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ENGINEERING GEOLOGY OF THE NENANA-REX AREA, ALASKA

By

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ENGINEERING GEOLOGY OF THE NENANA-REX AREA, ALASKA

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INTRODUCTION

A geological examination of the Nenana-Rex area, Alaska, was made during August, 1954 by a Geological Survey party consisting of Reuben Kachadoorian, geologist, and Lloyd Plafker, field assistant. The area examined lies in parts of the Fairbanks A-4, A-5, B-4, B-5, C-4, and C-5 quadrangles (fig. 1). A preliminary highway route and the Alaska Railroad cross the area mapped. The preliminary highway route, surveyed in the summer of 1954 by the Alaska Road Commission, is a segment of a proposed road from Fairbanks to McKinley Park (pl. 1).

The area was mapped with special emphasis placed upon geologic factors that would affect construction of the new highway. This report is a result of the studies along the highway and railroad routes, and describes only those areas that are of immediate importance in planning and construction of the highway (pl. 1).

Methods of field work

Field mapping by the Geological Survey consisted of a series of foot and tracked-vehicle traverses during which geological information was gathered and plotted on vertical aerial photographs of 1:10,000 and 1:40,000 scales and later transferred to a topographic

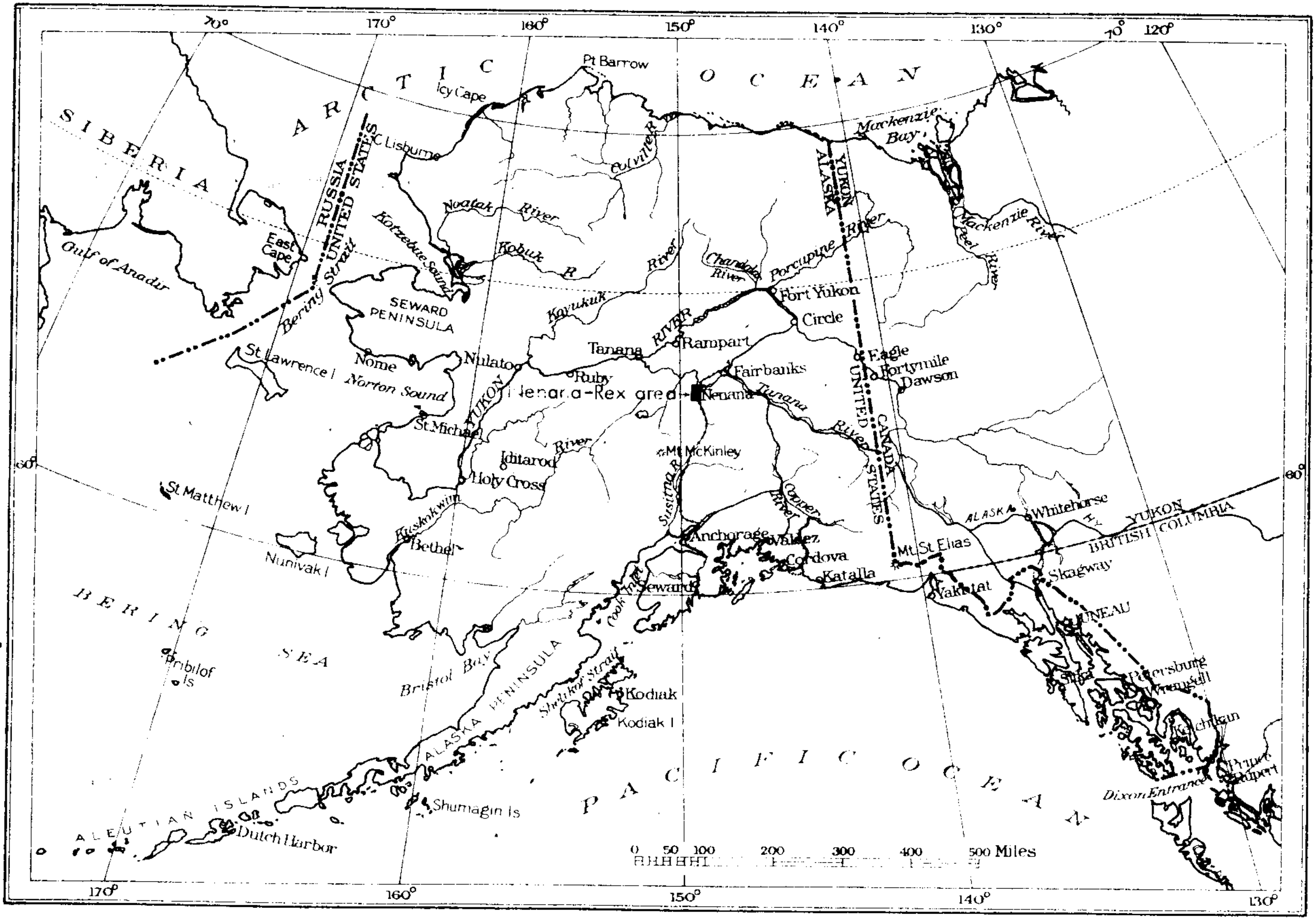

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Figure 1. Index map showing location of Nenana-Rex area, Alaska

map of 1:[illegible] scale. Areas not visited on the ground were mapped by photo-interpretation and reconnaissance from a light airplane. Areas west of Lost Slough and the Nenana River were mapped by photo-interpretation and aerial reconnaissance.

Acknowledgments

The field work was greatly facilitated by the cooperation of the Alaska Road Commission and The Alaska Railroad. Mechanical analyses of samples collected by the Survey were prepared by the Fairbanks District of the Alaska Road Commission. The Alaska District of the Corps of Engineers supplied subsurface information and mechanical analyses of material from the Clear area. The Anchorage Office of the Civil Aeronautics Administration furnished subsurface information of the Nenana area. Mr. I. P. Taylor of Seattle, Washington supplied information concerning the major channel change of the Nenana River in 19[illegible].

GEOGRAPHIC SETTING

Topography

The Nenana-Rex area lies in the Tanana Valley and is bounded on the north by the Yukon-Tanana Upland north of the Tanana River, on the south by the foothills of the Alaska Range, on the east by longitude 148° 5[illegible]' W., and on the west by the Nenana River. The Tanana Valley in this locality is approximately [illegible] miles wide, and slopes generally north, [illegible] to 5[illegible] feet per mile.

The area is drained by several small creeks and two large rivers (pl. [illegible]). Clear, Fish, Julius, and Windy Creeks flow into the northward-flowing Nenana River, which in turn joins the westward-flowing Tanana River. The confluence of the Nenana and Tanana Rivers is at the town of Nenana in the north-central part of the mapped area.

Vegetation

Vegetation in the Nenana-Rex area consists of sedges, grasses, mosses, lichen, shrubs, and trees. The shrubs are primarily Labrador tea, cranberry, blueberry, and dwarf birch. The trees consist of alder, willow, aspen, cottonwood, birch, and spruce. The type of vegetation on the various deposits in the Nenana-Rex area is controlled chiefly by the drainage of the deposits. Forest fires have interrupted the normal succession of plant growth in many parts of the area.

The hills of the Yukon-Tanana Upland, north of the Tanana River, are covered with birch, aspen, and spruce trees. These trees generally grow along the stream courses.

The glacial outwash plain ([illegible], pl. 1) is occupied by a thick growth of aspen, birch, and spruce trees generally [illegible] to [illegible] inches in diameter. However, spruce trees up to [illegible] inches in diameter are common. A thick growth of underbrush consisting of grasses, cranberries, small birch, and aspen carpets the whole outwash plain.

Birch, aspen, and willow trees up to [illegible] inches in diameter occupy the abandoned stream channels ([illegible]). A thin moss and lichen carpet lies beneath the trees. Along the edges of the channels, Labrador [illegible], grasses and sedges carpet the area beneath the spruce trees.

Vegetation on the interchannel silt areas ([illegible]) consists of a thick layer of dwarf birch, grasses, sedges, mosses, lichen, and occasional patches of stunted spruce trees. The dwarf birch and stunted spruce trees occupy the relatively drier portions of the interchannel silt areas. In the wetter areas, grasses, sedges, mosses, and lichen are the chief vegetation.

Grasses, sedges, mosses, lichen, and an occasional patch of dwarf birch occupy areas of swamps ([illegible]). Locally, peat accumulations several feet thick occur. More commonly, the vegetation cover of grass, moss, and lichen is less than 2 feet thick.

Vegetation on most of the alluvial fans ([illegible]) consists of sedges, grasses, dwarf birch, and abundant mosses and lichen. Aspen, willow, and spruce trees, [illegible] inches in diameter, line the water courses and lakes. Locally, spruce trees up to 12 inches in diameter occur. In the well-drained portion of the fans, birch and aspen are the dominant trees. In the more poorly drained areas, spruce and dwarf birch occur more frequently.

Recent alluvium ([illegible]) flood plains of the Nenana and Tanana Rivers are occupied by spruce, cottonwood, aspen, birch, alder, willow, dwarf birch, Labrador tea, blueberry, cranberry, moss, and lichen. The vegetation on better drained portions of the alluvium consists of cottonwood, aspen, spruce, and birch. The marshy or wet areas support a shrub growth of alder, willow, dwarf birch, Labrador tea, blueberry, cranberry, and a thick growth of moss and lichen.

GEOLOGY

The general geology of the Nenana-Rex area is shown on plate 1. Bedrock consists of Birch Creek schist of Precambrian age (Capps, 1940, p. 95) exposed in the dissected Yukon-Tanana Upland north of the Tanana River, and Nenana gravel of Tertiary age (Capps, 1940, p. 126-128) exposed in the southern part of the area. The Tanana Valley is mantled by unconsolidated deposits of Quaternary age of glacial and nonglacial origin.

Bedrock

Birch Creek schist

The Birch Creek schist of Precambrian age exposed in the Yukon-Tanana Upland consists chiefly of quartz, mica, calcareous schists, and minor amounts of greenstone. This schist is the result of mild metamorphism of shales, sandstones, and limestones. The most common phase of the Birch Creek schist is quartz-sericite schist.

Freshly exposed, unweathered schist is generally greenish, appears massive, and breaks into thick slabs. However, it weathers readily when exposed to the elements, becomes gray, brown or red, and breaks into thin slabs.

The schists of the Birch Creek formation will generally offer fair road foundations. They are undesirable, however, as surfacing material, for the schists are subject to mechanical disintegration into silt and clay-size particles. Thus, road surfaces mantled by Birch Creek schist will eventually be subject to frost action.

Nenana gravel

The Nenana gravel of Tertiary age is exposed in the foothills in the southern part of the mapped area. The gravel is generally brown and consists predominantly of medium- to fine-grained sandstone, shale, minor amounts of siltstone and claystone, and conglomerate interbedded with thin lenses of coarse-grained sandstone. Locally, lignite coal beds occur in the Nenana gravel.

At Mile 384.5 on The Alaska Railroad, the medium- to fine-grained sandstone, shale, siltstone, and claystone underlie the conglomerate layers and comprise about 60 percent of the exposed formation.

The conglomerate is well sorted, well cemented, and consists of 50 percent gravel and 50 percent sand. The pebbles comprising the conglomerate consist chiefly of schist, quartzite, graywacke, and igneous rocks of varying composition (Wahrhaftig, Hickcox and Freedman, 1951). The pebbles are generally well rounded and range in diameter from 1 to 3 inches. Locally, cobbles and boulders up to 6 inches in diameter occur. Many of the pebbles are weathered.

The Nenana gravel will generally provide sound road foundations, and is also a source of an ample supply of fine borrow material. It is a poor source of gravel, however, because of the abundance of fines and decomposed pebbles.

Unconsolidated deposits

The Tanana Valley lowland is mantled by unconsolidated deposits of glacial and nonglacial origin. During earlier stages of Pleistocene glaciation in the high and rugged mountains of the Alaska Range to the south, the rivers and streams flowing outward from the glaciers carried great amounts of glacial outwash consisting of gravel, sand and silt. The coarser fraction of the outwash was dropped along the southern part of the valley. The finer material was carried farther northward into the Tanana Valley. Shorter non-glacial streams flowing northward from the Alaska Range contributed substantial amounts of debris to the Tanana Valley along the mountain front and between the smaller valleys of the larger glacial streams. The coalescence of debris from the glacial and nonglacial streams thus built a large alluvial apron outward from the mountain front. This apron gradually forced the Tanana River to its present location along the north side of the Tanana Valley lowland.

The latest part of the outwash material of Pleistocene age is represented in the southwestern part of the Nenana-Rex area by a broad, fan-shaped area of gravel adjoining the Nenana River flood plain north of Clear (Qg, pl. 1). Elsewhere, the sediments of Pleistocene age are covered by sediments of Recent age consisting of channel sand (Qc), interchannel silt (Qic), swamps (Qs), recent alluvial deposits (Qra) of the Nenana and Tanana Rivers, and alluvial fans (Qaf) of Windy and Totatlanika Creeks.

Channel sand, interchannel silt, and the major portion of the swamps in the Nenana-Rex area are the result of relict drainage patterns of the Totatlanika Creek (which presently flows northward, 2 miles east of the area included on pl. 1), and minor streams flowing into the Nenana River.

Channel sand, interchannel silt, and swamp deposits east of Lost Slough were formed by Totatlanika Creek at a time when the creek flowed northwestward through the area. Channels that originally drained the outwash gravel plain (Qg) have been covered by these Totatlanika Creek deposits. Thus, these deposits were formed after the deposition of the outwash gravel plain. West of Lost Slough, the channels, interchannel silt areas, and the swamps were also formed after the deposition of the outwash gravel, but were deposited by minor streams flowing into the Nenana River.

These three mapped units represent distinct environments within a large complex alluvial fan. In detail, the surface of the fan consists of sinuous elevated ridges, generally 1 to 3 feet high, aboarded by gentle slopes and swales. The elevated ridges represent abandoned stream channels (Qc). Characteristic of streams on alluvial fans, these streams shifted occasionally because of alluviation. The aboarded gentle slopes are natural levees formed by over-bank deposition during the spring floods. The natural levee areas are represented by interchannel silt (Qis). The swales are areas that lie between natural levee deposits. The major portion of these swales are occupied by swamps.

Outwash gravel

Outwash gravel deposited by the Nenana River during late stages of Pleistocene glaciation is expressed topographically in the area as a broad, flat, fan-shaped gravel plain mantled by a few inches to 5 feet of flood plain and windblown fine sand and silt. The outwash plain has very little relief.

The outwash consists of interbedded sand and sandy gravel (Curve F, fig. 2, location of samples shown on pl. 1). The gravel pebbles are flat to well-rounded and consist chiefly of greenstone, quartz, and granite with minor amounts of conglomerate, muscovite schist, argillite and chert. The pebbles average 1 inch in diameter, but locally may be 6 inches in diameter. The sand in the interbedded sand and sandy gravel layers is clean and coarse grained.

Frost action and the infiltration of rain and snow melt have incorporated the mantle of flood plain and windblown fine sand and silt into the underlying coarse sandy gravel. Comparative results of two samples collected from different depths of the same test pit analyzed by the Alaska District, Corps of Engineers, are shown on figure 2 (Curves C & F). Sample C was collected at a depth of 2 feet, probably in the lowermost portion of the flood plain and windblown fine sand and silt. Sample F was collected at 4 feet, well into the underlying coarse sandy gravel. Thus, in this locality the fine sand and silt mantle is approximately 2 to 3 feet thick.

Areas underlain by outwash gravel are well drained. Consequently, no frost action is anticipated.

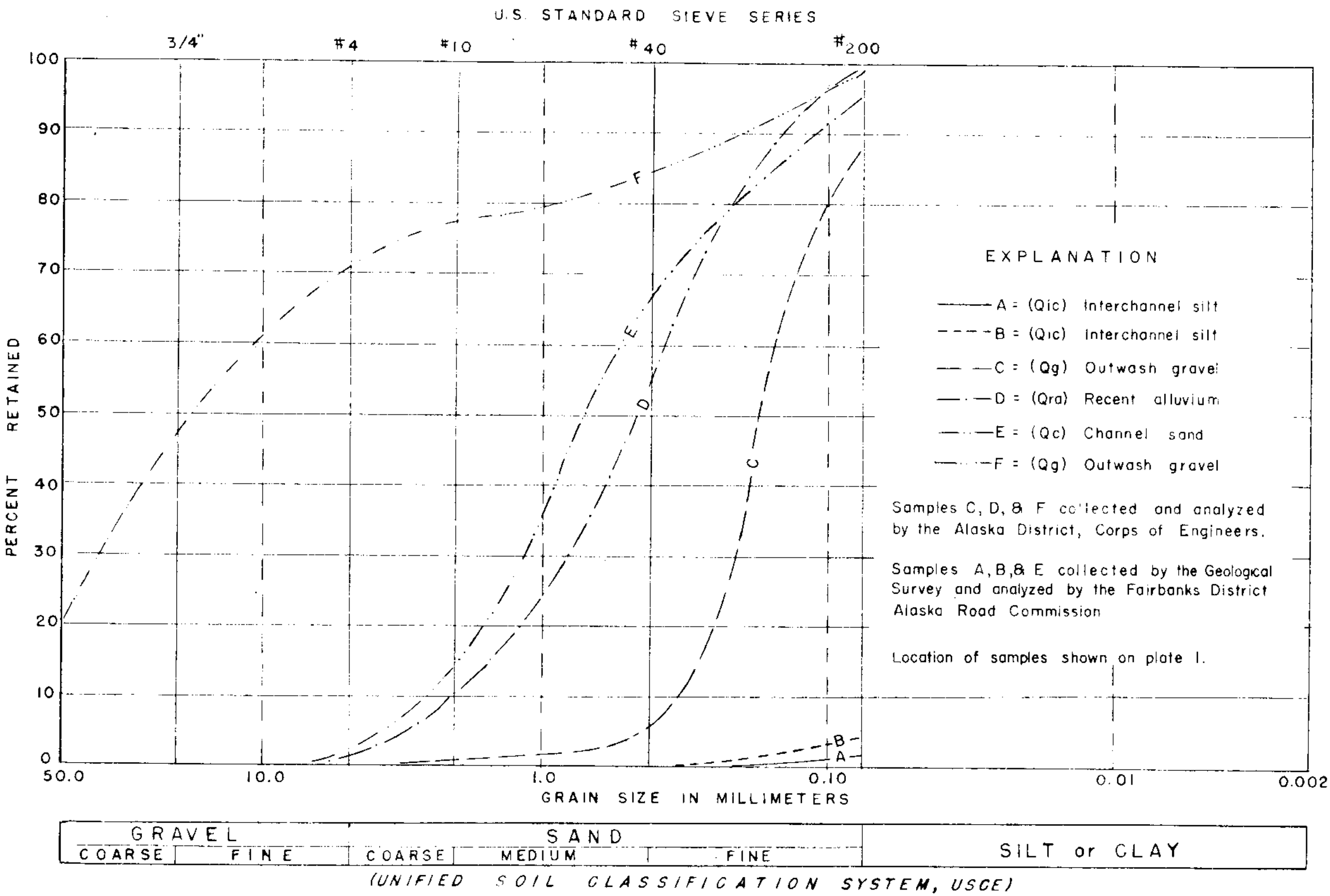

Figure 2: Cumulative size-frequency curves of deposits in the Nenana-Rex area, Alaska.

Depth to permafrost decreases from the base of the mountains to the edge of the gravel plain. A 30-foot test pit dug at Mile 392 on The Alaska Railroad by the Alaska District of the Corps of Engineers did not reach permafrost. In the gravel pit at Clear, permafrost is found at 20 feet. At the edge of the gravel plain, north of Clear, perennially frozen ground is approximately 10 to 15 feet below the surface.

The coarse sandy gravel outwash plain will offer a good road foundation and an excellent source of borrow. Removal of the flood-plain and wind-blown fine sand and silt may be necessary to prevent possible local frost action. The Alaska Railroad, in the past years, has used gravel from this deposit for ballast on the railroad.

Channel sand

Channel sand (Qc) is expressed topographically in the Nenana-Rex area as flat, generally narrow, meandering, abandoned stream channels. The channels are discontinuous with the exception of a relatively large channel that extends from the southeast corner of the area to approximately Mile 403.5 on the Alaska Railroad (pl. 1).

Channel sand deposits generally consist of 95 percent washed, medium- to coarse-grained sand and 5 percent subrounded to rounded fine gravel (Curve E, fig. 2). Locally, the gravel content is as high as 30 percent. Fine wind-blown sand and silt, 6 to 13 inches thick, locally mantles the channels.

The major portion of the weathered fraction of the sand and gravel has been carried away by water. Thus, channel sand deposits contain very few weathered pebbles.

Surface drainage on the abandoned channels is generally good. Subsurface drainage is fair, but where the water table lies within 1 to 2 feet of the surface the drainage is poor.

Frost action should be mild or lacking in channel sand deposits. Locally, where the water table lies close to the surface, and where channels are mantled by a thick layer of wind-blown fine sand and silt, mild frost action should be anticipated.

Test pits up to 6 feet deep were dug in the channel sand deposits and permafrost was not found.

Channel sand deposits are especially suitable as road foundations, because of good surface drainage, and relatively mild frost action. However, the wind-blown fine sand and silt should be removed to minimize frost action. Local construction problems may arise where the water table lies within 1 to 2 feet of the surface. An ample supply of fine borrow can be obtained from areas of channel sand.

Interchannel silt

Interchannel silt (Qis) is the predominant unconsolidated deposit in the Nenana-Rex area and is expressed as gently sloping, low-lying surfaces interrupted by swamps (Qs) and abandoned stream channels (Qc). Locally, interchannel silt areas are marshy.

Interchannel silt areas are flood plains of the relict stream channels (Qc). Thus, interchannel silt was formed contemporaneously with the abandoned channels. During flood stage, areas originally underlain by glacial outwash debris of Pleistocene age were covered by silt-laden water from Totatlanika Creek and the minor streams flowing into the Nenana River. Thus, the glacial outwash that originally mantled the Tanana Valley was covered in a great part by interchannel silt deposits. The depth of silt ranges from 3 to 10 feet. Undoubtedly, the flood plain deposits were enriched slightly in silt by wind-blown material. The amount of enrichment, however, is indeterminable.

Interchannel deposits consist of approximately 95 percent silt and 5 percent fine sand (Curves A and B, fig. 2).

Areas of interchannel silt are poorly drained. Thus, intense frost action will be found in these deposits. Telephone poles placed in interchannel silt show intense frost heaving and have to be reburied periodically.

Permafrost generally exists in interchannel silt areas at depths of 3 to 4 feet. Locally, permafrost may immediately underlie the vegetation cover. The perennially frozen ground is kept frozen by the accumulation of vegetation. If this vegetation cover is destroyed or disrupted, the surface of the permafrost will thaw and swampy areas will develop in the poorly drained interchannel silt. Many of the smaller swampy areas adjacent to The Alaska Railroad developed as a result of tracked vehicles crossing over such areas.

The vegetation cover was disrupted or destroyed by the tracked vehicles during the winter months. The following summer, swampy areas containing as much as one foot of standing water were observed.

Poor drainage, frost action, and permafrost make areas of interchannel silt unfavorable for highway foundations. If construction of roads on interchannel silt cannot be avoided, construction methods that allow the vegetation cover to be left intact should be adopted. Areas of interchannel silt are a poor source of borrow material because of the high silt content.

Swamps

Large swamps (Qs) are scattered throughout the Nenana-Rex area and are especially abundant north of Clear. The swamps chiefly overlie areas of interchannel silt. An occasional swamp occurs in the poorly drained alluvial fans (Qaf).

The swamps consist of large areas of impeded drainage in which soils are saturated throughout the year. Standing water a few inches deep covers much of the surface, but locally the water is 4 to 5 feet deep. Many areas mapped as swamps do not generally contain any standing water. They do, however, become marshy and contain water 2 to 3 inches deep after a few days of rain. Although such areas may be intermediate between interchannel silt and swamps, they are considered and mapped as swamps in this report.

The swamps are underlain by peat and silt generally more than 2 to 3 feet thick; the maximum thickness is unknown but it may be as much as 1[illegible] feet. Underlying the peat, and silt is an unknown thickness of silt and fine-grained sand.

Areas of swamps are underlain by permafrost at depths of 2 to 3 feet. Locally, the perennially frozen ground lies within one foot of the surface. Lenses and stringers of clear ice up to [illegible] inches thick are common in the permafrost.

The swamps are unfavorable for highway construction and should be avoided wherever possible. If construction of roads on swamps cannot be avoided, however, the adoption of construction methods that permit leaving the natural vegetation intact will be helpful in combating construction and maintenance problems.

Alluvial fans

Alluvial fans (Qaf) occur chiefly along the base of the foothills in the southern part of the mapped area. The large alluvial fan in the southern part of the mapped area was formed by the coalescence of numerous smaller fans of the creeks draining the foothills. Individual fans have relatively little relief and stand 2 to 3 feet above the stream channels. However, where the fans adjoin one another, relief of [illegible] to [illegible] feet is common.

Alluvial fans are generally well drained and dry. Locally, however, swampy areas occur, especially where the smaller fans adjoin one another. The water table ranges from 15 feet below the surface at the head of the fans to 5 feet at the toe of the fans.

Alluvial fans consist of interfingering lenses of clean cobbles, coarse and fine gravel, and minor quantities of sand and silt. Average grain size of the material decreases with increasing distance from the foothills. The surfaces of alluvial fans are commonly mantled by a few inches of flood-plain and wind-blown silt. Rain and snow melt have incorporated slight amounts of this silt into the underlying gravel, silt and sand. The degree of incorporation is undetermined.

Permafrost was not found in several 4-foot deep test pits in alluvial fans. It is probable, however, that permafrost exists, locally, 15 to 20 feet below the surface. Thus, if permafrost does exist in alluvial fans, its low ice content and depth would not affect construction and maintenance of the highway.

Alluvial-fan areas provide good foundation for highways. The flood-plain areas of fans are subject to occasional flooding and thus should be crossed on fills several feet high. Occasional radical channel changes during or following floods must be anticipated. Alluvial fans are a good source of borrow material. Because of rapid size gradation from coarse gravels at the heads of fans to fine gravels at the toes, gravel of any desired average size may be obtained by the proper position on the fan. Borrow pits will be limited to depths of 5 feet or less by high water table at the toes of the fans. At the heads of the fans where the water table is much deeper, deeper cuts may be excavated.

Recent alluvium

Deposits of recent alluvium (Qra) underlie the Nenana and Tanana Rivers and their flood plains. The flood plains underlain by this deposit are nearly flat surfaces crossed by numerous recently abandoned stream channels, a few winding sloughs and minor streams, and channels occupied only during flood stages of the Nenana and Tanana Rivers.

Recent alluvium consists of interfingering lenses of washed, clean gravel, sand and silt. In the area mapped, the recent alluvium of the Tanana River consists chiefly of sand and silt. The Nenana River flood plain alluvium, however, varies greatly. The average size of the gravel contained in the Nenana River recent alluvium decreases with increasing distance from the base of the mountains. Near Rex, the alluvium consists chiefly of coarse gravel and local occurrences of cobbles and boulders up to 3 feet in diameter. Near the town of Nenana, this same alluvium is composed predominantly of sand and silt.

A large portion of the pebbles comprising the recent alluvium of the Nenana River is reworked glacial debris. Thus, the pebbles are in large part lithologically similar to those found in outwash gravel (Qg). The sand and silt of the Tanana River flood plain alluvium consists chiefly of quartz grains.

The water table lies generally at depths less than 5 feet below the flood plain surface. The entire area of recent alluvium is subject to occasional flooding. During high water in the late fall of 1917, a portion of the Nenana River flooded into Lost Slough, a minor stagnant slough approximately 60 feet wide. At the present time, Lost Slough is the main channel of the Nenana River and is approximately 150 feet wide (pl. 1).

Frost action in recent alluvium will range from virtually none in the gravel portions to mild in the sand and silt areas. Permafrost has not been recognized in the alluvium, but may be present locally at depths of 5 to 6 feet.

Flood plain areas underlain by recent alluvium are generally unfavorable for highway foundations because they are subject to seasonal flooding and possible radical change of stream channels. They are, however, a good source of borrow material.

Icing

Icing in the Nenana-Rex area should be anticipated locally along the creeks. Local residents report icing along Julius Creek and icing scars were observed on trees along the creek to heights as great as 3 feet above the base of the trees. Icing scars were not observed along the Nenana and Tanana Rivers. Although overflow icing is more common on the smaller creeks of the area, it is probable that the Nenana and Tanana Rivers may ice over into their flood plains. Thus, icing should be considered in the design of structures crossing the various creeks and the Nenana and Tanana Rivers.

Seismic activity

The Nenana-Rex area lies in a seismic zone of major intensity. In 1937 and again in 1947 severe earthquakes shook this area. The epicenter of the 1947 earthquake was at Clear, within the Nenana-Rex area. St. Amand (1948, p. 622) has determined an intensity of VIII-plus on the Mercalli Scale for this earthquake at Clear. The epicenter of the 1937 earthquake was near Salcha (Bramhall, 1938, p. 71-75) approximately 55 miles east of Nenana, and this earthquake was slightly less intense than the 1947 earthquake. Recurrence of earthquakes of similar intensity in the Nenana-Rex area is probable. Therefore, man-made structures in the Nenana-Rex area should be made earthquake-resistant.

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