

- Important Notes: 1. This portion of the proposed trans-Alaska pipeline route is considered to be subject to the following maximum probable earthquakes--from north edge of quadrangle to Willow Lake, Richter magnitude 7.0; from Willow Lake to terminal site of pipeline, Richter magnitude 8.5.
2. The seismic and tectonic history of the Chugach Mountains indicates that faults are present; however, it is difficult to locate fault zones because of the uniform character of the bedrock (Map Unit Kv) and its altered condition.
3. Temperature of permafrost at depths below the zone of seasonal variation is generally above -2°C (about 28°F).

Map Unit	Name	Description	Distribution and Thickness	Topography and Vegetation	Permafrost	Susceptibility to Frost Action	Drainage Surface	Subsurface (if thawed)	Susceptibility to Erosion	Construction Uses	Remarks
Qac	Active flood plain	Coarse, sandy gravel and sand with minor amounts of silt. Gravel clasts subrounded to rounded; locally many scattered boulders. Generally poorly stratified with local beds and lenses of sand.	Occurs discontinuously along the major rivers. Thickness probably less than 25 feet in most areas; however, the lower reaches of the Lowe River and the river emanating from Valdez Glacier have more than 100 feet.	Generally flat plain with a complex network of braided channels with local relief of 1 to 10 feet. Generally bare of vegetation, but if present consists of low or high brush.	Generally absent.	Low	Good	Good	High	Sand and gravel excellent for fill, base course, surface course, and aggregate; locally boulders can be screened for riprap.	Locally subject to suffa conditions, flooding, and intensive erosion. Shallow ground-water table restricts depth of excavation. Major rivers subject to flooding during spring breakup, especially when river ice jams occur.
Qca	Colluvium, alpine type	Unsorted to poorly sorted gravelly sandy silt with angular rock fragments; in rugged parts of the Chugach Mountains, deposits are chiefly rock fragments. Stratification, where present, generally parallels surface at about angle of repose.	Occurs on and at base of many slopes in the Chugach Mountains. Thickness highly variable but generally less than 50 feet.	Very steep to moderately steep mountain slopes. Generally bare of vegetation; at lower altitudes stable slopes have low or high brush.	Generally absent, present locally in fine-grained materials. Permafrost not present in any deposits along the proposed pipeline route south of Thompson Pass.	Generally low, high locally in fine-grained deposits.	Good	Generally good	Generally low	Coarse-grained colluvium good for coarse fill, crushed rock, and riprap.	Colluvial slopes generally unstable, especially where disturbed by construction.
Qcr	Colluvium, river bluff type	Unsorted to poorly sorted gravelly sandy silt; varies laterally and vertically from silt to sand to gravel, or to any mixture of these materials. Locally includes boulders, large blocks of unconsolidated silty soil, and organic matter. Stratification, where present, generally parallels surface at about angle of repose.	Occurs on and at base of slopes of river bluffs 50 to 350 feet high, along the Copper, Klutina, and Tonsina rivers and their major tributaries. Thickness generally less than 15 feet on slopes but at base of slopes can be more than 50 feet.	Very steep to moderately steep river bluffs 50 to 350 feet high. Very steep unstable slopes generally bare of vegetation; slopes have low or high brush and scattered small trees.	Generally present within 4 feet of the surface on north-facing slopes, but the permafrost table is much deeper on south-facing slopes; where materials are granular, permafrost commonly absent.	Variable, but generally high	Good	Generally poor	High	Gravel-sand-silt mixtures generally fair to poor for fill and base course and unsuited for surface course.	Where ice-rich permafrost is present, construction disturbance can cause unstable slope conditions to develop.
Qsw	Swamp deposits	Fibrous, matted peat with lenses and beds of organic-rich silt and fine sand.	Bogs, marshes, and muskegs developed on the major rivers. Occurs in the Copper River Basin, locally in the uplands east of the Tonsina River and in the valley of Little Tonsina River. Generally less than 15 feet thick, but locally as much as 15 feet.	Flat to gently sloping depressions, abandoned drainages, and valley bottoms. Vegetation consists of peat and sedge grasses in very wet areas; in drier areas, low brush and scattered small spruce trees.	Generally present within 5 feet of surface, but absent along Little Tonsina River. Where present, commonly ice-rich.	High	Poor	Poor	Generally low	Unsuited for all construction purposes, except possible limited development of peat for use as insulation.	Locally, where soils are saturated, seasonal frost does not penetrate to the permafrost table during the winter season, thereby leaving a thawed zone at a depth of 1 to 2 feet.
Qaf	Alluvial fans	Poorly sorted silty gravel and sand. Deposits coarse grained at apex of fan, but grade to finer grained material toward base. Most deposits include numerous boulders.	Occur along hillsides bordering Copper River Basin and along the major river channels in the Chugach Mountains. Thickness highly variable, ranging from a few feet at apex and along sides of fan to more than 50 feet in the middle.	Steep slopes at the apex, gradually becoming less steep toward the toe of the fans which have moderate to gentle slopes. Vegetation at higher altitudes consists of dense high or low brush; at lower altitudes, dense brush or trees.	Locally present; along Rock Creek just south of Willow Lake upper reaches of fans are present. Permafrost not present in any deposits along the proposed pipeline route south of Thompson Pass.	Generally low	Good	Good	High along stream courses	Generally fair for fill and base course. Where fine grained generally unsuited.	Subject to torrential floods, shifting channels, and local icings.
QRG	Rock glaciers	Extremely coarse, angular, rock rubble, primarily phyllitic graywacke (Kv). Finer material, and probably locally, occur at base of deposits.	A few isolated occurrences in the central portion of the Chugach Mountains. Maximum thickness probably less than 75 feet.	Steep to moderately sloping glacier-shaped accumulation of coarse rubble. Bare of vegetation.	Probably present locally.	Low	Good	Good	Low	Excellent for fill, riprap, rubble masonry, and base course.	Difficult to develop because of large size of boulders, and instability of some slopes, and difficult access.
Qas	Fine-grained alluvium	Poorly sorted silty sand, sand, and locally, gravelly sand. Includes fine-grained colluvium where valley walls border unit.	Occurs as terrace and flood-plain deposits of sluggish, low-gradient streams in the Copper River Basin, and along the upper reaches of the Little Tonsina River. Thickness generally ranges from 10 to 75 feet.	Flat terraces and flood plains. Vegetation consists of low brush, scattered small spruce trees, and numerous small areas of marsh and muskeg.	Generally present within 2 feet, but generally absent along upper reaches of Little Tonsina River. Where present, locally ice rich.	Generally high	Generally poor	Generally poor to moderately good	Moderately high	Generally unsuited for construction purposes. Locally, where granular and not silt rich, suitable for fill.	Severe differential settlement occurs when ice-rich permafrost is allowed to thaw.
Qt	Alluvial terrace	Coarse, sandy gravel and sand with minor amounts of silt. Gravel clasts subrounded to rounded; locally includes many scattered boulders. Generally poorly stratified with local beds and lenses of sand. Commonly mantled by 1 to 5 feet of organic-rich silty sand and sandy silt.	Occurs as terrace deposits along the Copper, Klutina, Tonsina, Tielak, Tesna, and Lowe rivers and their major tributaries. Thickness generally ranges from 15 to 150 feet; however, along the lower reaches of the Lowe River and the river emanating from Valdez Glacier thicknesses probably are greater than 100 feet.	Series of flat-topped terraces bordering the major streams of the area. Separated from active flood plain by a terrace scarp. Vegetation generally dense deciduous and evergreen trees or high brush.	Generally absent except for local lenses of silty gravelly sand. Permafrost not present in any deposits along the proposed pipeline route south of Thompson Pass.	Generally low	Good	Good	Generally low, except moderately high for silty overburden.	Sand and gravel excellent for fill base course, surface course, and aggregate; locally boulders can be screened for riprap. In some places, numerous micaceous rock fragments deleterious to aggregate.	Local concretions of large boulders pose excavation problems, and shallow ground-water table under low terraces limits depth of excavation. Low terraces near active flood plain are subject to bank erosion and occasional flooding.
Qm	Unmodified moraine	Unsorted heterogeneous mixture of gravel, sand, and silt generally consisting of silty, sandy gravel. Gravel clasts generally angular to subrounded. Deposits include irregular lenses and pockets of sandy gravel and gravelly sand.	Occurs near the termini of glaciers in the higher parts of the Chugach Mountains.	Very steep slopes of hummocky terminal and lateral moraines. Bare of vegetation.	Probably present locally.	Generally low, high locally in fine-grained deposits	Good	Generally good	Generally low	Generally unsuited as source of borrow for all purposes except deep fill.	Excavation commonly hindered by large boulders.
Qls	Landslide	Extremely coarse, angular rock rubble, primarily phyllitic graywacke (Kv) with minor amounts of gravelly sandy silt in lower part of deposit. Landslide appears to have been stable for at least a few hundred years.	Occurs on north side of mountain slope near Fort Liscom on south side of Fort Valdez. Maximum thickness probably less than 100 feet.	Steep to moderately sloping surfaces on tongue-shaped accumulation of coarse rubble. Vegetation consists of dense high brush and scattered trees.	Absent	Low	Good	Good	Low	Excellent for fill, riprap, rubble masonry, and base course.	Difficult to develop because of large size of boulders and instability of some slopes.
Qgn	High-level alluvium	Coarse, sandy gravel and sand with minor amounts of silt. Gravel clasts subrounded to rounded; locally includes many scattered boulders. Generally poorly stratified with local beds and lenses of sand.	Occurs at altitudes higher than present-day streams as discontinuous remnants of old terraces on both sides of the major valley through the central part of the Chugach Mountains and just south of the Tonsina River. Maximum thickness probably less than 100 feet.	Flat-topped terrace remnants bordered by steep to moderately steep scarps on downslope side. Vegetation generally dense high brush.	Absent	Low	Good	Good	Low	Sand and gravel excellent for fill, base course, surface course, and aggregate; locally, boulders can be screened for riprap. In some places, numerous micaceous rock fragments deleterious to aggregate.	Local concretions of large boulders pose excavation problems.
Qvy	Young moraine	Unsorted heterogeneous mixture of gravel, sand, silt, and minor amounts of clay, generally ranging from gravelly sandy silt to silty sandy gravel. Gravel clasts generally subangular to subrounded. Deposits include irregular lenses and pockets of sandy gravel and gravelly sand.	Occurs on relatively gentle to moderately steep slopes of mountain front of Chugach Range. Generally, unappreciable thin patches occur on the few flat surfaces present in the rugged central part of the range. Thickness highly variable.	Gentle to moderately steep undulating terrain. Vegetation at higher altitudes consists of low brush, at lower altitudes dense, high brush.	Where soils are granular permafrost is absent or if present has low ice content. Permafrost not present in any deposits along the proposed pipeline route south of Thompson Pass.	Variable	Moderately good to poor	Moderately good to poor	Generally low; locally moderately high	Generally poor as a source of borrow for all purposes, except deep fill; local beds and pockets of sand and gravel fair to good for fill, surface and base course, and aggregate.	Excavation commonly hindered by large boulders.
Qic	Ice-contact deposits	Well- to poorly sorted silty sand, sand, gravelly sand, and sandy gravel; generally irregularly bedded. Mantled by as much as 5 feet of Qlc below 2,450 feet.	Occur discontinuously along the valley occupied by the upper reaches of the Little Tonsina and Tielak rivers; also near Phipps Lake. Thickness highly variable but generally less than 100 feet.	Flat-topped kame terraces bordered by steep scarps toward center of valley, and steep slopes of eskers. Vegetation consists of dense, high brush or dense trees.	Generally absent or if present has low ice content.	Low	Good	Good	Low	Excellent for fill, base course, surface course, and aggregate. In some places, numerous micaceous rock fragments can be deleterious to aggregate.	These deposits are slumped and ground cracks formed along the scarp bordering Little Tonsina River on both sides of the Richardson Highway.
Qlc	Lacustrine deposits	Predominantly massive to well-laminated clayey silt and gravelly sandy silt with beds and lenses of sand and sandy gravel. Feathers, rafted pebbles, cobbles, and locally, boulders, are scattered throughout fine-grained materials. Deposits tend to become more granular south of Klutina River.	Underlie most of Copper River Basin below an altitude of 2000 feet and extend southward into the valleys of the Tonsina and Little Tonsina rivers. Thickness generally greater than 50 feet and locally greater than 100 feet in central part of basin.	Gently sloping to flat terrain. Vegetation consists of dense deciduous and evergreen trees or high dense brush in better-drained areas, and scattered spruce trees and low brush in poorly drained areas.	Generally present within 2 feet of the surface, except for areas burned over in forest fires or disturbed in other ways where permafrost is as deep as 30 feet. From a point a few miles north of Willow Mountain to the southern limit of these deposits, ice-rich permafrost is present only locally.	Generally high	Generally poor	Poor	High	Generally unsuited as a source of borrow for all purposes.	The rapid vertical and horizontal changes in the character of these deposits and the unpredictable distribution of ice-rich permafrost, even at considerable depths and (greater than 50 feet) pose serious differential settlement problems if permafrost is allowed to thaw.
Qsu	Glacial and lacustrine deposits undifferentiated	Undifferentiated young moraine deposits (Qvy) and lacustrine deposits (Qlc). Lacustrine deposits generally include less silt and clay-sized material than the typical deposits mapped as Qlc.	Occur on the lower slopes of mountains from Willow Mountain southward for a distance of 17 miles, generally at altitudes between 2,000 feet and 2,450 feet. Thickness generally greater than 50 feet at lower altitudes, but thins considerably at higher altitudes.	Moderately sloping to flat terrain. Vegetation consists of high brush, or low brush with scattered spruce trees.	Generally present within 2 feet of surface. Locally where soils are granular, permafrost absent or where present has low ice content.	Variable	Generally poor	Generally poor	Moderately high	"	Subject to differential settlement if ice-rich permafrost is allowed to thaw.
Pal	Paleozoic limestone	Dark-gray, finely crystalline limestone or light-gray or white coarsely crystalline limestone. Dark-gray limestone commonly bedded and has closely spaced joints; white limestone generally massive and has widely-spaced joints.	One area of outcrop; occurs near top of mountain on east side of Little Tonsina River Valley about 11 miles south of Tonsina.	Steeply sloping mountain side. Low brush or bare of vegetation.	Depth to permafrost quite variable depending on thickness and character of soil and vegetation cover, and exposure to solar radiation. Essentially no ice present except in fractures and joints.	Low	Good	Good	Low	Excellent for riprap, dimension stone, crushed rock, and coarse fill.	No special problems.
Kv	Valdez group, Cretaceous phyllitic graywacke and related rocks	Dark-gray, hard, well-cemented, fine-grained sandstone with numerous veinlets and stringers of white quartz. Predominantly massive and well jointed; sheared and strongly foliated locally. Foliation trends east-west, jointing north-south. Both foliation and joints dip steeply. Flat areas and depressions commonly mantled by 1 to 5 feet of "Qvy."	Underlie most of Chugach Mountains.	Rugged mountainous terrain. Generally bare of vegetation at higher altitudes, on lower slopes, dense high or low brush.	Depth to permafrost quite variable depending on thickness and character of soil and vegetation cover, and exposure to solar radiation. Essentially no ice present except in fractures and joints.	Low	Good	Good	Low	"	Avalanche hazard exists locally between Keystone Canyon and Ernestine.
qm	Tertiary or Mesozoic quartz monzonite	Grayish-white, hard intrusive quartz monzonite, forming dikes and sills generally less than 10 feet wide; commonly massive.	Widely scattered throughout map unit Kv.	"	"	Low	Good	Good	Low	"	"
gr	Tertiary or Mesozoic granitic intrusive rocks	Predominantly hard quartz diorite and granite but locally gabbro. Surfaces generally little weathered; rocks little altered. Iron-bearing minerals in basic rocks strongly oxidized. Generally massive with widely spaced joints and fracture zones.	Underlie mountain just south of Willow Mountain and mountain east of Richardson Highway about 5 miles south of Tonsina.	"	"	Low	Good	Good	Low	"	No special problems.
Jv	Jurassic volcanic and some sedimentary rocks	Gray or greenish-gray lavas and tuffs; at Stuck Mountain consists of altered porphyritic andesite, a few small bodies of pectachyolite, and recrystallized rhyolitic ash beds. Locally includes interbedded argillite and limestone. Generally has closely spaced open fractures.	Underlie Stuck Mountain and nearby small hills.	"	"	Low	Good	Good	Low	Excellent for riprap and coarse fill; fair for crushed rock and dimension stone.	No special problems.