and others (1984a, b)	5	5
		5	5

Quadrangle	Reference	Data Quality Bedrock Geology	 Surficial Geology
Mount Katmai	Riehle and others (1987)	3	3
Mount McKinley	Bundtzen and others (1976) Reed (1961) Ten Brink (1984)	5 3 -	- 3 4
Mount Michelson	Carter and others (1986) Rawlinson (1990)	- -	3 5
Naknek	Ottley (1982) Reger (1992 photointerpretation) Riehle and others (1987)	- - 3	5 3 -
Noatak	Beikman and Lathram (1976) Krause (1985) Pinney (1992 photointerpretation)	1 1 -	- 2 3
Norton Bay	Cass (1959) Riehle and others (1981)	2 -	2 4
Nulato	Bickel and Patton (1957) Cass (1959) Martinson (1982)	3 3 -	2 2 -
Ophir	Bundtzen and Laird (1980) Chapman and others (1985)	5 3	5 3
Petersburg	Brew and others (1984)	3	2
Philip Smith Mountains	Brosgé and others (1979) Hamilton (1978)	3 -	- 3
Port Moller	Reger (1992 satelline-imagery interpretation Wilson and others (1991)	- 3	2 -
Ruby	Cass (1959) Pinney (1992 photointerpretation)	2 -	- 3
Russian Mission	Bundtzen and Laird (1991) Hoare and Coonrad (1959b)	5 2	5 2

Quadrangle	Reference	Data Quality	
		Bedrock Geology	Surficial Geology
Sagavanirktok	Beikman (1976)	1	-
	Ferrians (1971)	3	3
	Pinney (1992 photointerpretation)	-	3
	Yeend (1971)	3	3
Selawik	Patton and Miller (1968)	3	2
Shungnak	Fernald (1964)	-	3
	Fritts (1969, 1970)	5	-
	Hitzman and others (1982)	5	-
	Pallister and Carlson (1988)	3	-
	Patton and others (1968)	5	-
		3	2
Sleetmute	Decker and others (1984)	5	-
	Miller and others (1989)	3	3
	Reger (1992 photointerpretation)	-	3
	Reifenstuhl and others (1984)	5	-
	Robinson and others (1984)	5	-
	Waythomas (1990)	-	5
Solomon	Kaufman (1986)	-	3
	Till and others (1986)	3	-
Survey Pass	Hamilton (1981)	-	3
	Nelson Grybeck (1980)	3	-
Taku River	Beikman (1975)	1	-
	Brew and Ford (1985)	3	-
	Pinney (1992 photointerpretation)	-	3
Talkeetna	Nelson and Reed (1978)	-	3
	Reed and Nelson (1980)	3	2
Tanana	Chapman and others (1982)	3	3
Taylor Mountains	Beikman (1974)	1	-
	Cady and others (1955)	2	-
	DGGS (unpub. data)	3	2
	Reger (1992 photointerpretation)	-	3
Teshekpuk	Carter (1983)	-	3

Quadrangle	Reference	Data Quality	
		Bedrock Geology	Surficial Geology
Tyonek	Barnes (1966)	5	-
	Detterman and others (1974, 1976)	-	3
	Magoon and others (1976)	3	-
	Odum and others (1988)	3	-
	Rawlinson and others (1982a, b, c)	-	3
	Reger (1978)	-	5
	Reger and Updike (1983)	-	5
	Schmoll and Yehle (1987)	-	5
	Solie and others (1991)	-	5
	Weber (1961)	-	3
		5	5
		5	5
		-	3
Ugashik	Detterman and others (1987)	3	3
Umiat	Carter and Galloway (1986)	2	3
Unalakleet	Cass (1959)	2	2
	Patton and Moll (1985)	3	2
	Riehle and others (1981)	-	4
Utukok River	Yeend (1984)	2	3
Wiseman	Dillon and others (1986)	3	-
	Hamilton (1979)	-	3