3.0 METHODS AND APPROACH

As previously outlined, the soils study investigations were of broad scope providing corridor-wide information involving soils, bedrock geology, and geomorphology. The investigations were coordinated to generate needed information while avoiding duplication of effort. Communication between project participants ensured that a unified final report was produced which integrates with other project activities. To aid in the presentation and evaluation of mapped data, the project corridor was divided into geographic segments and standardized base maps were prepared. Details of the methods and approach used in the studies are presented below.

3.1 Terrain Unit Analysis

The general objective of the airphoto interpretation process was to document geological features and geotechnical conditions that would affect the design and construction of the project features. More specifically, the task objectives included the delineation of terrain units of various origins on aerial photographs, noting the occurrence and distribution of geologic factors such as permafrost, potentially unstable slopes, potentially erodible soils, potential construction materials, active floodplains, organic materials, etc. Frost (1950) and Department of the Army (1966) present further detail on terrain analysis and airphoto interpretation in cold regions.

The terrain unit is defined as a special purpose term comprising the landforms expected to occur from the ground surface to a depth of about 20 to 25 feet. The terrain unit is used in mapping landforms on an areal basis. A landform is defined (Kreig and Reger, 1976) as any element of the landscape which has a definable composition and range of physical and visual characteristics. Such characteristics can include topographic form, drainage pattern, and gully morphology. Landforms classified into groups based on common modes of origin are most useful because similar geologic processes usually produce similar topography, soil properties, and engineering characteristics.

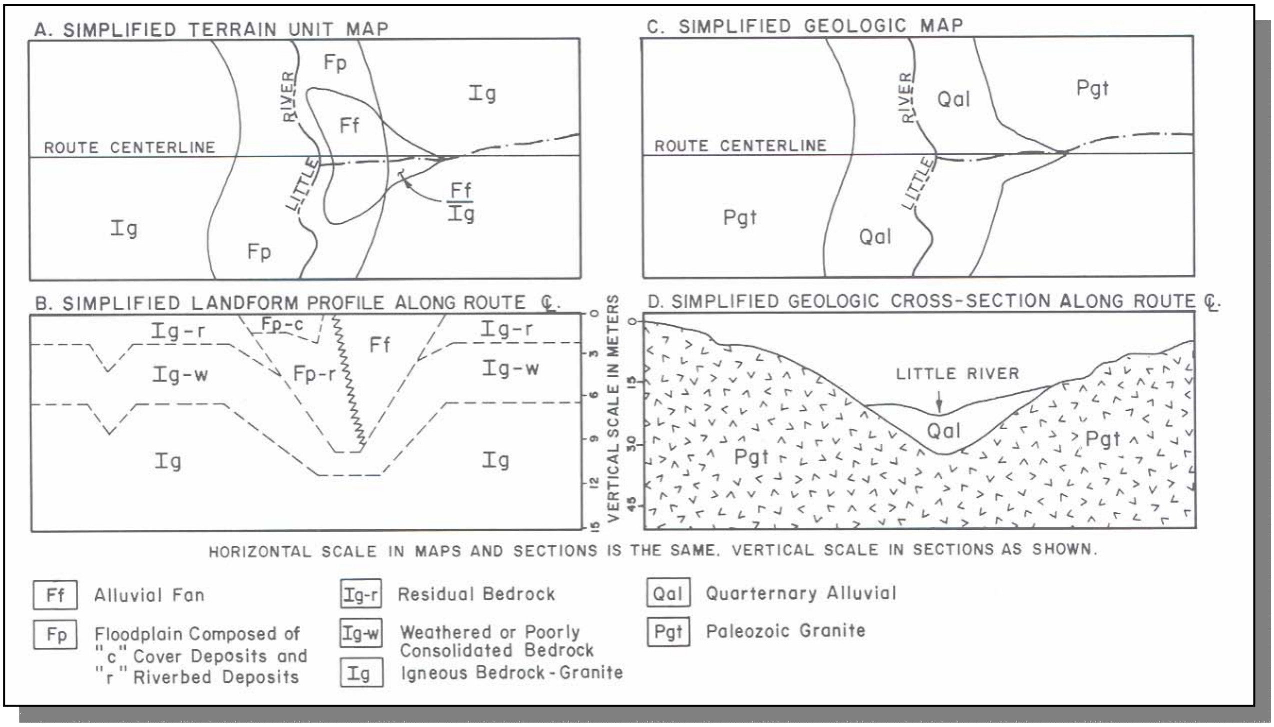
Airphoto interpretation consisted of several activities culminating in a set of Terrain Unit Maps (TUMs) delineating surface materials and geologic features and conditions in the project area. Figure 3 presents a comparison of a terrain unit map with a conventional geologic map. The first step consisted of a review of the literature concerning the geology of the route and transfer of the information gained to sets of high-level photographs. Interpretation of the high-level photos created a regional terrain framework which aided in the interpretation of the low-level photos. Major terrain divisions identified on the high-level photos were then used as an areal guide for delineation of terrain units on the low-level photos.

The primary effort of this task was the interpretation of numerous photos covering the alignment (see References). The land area covered in the mapping exercise is shown on the Route Index Maps (Appendix A) and displayed in detail on the Route Soil Conditions sheets.

The terrain units, as shown on the Route Soil Conditions sheets and described in this text, document the general geology and geotechnical characteristics of the Glennallen to Palmer Spur Line Route. However, a few comments are in order.

FIGURE 3

COMPARISON OF TERRAIN UNIT MAP WITH CONVENTIONAL GEOLOGIC MAP



NOTE: Landform profiles as shown in Section B above were not prepared for this project. Borehole data are typically required to produce landform profiles.

After Schraeder, et al., 1996.

On the maps each terrain unit is identified by letter symbols, the first of which is capitalized and indicates the genetic origin of the deposit. Subsequent letters differentiate specific terrain units in each group. Figure 4 presents an explanation of terrain unit symbols.

During terrain unit mapping, bedrock was identified but no effort was made to determine the type or characteristics of the bedrock. Bedrock type is presented on the data band shown below the map, as determined from the various published mapping sources.

In general, the organic deposits identified on the photos are probably less than 25 feet in depth which is the maximum mapping thickness. However, by convention the organic materials were not called out as overlying the surrounding terrain unit.

Physical characteristics and typical engineering properties were developed for each terrain unit and are displayed on a single table. This data, with some supplemental information, will provide a base for making geologic decisions about the more desirable and less desirable portions of the corridor. The terrain unit maps for the project corridor show the areal extent of the specific terrain units which were identified during the airphoto investigation. These terrain units were corroborated in part by limited on-the-ground investigations (see Section 3.2). Site-specific field data are included in Appendix B.

This is a generalized study which is intended to collect geologic and geotechnical data for a very large area. Toward this goal, the work has been greatly successful; however, there are certain limitations to the data and interpretations. The engineering characteristics of the terrain units have been correspondingly generalized and described qualitatively. When evaluating the suitability of a soil for predesign work, the actual properties of that unit must be identified by additional on-site subsurface investigation, sampling, and laboratory testing.

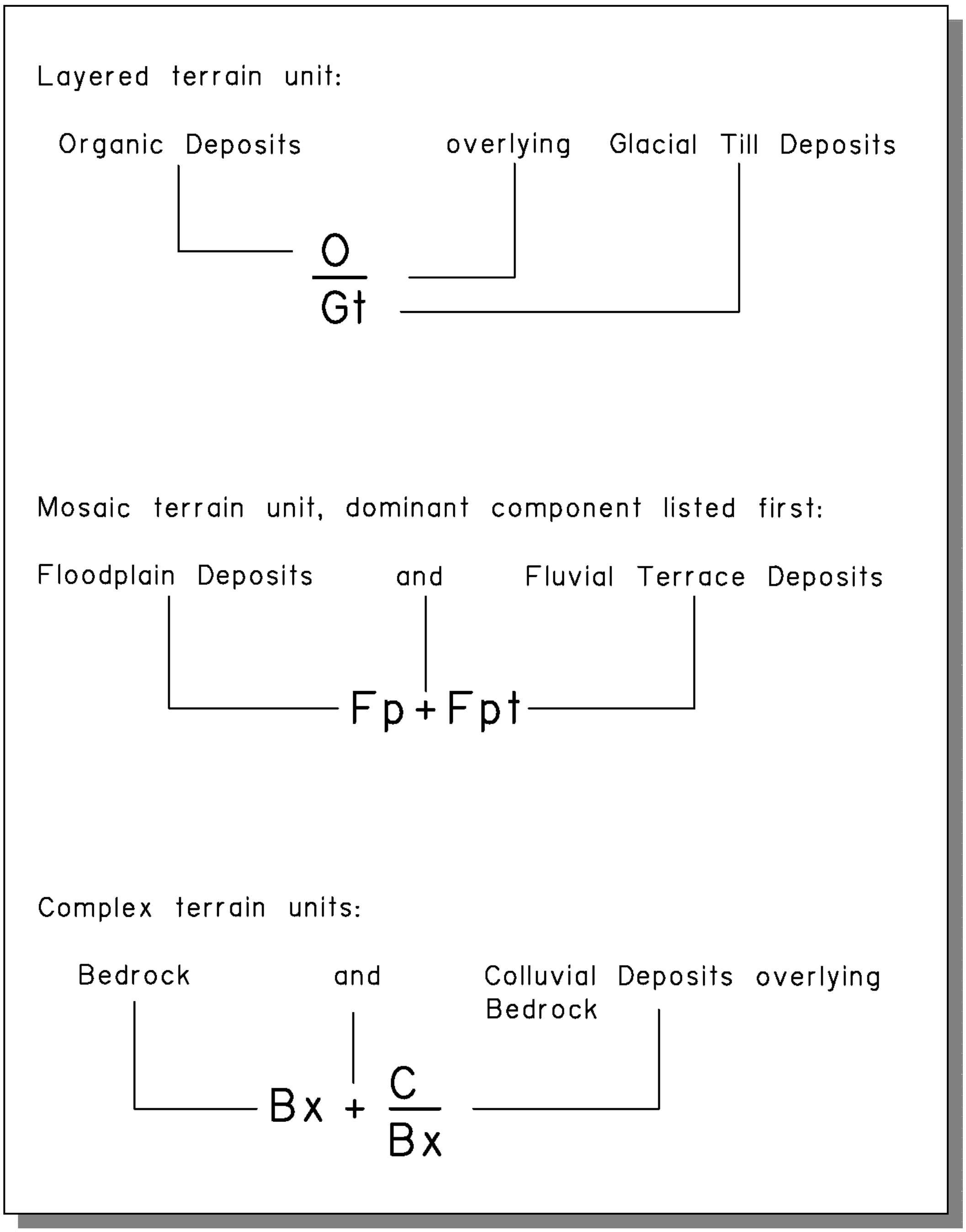
3.1.1 Terrain Unit Descriptions

For this airphoto interpretation exercise soil types, engineering properties and geological conditions have been developed for individual terrain units briefly described below. Several of the landforms have not been mapped independently but rather as compound terrain units. Compound terrain units result when one landform overlies a second recognized unit at a shallow depth. The compound terrain units behave and are described as a composite of individual landforms comprising them. The stratigraphy, topographic position and areal extent of all units are summarized on the terrain unit properties and engineering interpretations chart.

Bx - Bedrock: In-place bedrock that is overlain by thin unconsolidated colluvium or exposed at the surface. Various bedrock types have not been differentiated but instead the symbol is used for all types of bedrock whether igneous, sedimentary or metamorphic. Bedrock types are indicated on the data band portion of the Route Soil Conditions sheets. Bedrock at higher elevations is probably frozen.

FIGURE 4

TERRAIN UNIT SYMBOL EXPLANATION



C - Colluvium:	Deposits of widely varying composition that have been moved downslope chiefly by gravity. Fluvial slopewash deposits are usually intermixed with colluvial deposits. Sporadic permafrost may occur in colluvial deposits (especially when associated with organics).
Cf - Colluvial Fan:	Formed where solifluction deposits (Cs) emerge from a confined channel on a hillside onto a level plain or valley. Commonly includes incorporated fine-grained alluvial fan material.
Cl - Landslide:	A lobe- or tongue-shaped deposit of rock rubble and unconsolidated debris or an intact large block that has moved downslope. Includes rock and debris slides, slump blocks, earth flows and debris flows.
Cs - Solifluction Deposits:	Solifluction deposits are formed by the slow downslope, viscous flow of saturated soil material and rock debris in the active layer. Frost creep is also a major component in forming these deposits. This unit is generally used where obvious solifluction flow lines or stripes are identifiable. The landform includes fine-grained colluvial fans formed where solifluction deposits emerge from confined hillside channels onto a level plain or valley floor. This landform is composed of modified glacial till, and overlies in-situ glacial till. In solifluction deposits within the project corridor sporadic permafrost can be expected.
Ct - Colluvial Talus:	Deposits of angular rubble and rock fragments accumulated by gravity at the base of steep slopes and cliffs. Generally the deposits are steeply sloping, and only marginally stable.
El - Eolian Loess:	Wind deposited angular silt (which in the Palmer area forms a blanket overlying glaciofluvial material).
Es - Eolian Sand:	Wind deposited sand forming either blanket-like deposits or dunes (which in the Palmer area overlie outwash gravels).
Ffg - Alluvial Fan (Granular):	A gently sloping cone generally composed of granular material with varying amounts of silt deposited upon a plain by a stream where it issues from a steep narrow valley. The primary depositional agent is running water. Can include varying proportions of avalanche or mudflow deposits, especially in mountains regions.

Ffs - Alluvial Fan (Fine-Grained):	Used for alluvial fans composed of predominantly finer-grained materials (generally sand and silt). Deposits in these fans are laid down by stream action rather than sheet flow and solifluction.
Fp - Floodplain (Granular):	Sediments transported and deposited by a river or stream during period of highest water in the present stream regimen. Floodplains are composed of two major types of alluvium. Generally granular riverbed deposits are formed by lateral accretion. The Matanuska, Chickaloon, and Kings rivers are characterized by coarse granular riverbed deposits. The floodplain designation indicates that the environment is active and has the potential for undercutting, flooding, and sedimentation, etc.
Fpf - Floodplain (Fine-Grained):	Generally fine-grained cover (vertical accretion) deposits laid down above the riverbed deposits by streams at bank overflow (flood) stages.
Fpt - Stream Terrace:	An old, elevated floodplain surface no longer subject to frequent flooding. Occurs as horizontal benches above present floodplains, and generally composed of materials very similar to the active floodplains.
Gt - Glacial Till:	Predominantly basal glacial till sheets, with subdued moraine morphology, probably deposited during the Naptowne and older glaciations. Generally the till has a silty sandy matrix with numerous cobbles and a high gravel content; however, at least one very clayey, highly plastic till was noted south and southeast of Sheep Mountain. The till sheets east of Sheep Mountain are thought to be frozen at depth while those down valley of Sheep Mountain are generally unfrozen.
GF - Glacial Fluvial (Undifferentiated):	Deposits laid down by streams flowing on, under, or from glaciers.
GFl - Glacial Fluvial (Lowland)	Deposits laid down by streams flowing on, under, or from glaciers into a lowland area.
GFo - Glacio-Fluvial Outwash:	Coarse, granular relatively level floodplain formed by a braided stream flowing from a glacier. Outwash east of Sheep Mountain probably contains sporadic permafrost, whereas outwash, roughly down valley of Sheep Mountain, is not frozen.

GFe - Glacio-Fluvial Esker Deposits:	Long ridges of granular ice contact deposits formed by streams as they flow in or under a glacier.
GFk - Glacio-Fluvial Kame Deposits:	Hills, crescents and cones of granular ice-contact deposits formed by streams as they flow on or through a glacier.
GL - Glacial Lacustrine:	Also known as glacial lake deposits. Fine-grained material that is generally frozen and having a high ice content.
Ht - Mine Tailings:	Coarse- to fine-grained deposits resulting from mining activities.
L - Lacustrine Deposits:	Generally fine-grained materials laid down in glacial and non-glacial lakes. Generally frozen and probably having a high ice content.
Lt - Lacustrine Thaw Basin / Lake Deposits:	Generally fine-grained organic-rich deposits in lakes and depressions formed by thawing of ground ice.
Me - Marine Estuarine Deposits:	Silt and sand possibly with a thin organic cover deposited in an estuarine environment subject to transport and reworking by tidal action. In places, the remnants of stream channels can be found.
O - Organic Deposits:	Deposits of humus, muck and peat generally occurring in bogs, fens, and muskegs. Frequently overlies frozen material.
Vm - Mud Volcano:	An accumulation of mud formed by escaping petroliferous gases. Found in the greater Glennallen area.
Wl - Water Body (Lake):	Lakes.

3.1.2 Terrain Unit Properties and Engineering Interpretations Chart

In order to evaluate the impact of a terrain unit with respect to specific project features, an interpretation of the engineering characteristics of each unit is provided. On the chart the terrain units are listed in horizontal rows and the engineering properties and parameters being evaluated are listed as headings for each column. Within the matrix formed are relative qualitative characterizations of each unit. The engineering properties and evaluation criteria are briefly discussed below. The chart is presented for general engineering planning purposes. In this form, the data are not adequate for final design purposes but when additional laboratory and field information is acquired and synthesized, site-specific development work can be minimized.

Topography and Areal Distribution:	Topographic form and horizontal extent of a terrain unit.
Soil Stratigraphy:	The general lithologic composition of a terrain unit.
Slope Classification:	Following guidelines established by the U.S. Forest Service, the Bureau of Land Management and the American Society of Landscape Architects, slopes in the project corridor have been divided into the following classes: Flat - 0 to 5%; Gentle - 5 to 15%, Moderate - 15 to 25%, and Steep - greater than 25%. References have been made to steep local slopes to account for small scarps and the similar short but steep slopes which characterize ice contact glacial drift.
Probable Unified Soil Types:	Based on field observations, previous work in similar areas, and definitions of the soils, a range of Unified Soil Classification (USC) Types has been assigned to each terrain unit. Often several soil types are listed, some of which are much less prevalent than others. Information in the soil stratigraphy column will aid in understanding the range and distribution of soil types. Table 4 presents a listing of the various USC Types.

TABLE 4

UNIFIED SOIL CLASSIFICATION TYPES

Soil Type or Characteristic	USC Code	Particle Size
Cobbles, Boulders	None	Retained on 3-inch sieve
Gravel	G	Passes 3-inch sieve, retained on No. 4 sieve
Sand	S	Passes No. 4 sieve, retained on No. 200 sieve
Silt	M	Passes No. 200 sieve
Clay	C	Passes No. 200 sieve
Organic Material	O	N/A
Peat	Pt	N/A
Well Graded	W	N/A
Poorly Graded	P	N/A
Low Plasticity	L	N/A
High Plasticity	H	N/A

Drainage and Permeability:	How the soils comprising the terrain units handle the input of water is characterized by their drainage and permeability. Permeability (hydraulic conductivity) refers to the rate at which water can flow through a soil. Drainage

describes the wetness of the terrain unit, taking into account a combination of permeability, slope, topographic position, and the proximity of the water table.

Erosion Potential:	Erosional potential as described here considers the materials' likelihood of being moved by eolian and fluvial processes such as sheetwash, rill and gully formation, and larger channelized flow. In general, this relates to the particle size of the soil, however, the coarse sediments of floodplains have been rated as high because the surface is very active, and likewise coarse terrace deposits can have a high rating because of their proximity (by virtue of their origin) to streams. (Mass wasting potential is considered under slope stability.)
Groundwater Table:	Depth to the groundwater table is described in relative terms ranging from very shallow to deep. In construction involving excavation and trenching work, special techniques and planning will be required in most areas with a shallow water table and in some of the areas with a moderately deep water table. In areas of impermeable permafrost a shallow perched local water table may occur.
Probable Permafrost Distribution:	The occurrence of permafrost and the degree of continuity of frozen soil is described on the Engineering Interpretation Chart by the following relative terms: Generally Absent; Sporadic; Discontinuous and Generally Frozen as proposed by Kreig (1985). Additional detail is provided in Section 4.0.
Frost Heave Potential:	Those soils which contain significant amounts of silt and fine sand have the potential to produce frost heave problems. A qualitative low, moderate, and high scale rates the various soils based on the potential severity of the problem. Where the soil stratigraphy is such that a frost susceptible soil overlies a coarse-grained deposit, a dual classification is given; for these soils it may be possible to strip off the frost susceptible material.
Thaw Settlement Potential:	Permafrost soils with a significant volume of ice may show some settlement of the ground surface upon thawing. In general, clays, silts and fine sands have the greatest settlement potential, forming the basis for the three-fold classification presented on the chart. Unfrozen soils do not have the potential for thaw settlement. Thawing problems

may be initiated or accelerated by disturbance of the surficial soil layers or the organic mat.

Bearing Strength:	Based on the terrain unit soil types and stratigraphy, a qualitative description of bearing strength is given. In general, coarse-grained soils have a higher bearing strength than fine-grained soils, but the presence of permafrost may significantly increase the strength of some fine-grained soils (as indicated on the chart by the thermal state qualifying statement).
Slope Stability:	The slope stability qualitative rating was derived through evaluation of each terrain units' topographic position, slope, soil composition, water content, ice content, etc. The stability assessment considers all rapid mass wasting processes (slump, rock slide, debris slide, mudflow, etc.). Several terrain units which have characteristically gentle slopes and are commonly in stable topographic positions have been oversteepened by the recent, active undercutting of streams and/or man (or by older processes not currently active such as glacial erosion and tectonic uplift and faulting). The stability of the terrain units on oversteepened slopes and natural slopes is described on the Engineering Interpretation Chart.
Suitability as a Source of Borrow:	The rating considers suitability as pit run or processed aggregate and takes into account the materials present as well as the problems associated with extracting material from the various terrain units.

3.2 Route Reconnaissance

Limited on the ground reconnaissance was conducted on August 15 and 16, 2005 by an R&M engineering geologist. This reconnaissance was performed in conjunction with two engineers, from Michael Baker Jr., Inc. (Baker), conducting a portion of Baker's field reconnaissance activities. The purpose of the field reconnaissance was to obtain geotechnical data of the proposed crossings at Kings River, Chickaloon River, Startup Creek, and Caribou Creek. Access to these crossings was gained by utilizing ATVs and on foot (Figure 5). Locations of the proposed stream crossing were determined through handheld GPS methods. Visual observations were recorded and photographs were taken at each of the four crossings regarding terrain units, bedrock exposures, geotechnical hazards, and cobble and boulder prevalence.

Additionally, on September 2, 2005 two R&M engineering geologists and a geotechnical engineer performed general reconnaissance of the entire spur line route via helicopter. A Robinson Model R44 helicopter was chartered from JayHawk Air of Anchorage, Alaska.

FIGURE 5

ROUTE RECONNAISSANCE PHOTOGRAPHS (ATV)

Engineering geologist performing field reconnaissance at the Caribou Creek Crossing (MP 75.6). August 16, 2005.

Engineers traveling along Squaw Creek Valley, approx. MP 71. August 16, 2005.

Oblique aerial photographs were obtained for many features and areas of interest. The helicopter also landed at various locations for more detailed on-the-ground reconnaissance (Figure 6).

Photographs and other data collected from the route reconnaissance are presented on the Field Site Description sheets included in Appendix B.

FIGURE 6

ROUTE RECONNAISSANCE PHOTOGRAPHS (HELICOPTER)

Geotechnical engineer and engineering geologist evaluating landslide conditions at upper Boulder Creek Valley (approx. MP 91.5). September 2, 2005.

As above.