4.0 INTERPRETED GEOTECHNICAL CONDITIONS

Geotechnical characterization parameters for the Glennallen to Palmer Spur Line route are shown on the "Route Soil Conditions" sheets found in Appendix A. These route sheets, numbered 001 through 027, provide coverage of the entire spur line route. Sheet 001 begins near Glennallen at the start of the pipeline and Sheet 027 is located in the vicinity of Matanuska Lake near Palmer. An index of these sheets has also been prepared. Included on the 27 route sheets are a topographic map base and data bands, with explanations of information shown in the data bands. A full explanation of terrain unit definitions is provided on the Terrain Unit Properties and Engineering Interpretations Chart.

Base maps, shown at the top of each route sheet, were taken from U.S. Geological Survey (USGS) topographic quadrangle maps at a scale of 1 inch = 1 mile (1:63,360) and enlarged to approximately 1 inch = 2,000 feet (1:24,000). It is important to note that the maps were inverted (generally facing south rather than north) in order to use normal pipeline convention of BOP to EOP being shown left to right. Information on the base maps includes topography, water, proposed pipeline mileposts, terrain units, and cultural features; also, the Glenn Highway is shown as was mapped by the USGS. It should be noted that both the Glenn Highway and Parks Highway have been upgraded in many locations during recent years. Therefore, the location shown on these maps may not reflect the exact current location of the highways. Each sheet presents a portion of spur line route approximately two miles wide by about five miles long.

As explained below, the data bands are representations of certain selected geotechnical information and can be found directly below the strip maps. Boundaries between adjacent classifications in the data band were projected vertically downward from the strip maps in all cases. Because of this, it is important to note that lengths along the individual data bands are not true horizontal scale distances. To arrive at an accurate lineal summary of data it is necessary to project the data band boundary marks to the strip map and measure actual horizontal distances on the map.

Terrain Unit Band

This band contains a lineal representation of the terrain units (landform profiles) present on centerline. Each terrain unit crossed by the route is noted, as are all terrain unit boundaries.

Representations are shown depicting terrain units to a depth of about 20 to 25 feet. Abbreviated terrain unit symbols can be found on the explanation portion of the route sheet. A full explanation with terrain unit definitions is provided on the Terrain Unit Properties and Engineering Interpretations Chart.

Bedrock Band

This band contains a lineal representation of the bedrock/surficial geology units present along centerline. Formation names or symbols were generally obtained from the published geologic literature.

Hazards Band

Potential hazards/stability concerns are shown on this data band. These concerns include landslides, mud slides, erosion features, etc. It should be noted that fault crossings are not shown as these features are under current study by others.

Permafrost Band

The permafrost band contains the estimated area-wide permafrost description. Data used for assessing permafrost classification for this band include occurrence of permafrost as noted in any available boreholes and their relationship within terrain units, aerial photographs, slope aspect, topography and surface disturbance.

The permafrost classification system consists of four categories (Kreig, 1985):

> GA - Generally Absent: estimate 0 to 10 percent of the map area represented by the segment shown in the band is underlain by near-surface permafrost.
>
> S - Sporadic: estimate 11 to 50 percent of the map area represented by the segment shown in the band is underlain by near-surface permafrost.
>
> D - Discontinuous: estimate 51 to 90 percent of the map area represented by the segment shown in the band is underlain by near-surface permafrost.
>
> GF - Generally Frozen: estimate 91 to 100 percent of the map area represented by the segment shown in the band is underlain by near-surface permafrost.

This system is used to describe only the aerial distribution of permafrost beneath the mapped area. It does not apply to and is not used to describe the vertical distribution of permafrost.

Comments Band

Included here are physiographic province/subprovince divisions and locations of major stream or trail crossing and any other items that may be of interest in an overall assessment of route soil conditions.

Potential Material Sites Band

This band indicates the milepost of potential material sites. These sites were selected based on existing information, aerial photographs and aerial reconnaissance. Other sites may be available but would require on-the-ground reconnaissance to delineate.

Proposed Disposal Sites Band

This band is used to show the milepost of proposed disposal sites. Disposal sites were laid out on a five-mile spacing in locations that did not appear to impact water bodies.

4.1 Segment 1, BOP to MP 16 - Copper River Lowland

General Topography – This portion of the proposed alignment is a relatively smooth plain, approximately 1,500 to 2,000 feet in altitude with slope gradients less than two degrees (Figure 7).

Surface Waters – Thaw lakes are abundant throughout this area. This portion of the alignment is anticipated to cross five creek drainages. Much of the area is underlain by a shallow permafrost table and the soils are poorly drained.

Permafrost – The lowland is generally underlain by moderately thick to thin permafrost. Permafrost is anticipated to be present within areas of predominately fine-grained deposits. Maximum determined depth of permafrost is about 600 feet. The permafrost table is anticipated to be within five feet of the surface. Locally, close to large water bodies, permafrost is anticipated to be absent. Finely segregated ice crystals appear to be the dominant type of ground ice (Nichols, 1956).

Vegetation – Predominant vegetation type is lowland spruce-hardwood forest consisting primarily of pure stands of black spruce, shrubs, and grasses. The far western portion of this segment, along Tolsona Creek, consists of upland spruce-hardwood forest. Predominant vegetation here consists of a fairly dense forest composed of any combination of white spruce, Alaska paper birch, quaking aspen, black cottonwood, and balsam poplar.

Geology – This entire spur line segment, within the Copper River Lowland, occupies the site of a large lake that existed during glacial times. Soils are predominantly silty or clayey, formed from glacial lacustrine sediments. The region is mantled in Pleistocene proglacial lake deposits that are reported as tens to hundreds of feet thick. Based on 9,471 linear feet of borehole drilled in this terrain unit for the Trans-Alaska Pipeline, Kreig and Reger (1982) report that the glacial lacustrine material has an average moisture content of about 18% and an average dry density of about 105 pcf.

Bedrock is interpreted to underlie the area at a depth of at least 500 feet (Wahrhaftig, 1965). A thin non-marine Tertiary section is interpreted to be underlain by as much as 3 km of Cretaceous through middle Jurassic marine rocks, in part turbidities, that are complexly folded and faulted and overlay a lower Jurassic volcaniclastic basement (Nokleberg et al., 1994).

Eleven exploratory wells have been reported in the Mesozoic and Tertiary section with no commercial production established and only minor oil and gas shows (Kirschner, 1994). Most of these exploratory wells have been drilled in an area northwest of Glennallen (AO&GCC, 1976). Additionally, a more recent exploratory well has been drilled at a collar elevation of 1,506 feet approximately two miles north of the Gulkana Airfield. Although the available records do not indicate a precise depth to bedrock, the record does show that the hole was cased to a depth of 1,003 feet.

FIGURE 7

COPPER RIVER LOWLAND PHOTOGRAPHS

Typical topography and vegetation of Copper River Lowland in the vicinity of Moose Creek (MP 3.8), facing north. September 2, 2005.

Mud volcano located at approximately MP 15, facing north. September 2, 2005.

4.2 Segment 2, MP 16 to MP 65 - Copper River Lowland (Lake Louise Plateau)

General Topography – The western part of the Copper River Lowland, the Lake Louise Plateau, is a rolling upland, 2,000 to 3,500 feet in altitude, and has a morainal and stagnant-ice topography with slope gradients generally less than two degrees (Figure 8).

Surface Waters – Large lakes occupy deep basins in the mountain fronts and those lakes in the plateau occupy abandoned melt-water channels: those in morainal depressions in the western plateau are as much as six miles across. Most rivers head in glaciers in surrounding mountains and have braided upper courses. Much of the area is underlain by a shallow permafrost table and the soils are poorly drained, resulting in abundant thaw lakes. This portion of the alignment is anticipated to cross twenty-two drainages.

Permafrost – The lowland is generally underlain by moderately thick to thin permafrost. Permafrost is anticipated to be present within areas of predominately fine-grained deposits. Maximum determined depth of permafrost is about 600 feet. The permafrost table is anticipated to be within five feet of the surface. Locally, close to large water bodies, permafrost is anticipated to be absent.

Vegetation – Predominant vegetation type is of lowland spruce-hardwood forest consisting primarily of pure stands of black spruce, shrubs, and grasses. The far eastern portion of this segment, along Tolsona Creek, consists of upland spruce-hardwood forest. Predominant vegetation here consists of a fairly dense forest composed of any combination of white spruce, Alaska paper birch, quaking aspen, black cottonwood, and balsam poplar.

Geology – The eastern portion of this spur line segment occupies the boundaries of a large lake that existed during glacial times. Soils in the eastern portion are predominantly silty or clayey, formed from glacial lacustrine sediments. The region is mantled in Pleistocene proglacial lake deposits that are reported as tens to hundreds of feet thick. The western margin of this pipeline segment occupies the boundaries of a large lake and glacial advance margins, where glaciofluvial and glacial till deposits may be encountered. Bedrock may be encountered at shallower depths along the southern flank of Slide Mountain and along the Little Nelchina River crossing.

4.3 Segment 3, MP 65 to MP 84 - Southeastern Talkeetna Foothills

General Topography – Topography of the southeastern Talkeetna foothills generally consists of rugged peaks 3,000 to 6,000 feet in elevation bisected by numerous drainages. The spur line is anticipated to be routed from MP 65 down the Squaw Creek drainage to intersect the Caribou Creek drainage (Figure 9). From the Squaw/Caribou Creek confluence, the spur line is to be routed up the Caribou Creek drainage to an elevation of approximately 2,800 feet where it enters the Central Talkeetna Mountains.

Surface Waters – West of MP 65, the alignment parallels the northern slope of the Squaw Creek drainage downvalley to the confluence with Caribou Creek. No crossings of Squaw Creek are planned; however twelve minor crossings of Squaw Creek tributaries are anticipated.

FIGURE 8

COPPER RIVER LOWLAND (LAKE LOUISE PLATEAU) PHOTOGRAPHS

Typical topography, surface waters and vegetation in the vicinity of Little Woods Creek (MP 20.1), facing east. September 2, 2005.

Typical topography, vegetation and material site, located at approximately MP 58, facing east. September 2, 2005.

FIGURE 9

SOUTHERN TALKEETNA FOOTHILLS PHOTOGRAPHS

Typical topography, surface waters and vegetation of the Caribou Creek Valley, in the vicinity of MP 75, facing north and upgradient. September 2, 2005.

Typical topography and vegetation of the Squaw Creek Valley, in the vicinity of the Squaw Creek and Caribou Creek confluence (MP 74-75), facing east and upgradient of the Squaw Creek Valley. September 2, 2005.

From the Squaw/Caribou Creek confluence, the route trends in a northwestly direction up the Caribou Creek valley to the confluence with an unnamed tributary of Caribou Creek near MP 84. One crossing, from east to west, of Caribou Creek is anticipated. Nine minor crossing of Caribou Creek tributaries and one crossing of Divide Creek are anticipated within this section.

Lakes are generally absent along this section of the spur line alignment.

Permafrost – This segment of the spur line route is anticipated to be generally underlain by discontinuous permafrost. The eastern portion of this segment is considered generally frozen. Both temperature of permafrost at depth just below the zone of seasonal variation and air temperature are extremely variable.

Vegetation – Vegetation along the spur line route paralleling Squaw Creek and upper sections of Caribou Creek is generally characterized as moist tundra. This low-growing vegetation type usually forms a complete ground cover and is extremely productive during the growing season. Composition varies from almost continuous cottongrass, with a sparse growth of sedges and dwarf shrubs, to stands where dwarf shrubs dominate. This type of vegetation is generally characterized by cottongrass tussocks.

Vegetation along the lower elevations of the Caribou Creek spur line route is generally characterized as upland spruce hardwood forest. This is a fairly dense, mixed forest canopy composed of white spruce, Alaska paper birch, quaking aspen, black cottonwood and balsam poplar. Pure stands of white spruce and mixed stands of black cottonwood and balsam poplar are likely to occur along streams. Combined stands, including these species and birch and aspen but excluding black spruce, are commonly found on well-drained, south-facing slopes.

Geology – As the spur line route enters the Southeastern Talkeetna Foothills at approximately MP 65, it is routed parallel to the Squaw Creek drainage system and travels downstream in a westerly direction. Between MP 65 and MP 70, interpreted terrain units consist of colluvium deposits overlying bedrock, alluvial fan deposits, and organic deposits. Although the spur line is anticipated to be routed to the north of any widespread organic deposits, sporadic deposits of organics may occur within the colluvium and alluvial fan deposits.

From MP 70 to the confluence of Squaw Creek and Caribou Creek, at approximately MP 74.5, interpreted terrain units consist of alluvium fan, floodplain, colluvium overlying bedrock, and glacial till deposits. Between MP 69.3 and MP 69.7 the spur line is adjacent to a landslide deposit interpreted as consisting of rubble, large rock masses, and soils consisting of silty gravels to sandy silts.

North of the Squaw Creek and Caribou Creek drainage at MP 74.5, the spur line is routed up the Caribou Creek valley until intersecting the Central Talkeetna Mountain province at MP 84. Throughout this section, the spur line route is anticipated to encounter terrain units ranging from bedrock to floodplain deposits. Landslides consisting of rock rubble, large rock masses, and soils are common along the valley walls of this segment of the Caribou Creek drainage.

4.4 Segment 4, MP 84 to MP 104.6 - Central Talkeetna Mountains

General Topography – Alignment of the spur line is anticipated to bisect the southern boundary of the Central Talkeetna Mountain Range. Topography is generally composed of a compact group of extremely rugged peaks 5,000 to 7,000 feet in altitude. The spur line is planned to be routed up the Caribou Creek drainage to Chitna Pass at an elevation of approximately 4,800 feet. From Chitna Pass it is to be routed down the Boulder Creek drainage to intersect with the Matanuska Valley (Figure 10).

Surface Waters – From the Caribou/Chitna Creek confluence, the route trends northwest up Chitna Creek valley to Chitna Pass. One crossing of Chitna Creek and one crossing of it tributary is anticipated along this section.

From Chitna Pass, the proposed alignment trends southwest down the Boulder Creek valley and is planned to cross Boulder Creek four times. Six crossings of Boulder Creek tributaries and one of Blackshale Creek are also anticipated.

Lakes are generally absent along this section of the spur line alignment.

Permafrost – This segment of the spur line route is anticipated to be generally underlain by discontinuous permafrost. Both temperature of permafrost at depth just below the zone of seasonal variation, and air temperature are extremely variable.

Vegetation – Vegetation in the upper sections of Caribou Creek, Chitna Pass, and eastern facing slopes of the Boulder Creek drainage are generally characterized as moist tundra. This low-growing type usually forms a complete ground cover and is extremely productive during the growing season. Composition varies from almost continuous cottongrass with a sparse growth of sedges and dwarf shrubs, to stands where dwarf shrubs dominate. This vegetation type is generally characterized by cottongrass tussocks.

Alpine tundra and barren ground may be present in elevated areas within the Caribou and Boulder Creek drainage and Chitna Pass vicinity.

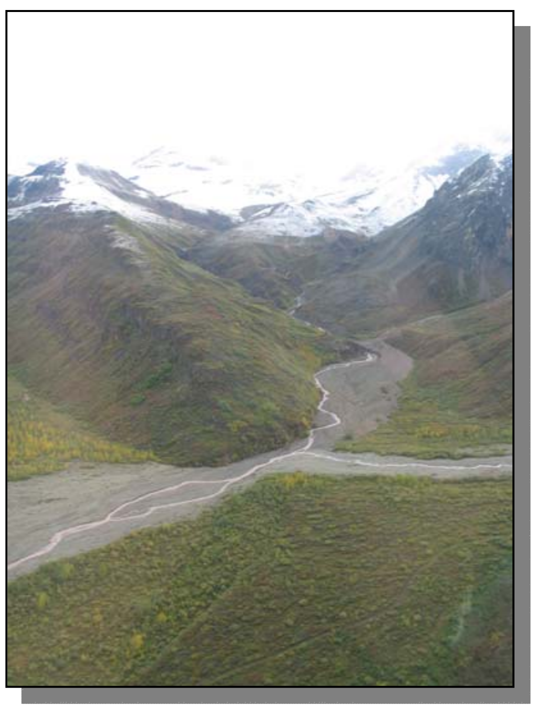
Geology – From MP 84, the spur line route generally parallels the Caribou Creek and Chitna Creek drainage systems in a northwesterly direction gaining altitude until summiting at Chitna Pass at approximately MP 88.8. Interpreted terrain units within this section include floodplain deposits, talus deposits overlying bedrock, glacial till, and glacial till overlying bedrock. Landslides consisting of rock rubble, large rock masses, and soils consisting of silty gravels to sandy silts are interpreted as being present on both sides of the pipeline route.

From Chitna Pass, the route enters the Boulder Creek drainage system and generally parallels Boulder Creek in a southwesterly direction, losing altitude, until intersecting with the Upper Matanuska Valley province. From Chitna Pass (MP 88.8) to approximately MP 93.4 the route traverses terrain units ranging from bedrock, colluvium and talus slopes overlying bedrock, glacial till deposits, floodplain and floodplain terrace deposits. Landslides consisting of rock

FIGURE 10

CENTRAL TALKEETNA MOUNTAINS PHOTOGRAPHS

Typical topography, surface waters and vegetation along lower elevations of the Central Talkeetna Mountains. View is facing upgradient and into the Boulder Creek Valley (approx. MP 104.5). September 2, 2005.



Typical topography, surface waters and vegetation along higher elevations of the Central Talkeetna Mountains. View is facing upgradient and into the Boulder Creek Valley toward Chitna Pass (approx. MP 92). September 2, 2005.

rubble, large rock masses, and soils are common along the valley walls of this segment of the Boulder Creek drainage. The route is anticipated to cross a portion of these landslide deposits in the vicinity of about MP 91 through MP 93.

The route from approximately MP 93.6 until exiting the Central Talkeetna Mountain province at MP 104.6, is anticipated to continue paralleling the Boulder Creek drainage. Interpreted terrain units within this section consist of floodplain and floodplain terrace deposits, alluvial fan deposits, and colluvium deposits including debris flows.

4.5 Segment 5, MP 104.6 to MP 137 - Upper Matanuska Valley

General Topography – The Upper Matanuska Valley is a glaciated trough two to five miles wide containing longitudinal bedrock hills 500 to 1,000 feet high and having steep bounding walls several thousand feet high (Figure 11). Altitude of its floor ranges from 800 feet on the west to 2,000 feet on the east.

Surface Waters – From the Boulder Creek crossing at MP 104.6 the route trends toward the southwest. Many small narrow lakes occupy ice-carved bedrock basins, and ponds are common in morainal areas. The proposed spur line route is aligned so as to avoid any of these lakes and ponds. This section contains an anticipated nine creek crossings.

Permafrost – This segment of the route is anticipated to be generally free of permafrost. A few small isolated masses may occur at high altitudes, and in lowland areas where ground insulation is high and ground insolation is low, especially near the border with the Central Talkeetna Mountains.

Vegetation – The dominant vegetation type anticipated along the higher elevations consists of upland spruce hardwood forest. This is a fairly dense, mixed forest composed of white spruce, Alaska paper birch, quaking aspen, black cottonwood and balsam poplar.

Along lower elevations of the Upper Matanuska Valley, the dominant vegetation type consists of bottomland spruce hardwood forest. This tall, relatively dense forest system primarily contains white spruce, locally mixed with large cottonwood and balsam poplar, found on level to nearly level floodplains, low river terraces, and south-facing slopes.

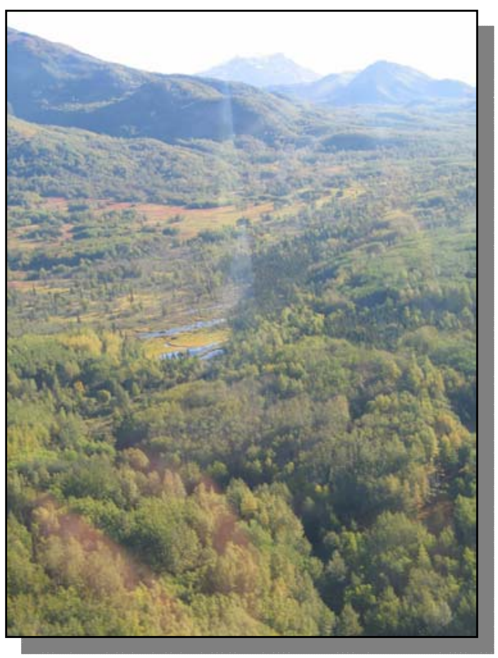
Geology – Once the spur line exits the Central Talkeetna Mountain province at MP 104.6, it is routed generally down-gradient through the Upper Matanuska Valley province. The Upper Matanuska Valley is a structurally controlled trough bounded on the north by the Castle Mountain fault, and on the south by a steep unconformity and faults (Wahrhaftig, 1965).

Terrain units throughout this segment are extremely varied. Along higher elevations and mountain fronts, terrain units generally range from floodplain and floodplain terrace deposits to glacial fluvial and colluvium deposits overlying bedrock. Some sporadic organic and landslide deposits are present along this section.

FIGURE 11

UPPER MATANUSKA VALLEY PHOTOGRAPHS

Overview of the Matanuska River and Moose Creek Valley showing typical topography, surface waters and vegetation of the Upper Matanuska Valley. View facing north (approx. MP 134). September 2, 2005.



Typical topography, surface waters and vegetation of the Upper Matanuska Valley. Facing east from the vicinity of Little Granite Creek (approx. MP 124-125). September 2, 2005.

Throughout the lower elevations and gentler topography of the Upper Matanuska Valley, terrain units consisting of eolian silts and sands overlying glacial fluvial outwash deposits are more common.

4.6 Segment 6, MP 137 to EOP - Cook Inlet-Susitna Lowland

General Topography – The Cook Inlet-Susitna Lowland is a glaciated lowland containing areas of ground moraine and stagnant ice topography, drumlin fields, eskers, and outwash plains (Figure 12). Most of the lowland is less than 500 feet above sea level and has local relief of 50 to 250 feet.

Surface Waters – From MP 137 the route trends southwest and then due south until its terminus. Many small narrow lakes occupy ice-carved bedrock basins, and ponds are common in morainal areas. The proposed spur line route is aligned so as to avoid any of these lakes and ponds. This section contains an anticipated nine creek crossings.

Permafrost – This segment of the spur line route is anticipated to be generally free of permafrost. A few small isolated masses may occur in lowland areas where ground insulation is high and ground insolation is low.

Vegetation – The dominant vegetation type anticipated along the higher elevations consists of upland spruce hardwood forest. This is a fairly dense, mixed forest composed of white spruce, Alaska paper birch, quaking aspen, black cottonwood and balsam poplar.

Along lower elevations of the Cook Inlet-Susitna Lowland, the dominant vegetation type is anticipated to consist of lowland spruce hardwood forest. This tall, relatively dense forest system primarily contains white spruce, locally mixed with large cottonwood and balsam poplar, found on level to nearly level floodplains, low river terraces, and more deeply thawed south-facing slopes.

Near the proposed spur line terminus, the dominant vegetation type is anticipated to consist of wet tundra. Sedges and cottongrass, usually occurring as mat rather than as tussocks are anticipated.

Geology - Throughout the lower elevations and more gentle topography, terrain units consisting of eolian silts and sands overlying glacial fluvial outwash deposits are more common, particularly in the Palmer area. The eolian deposits are interpreted as generally consisting of silt with some sand to sand with some silt deposited through wind action. Glacial fluvial outwash deposits are interpreted as generally consisting of gravels and sand containing cobbles and boulders.

Beginning at approximately the Glenn and Parks Highway interchange, marine estuarine deposits and organic deposits are anticipated. The marine estuarine deposits generally consist of silt, sandy silt, and fine sand with some organic material. Areas of organic deposits are interpreted as generally consisting of decomposed and undecomposed organic material with some silt.

FIGURE 12

COOK INLET-SUSITNA LOWLAND PHOTOGRAPHS

Approximate location of pipeline terminus at center of photo (MP 148). Facing north toward Cook Inlet-Susitna Lowland province. September 2, 2005.

Typical topography, surface waters and vegetation of Cook Inlet-Susitna Lowland province. Facing northwest from the vicinity of Spring Creek (MP 147.2). September 2, 2005.

Test borings placed at the new Parks/Glenn interchange indicate that bedrock is greater than 225 feet in depth (Shannon & Wilson, 2002).