5.0 CONCLUSIONS AND RECOMMENDATIONS

Our conclusions and recommendations regarding geologic hazards, possible realignments, stream crossings, material and disposal sites, and future design-level geotechnical investigations are presented in the following section. These conclusions and recommendations are based on our understanding of the terrain unit mapping data, limited route reconnaissance and of the proposed construction of the spur line. It is emphasized that our understanding of the planned spur line is limited to only very general information regarding the nature of the pipeline and the proposed construction. It should be realized that the terrain unit mapping data presented herein is not considered to be of sufficient detail for final civil and structural design analysis and the preparation of construction bid documents. Therefore, detailed site-specific subsurface investigation should be performed that may include test borings, test pits, laboratory testing, geophysical surveys and geotechnical analysis.

Because project planning is in the very early conceptual stage, some of our conclusions and recommendations are necessarily somewhat broad. It is anticipated that as the design progresses, we will have the opportunity to provide more specific comments, as may be required.

5.1 Geologic Hazards Recommendations

The following geologic hazards were identified during our soils studies. These potential hazards were detected by using existing file information, aerial photographs and aerial reconnaissance. Other hazards may be identified during any future design-level geotechnical programs.

Also, the spur line alignment passes through significant segments of frozen ground having highly variable ice content. Thermal degradation of disturbed ground through these segments will result in some pipeline subsidence that, combined with frost heave effects, will cause pipe movement and stress variation. These effects and potential mitigative measures for any adverse deformation will need to be addressed and accommodated during the spur line design phase.

Milepost 13.3 to 15.2: The proposed alignment passes through an area containing mineral springs that have forced mud to the surface, creating low mounds termed "mud volcanos". Mud volcanos are characterized by soft, wet silt and clay deposits that slowly build. The alignment presently passes between three of these mud volcanos near Tolsona Creek, but does not actually cross any of them. *This area should be accessed only during winter conditions when the ground is sufficiently frozen to support equipment. Any realignment in this area should take the presence of these mud volcanos into consideration.*

Milepost 16.0 to 16.8: West side of Tolsona Creek valley (Figure 13). The Glenn Highway at this location has suffered significant thermal erosion and resultant slumping where it climbs up the west valley slope. Old landslides were noted north and south of the highway alignment. *Consideration should be given to possible realignment of the spur line to the old gravel pit access road lying north of the highway. Drainage should be directed*

FIGURE 13

TOLSONA CREEK VALLEY PHOTOGRAPH

West side of Tolsona Creek valley (approx. MP 51). Alignment is presently following the right side of the highway. Access road to gravel pit is shown on the right side of photo. September 2, 2005.

Note the small erosion feature apparently caused by concentrated drainage downhill of the bend in the access road.

to minimize the concentration of water flow along this road. Detailed subsurface exploration should be performed to determine site-specific conditions.

Milepost 40 to 57: The organic mat has been stripped along this section of the spur line alignment during recent communication line installation. Adverse thermal disturbance appeared to be occurring in these stripped areas. *The alignment may need to be moved slightly north of this disturbed area.*

Milepost 42.3 to 50: South slope of Slide Mountain. Slide Mountain is underlain by fine-grained bedrock that is prone to landslides. There are presently several active landslides on the south side of the mountain. However, it appears that the slides have not impacted the highway and that they may also not impact the present pipeline alignment located along the north side of the highway. *Should the alignment need to move, we recommend that it be moved south of the existing highway, and not uphill to the north.*

Milepost 48.7 to 51.1: Little Nelchina River Canyon. The canyon walls are composed of fine-grained siltstone and shale bedrock, similar to bedrock that has experienced stability problems in this area. The embankment sections of the highway have experienced some deformation since construction was completed and current performance conditions should be reviewed with DOT&PF. *Both of these potential hazards should be investigated.*

Milepost 64.3 to 64.7: It appears that the present alignment crosses the top portion of a series of small landslide scarps on the west side of Startup Creek. These scarps appear to have been caused by thermal erosion. *The alignment should be moved north; away from these scarps and geotechnical investigations should be performed to determine whether there is any potential for further such failures elsewhere in the area.*

Milepost 65 to 73: Squaw Creek Valley. The alignment crosses a series of alluvial fans with what is interpreted to be ice-rich colluvial soils lying between the fans. The ice-rich soils along the existing trail have begun to degrade and large depressions have formed. *It may be advantageous to move the alignment uphill to avoid some of these problems (see exception below). Further study and exploration should be performed to determine the extent of this hazard and the feasibility of any proposed solutions.*

Milepost 69.1 to 69.8: The alignment crosses below a series of small landslides that appear to originate in the fine-grained bedrock of the Matanuska formation. *The alignment should not be moved northward (uphill) at this location.*

Further investigations should be performed to determine whether these landslides may affect the present alignment.

Milepost 82.2 to 84.3: The present alignment crosses near the toes of four large contiguous landslides on the south side of Caribou Creek. During our aerial reconnaissance, the head scarps of the slides appeared to have recently been active. There was no apparent evidence of recent movement near the toes, but due to time constraints, only a brief observation could be made. *Further evaluation of these slides should be performed.*

Milepost 84 to 93: Detterman et al. (1976) mapped several landslides in Chitna Pass between the upper reaches of Caribou Creek and Boulder Creek that could not be confirmed during this program, and thus all may not shown be on the maps in this report. The pipeline alignment crosses some of these reported slides and may be impacted by others. *These reported landslides should be analyzed as part of any future slope stability study.*

Milepost 86 to 88: The spur line crosses two landslides as it climbs from Chitna Creek into the pass. The alignment crosses over the first slide which Detterman et al. (1976) mapped as being stable. It crosses the toe of the second slide which was designated as partly stable. *These two slides should be further evaluated.*

Milepost 91.2 to 91.9: Two large landslides were observed on either side of a small creek flowing from Chitna Pass to Boulder Creek. The landslide on the east side of the creek was observed to be active during our field reconnaissance, as evidenced by numerous surface cracks and very loose surficial material. What appeared to be older, less active slides were observed on the west side of the creek. *We recommend that the alignment be moved out of this area. See Section 5.2.1.*

Milepost 92.4 to 92.8: The alignment traverses the toe of a large landslide on the east side of the Boulder Creek No. 4 crossing. The slide appeared to reach down to the edge of the floodplain. *Further evaluation of this slide should be performed, or the alignment should be moved to the south side of the creek.*

Milepost 94.6 to 94.8: An active glacier is located within about 2,000 feet upslope of the spur line alignment. The glacier appears to be retreating, but however unlikely it is to advance, it has the potential to surge across the valley overrunning the pipeline alignment. *The likelihood of this change in movement should be evaluated.*

Milepost 95.3 to 98.5: The alignment traverses several colluvial fans consisting of material which is interpreted to have been deposited by debris flows. This type of fan is generally accreting and material can be expected to accumulate over time. Debris flows can deposit significant quantities of material on their fans, therefore having the potential to bury the alignment. Debris flows can also create construction problems during periods of heavy rain. *Further evaluation of these fans should be performed. Relocating the alignment across the creek, where there are fewer colluvial fans may be appropriate.*

Milepost 107 to 109: Through this segment of the alignment the pipeline crosses along the top of a steep south bank of Boulder Creek. This slope appeared to be unstable and prior failures have occurred in several places along this side of the creek. Failure of this bank may be expected. *The alignment in this location should be moved south at least 1,000 feet.*

Milepost 110.5: Chickaloon River Crossing. *It is recommended that the alignment be shifted to avoid steep bedrock bluffs. See Section 5.2.2.*

Milepost 117.6 to 118.6: The alignment crosses along the bottom of a high, steep-sided ridge. *The stability of this ridge should be evaluated.*

Milepost 134.3: The alignment crosses Moose Creek at a point where the creek is deeply incised into soils overlying bedrock. A large erosional scar was noted immediately upstream of the proposed crossing. Preventing siltation of Moose Creek, a fish stream, may become a significant effort. *It may be advisable to move the crossing either downstream or upstream to a location with a wider floodplain, or more gentle slopes. See Section 5.2.3.*

5.2 Recommended Realignments

The following section presents suggested route realignments. Shorter site-specific areas which may be considered for realignment/modification are listed in Section 5.1.

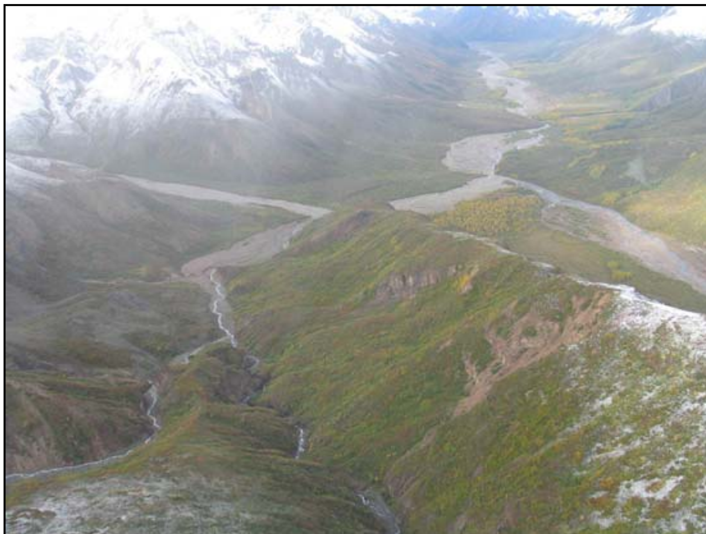
5.2.1 Chitna Pass Realignment

During our aerial route reconnaissance conducted on September 2, 2005, landslides were observed on the west side of Chitna Pass, at the point where the pipeline alignment descends out of the pass to Boulder Creek, as shown on Figure 14. The current pipeline alignment traverses the steep bedrock ridge on the west side of the creek. In this area, apparent landslides were observed on both sides of the creek. It should also be noted that the helicopter pilot did not consider the pass labeled as “Chitna Pass” on the U.S. Geological Survey map as Chitna Pass. He referred to the pass about two miles to the north as Chitna Pass.

On the west side of Chitna Pass, a large, very active landslide was encountered. Large cracks were observed on the surface with up to four feet of vertical displacement. The

FIGURE 14

BOULDER CREEK SLIDE/CHITNA PASS PHOTOGRAPHS



Looking south, down Boulder Creek Valley (MP 92) from the west end of Chitna Pass (?). The pipeline alignment is located on the east side of the narrow ridge on the west (right) side of the creek. A large active slide is seen on the east (left) side of the creek. What appeared to be older slides were observed along the west (right) side of the creek. September 2, 2005.

Looking north into the west side of Chitna Pass (?) from Boulder Creek (MP 92). September 2, 2005.

surficial material was very loose and difficult to traverse on foot. A small depression in the surface of the landslide indicated that there may be ice buried in the rubble. This landslide appeared to be advancing toward the creek and the toe was actively being removed by the creek. What appeared to be older slides were observed on the east side of the creek. These slides are more heavily overgrown and may be somewhat more stable. However, the creek appeared to also be cutting the toes out from under these slides. These slides may also still be active.

During our reconnaissance, other alternate routes through the pass were considered. Placing the alignment along the ridge to the west was considered, but the ridge is very narrow (footpath wide) in places and appeared to have unstable slopes on both sides. The trail marked on the USGS Anchorage (D-2) quadrangle map in Sections 27 and 28, T22N, R8E was also considered, but it appeared to be very steep and there was no evidence of any ATV traffic having used it. From the helicopter it appeared that the part of the trail that dropped down into Boulder Creek was so steep that even dozers would have difficultly working on it, and would likely need to be winched up and down the slope.

After observing the potential problems with this pass, we flew north and reconnoitered the pass that the pilot called Chitna Pass. Based on our over-flight, the western approaches to this pass from Boulder Creek appeared to present less difficulty than that in the southern pass (current alignment). However, the eastern approaches to the northern pass from Caribou Creek appeared to be very difficult. There is a narrow valley connecting the two passes that appeared more suitable for spur line construction. The summit elevation of the southern pass is at approximately 4,800 feet and the northern pass at 4,600 feet. The summit elevation in the small pass that connects the two routes is about 5,100 feet.

Due to time constraints and weather (snow and low ceiling), our reconnaissance effort in this pass was limited. *However, based on existing geotechnical information and what was observed during the aerial reconnaissance, we recommend that the proposed northern realignment, as shown in Figure 15 be given further consideration.*

5.2.2 Chickaloon River Crossing Realignment

The east bank of the present Chickaloon River Crossing is a steep 140-foot high bedrock cut bank that drops directly into the river. This river is anadromous fish habitat and it would be extremely difficult to construct a crossing at this location. *Thus we recommend shifting the alignment either up or downriver to a more advantageous crossing location.*

The realignment shown in Figure 16, Proposed Chickaloon Crossing Realignment, indicates a northern route that crosses slightly over a mile upriver of the present crossing. The route shown would lie along the north side of Boulder Creek and cross just upstream from its confluence with the Chickaloon River. This route would avoid the step cut bank at the present alignment and several private land issues north of the village of Chickaloon. However, it would cross at or near the bottom of a large landslide on the

FIGURE 15

PROPOSED CHITNA PASS REALIGNMENT

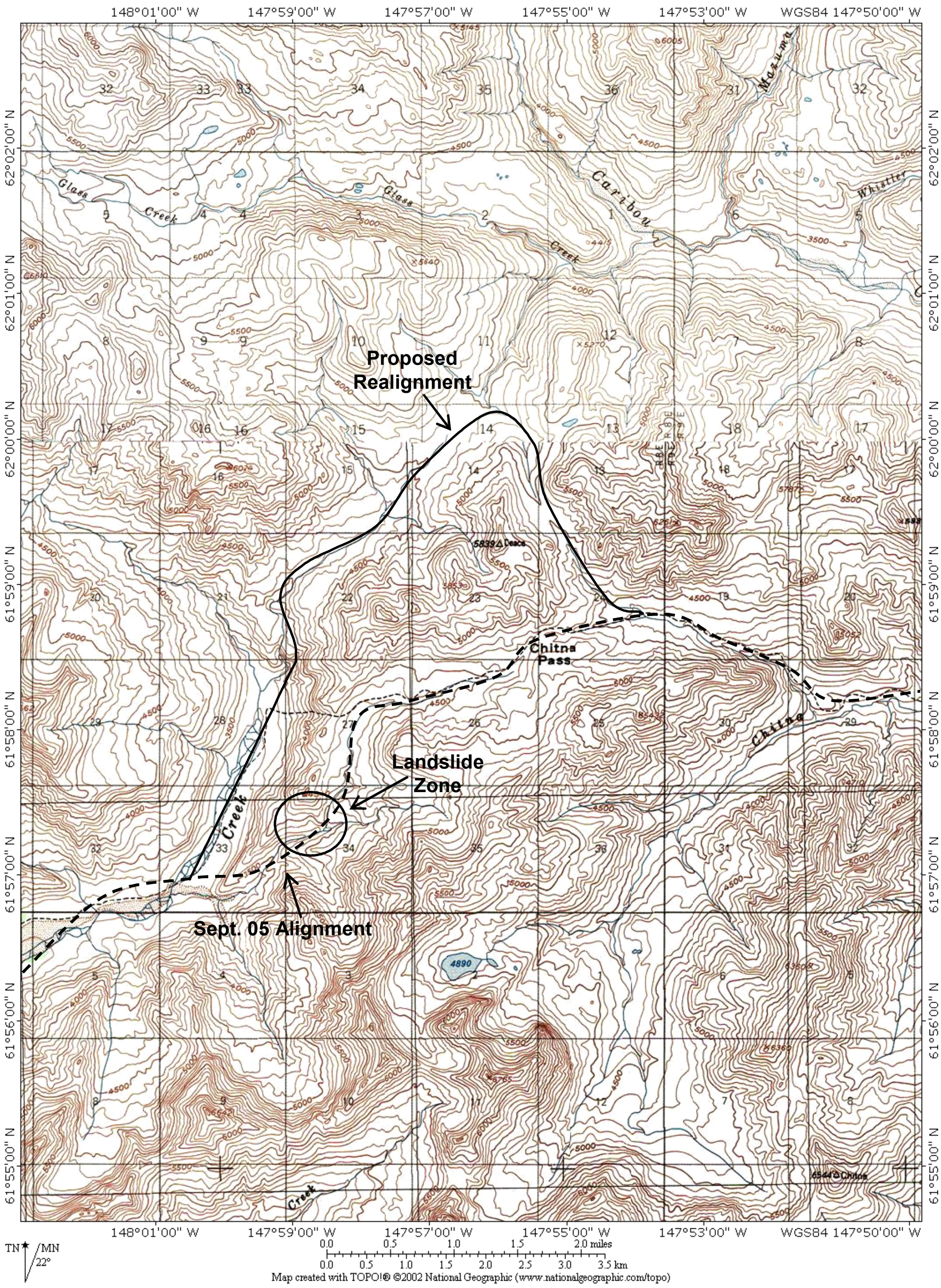
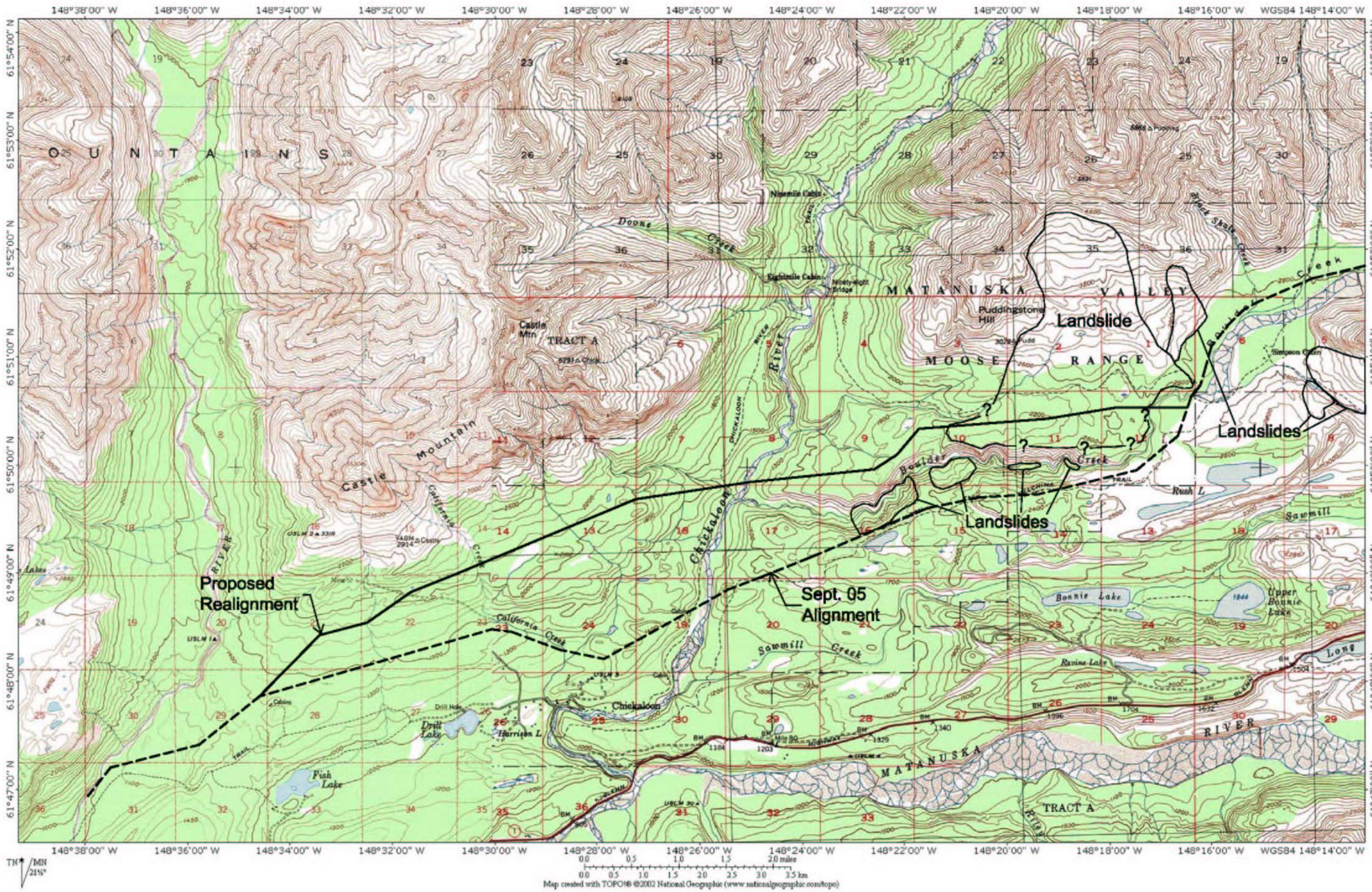


FIGURE 16

PROPOSED CHICKALOON RIVER CROSSING REALIGNMENT



south side of Puddingstone Hill. If this is not possible, then the alignment should stay south of Boulder Creek and cross the Chickaloon River on the south side of Boulder Creek.

The eastern portion of the realignment is shown on Figure 17. The western portion of this realignment would traverse a bench along the south side of Castle Mountain. There were no readily apparent landslides along this part of the realignment. Large, steep colluvial deposits were observed on aerial photos uphill of the proposed realignment.

5.2.3 Moose Creek Crossing Realignment

The alignment at the present Moose Creek crossing traverses a narrow steep-walled canyon, approximately 200 feet deep, at the crossing called Tsadaka Canyon. There is a large actively eroding section of the canyon wall upstream of the crossing and fine-grained soils appeared to be eroding into the stream. The stream is anadromous fish habitat and it would be difficult to construct the pipeline on these slopes without causing siltation of the creek. *Therefore, we recommend that consideration be given to moving the crossing either upstream as shown on Figure 18 or downstream to a location between the Glenn Highway and the Matanuska River.*

Two proposed upstream realignments are shown on Figure 18. Realignment 1 is the longer of the two, crossing in a location where both canyon walls are significantly lower and not as steep. Realignment 2 also crosses the creek at a point where the canyon walls are lower and the creek floodplain is wider. However, at this location the west canyon wall is steep and it may be difficult to find an acceptable route up the canyon wall.

5.2.4 Glenn Highway Alternative

The existing spur line alignment roughly follows the Glenn Highway from Glennallen to beyond Eureka Lodge at about MP 62. At that point, the alignment departs from the highway and is not in close proximity to the highway again until it reaches the end of the project near the Glenn/Parks interchange. We were asked to evaluate the viability, from a geotechnical standpoint, of the alignment following the highway the entire way to Palmer. In response, we studied geologic maps, aerial photographs and performed a brief aerial over-flight of the Glenn Highway alignment.

For consideration of geotechnical conditions, this alignment alternative can be separated into two parts: the area between Eureka Lodge and Kings River, and the area between Kings River and the EOP. In the first area, the Glenn Highway follows the relatively steep southern flank of the Talkeetna Mountains and then through glacial terrain along the north side of the upper Matanuska River valley. The second area continues along the north side of the Matanuska River valley to the EOP.

Geotechnical conditions along the first portion of the alignment alternative are generally similar to those found along the Chitna Pass route. Both routes have numerous areas of unstable bedrock and steep slopes. However, there appears to be two large areas, one at

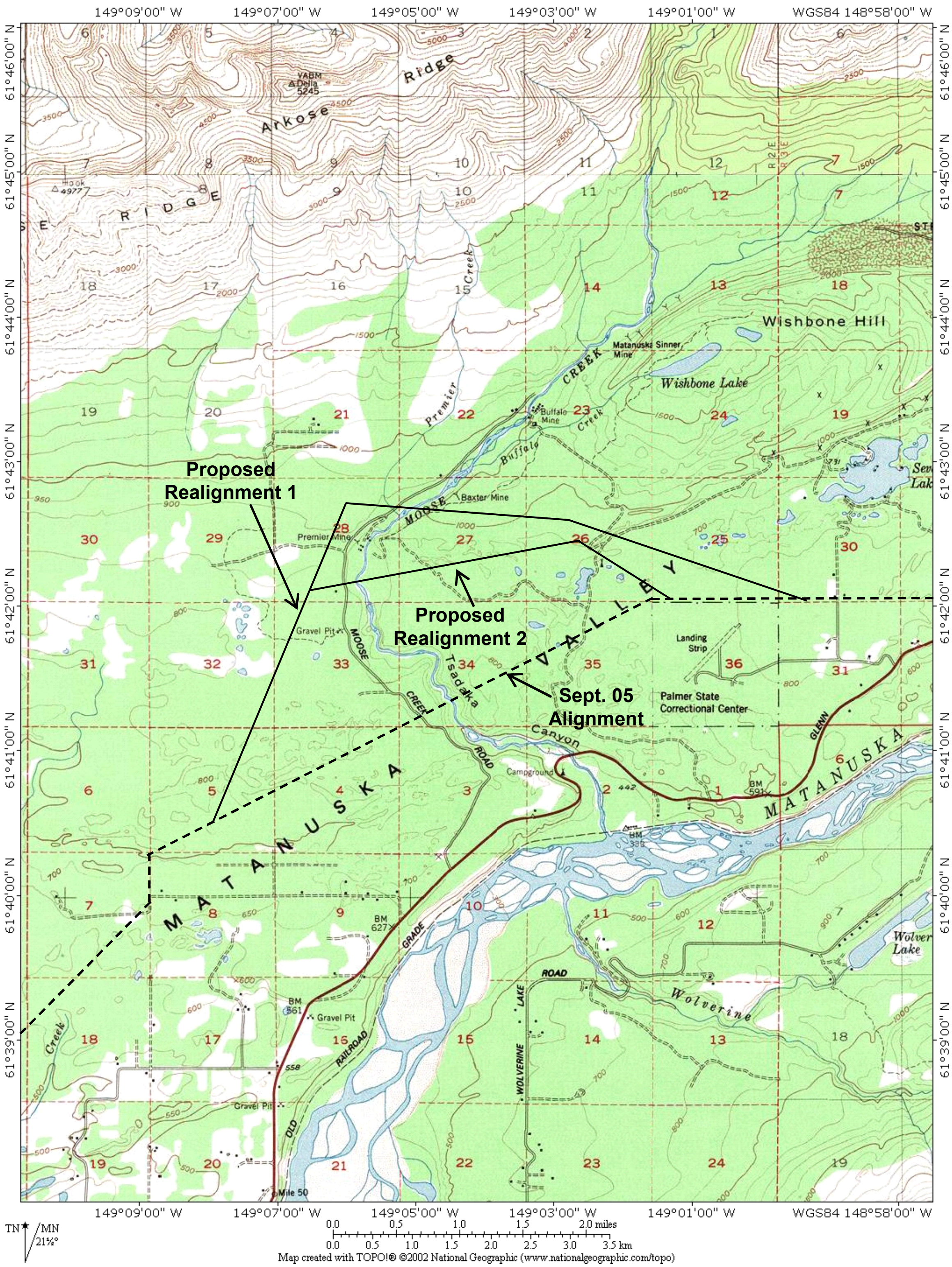
FIGURE 17

EAST END OF PROPOSED CHICKALOON RIVER CROSSING REALIGNMENT (PHOTOGRAPH)

Looking north, upstream into the Boulder Creek Valley. The proposed pipeline realignment crosses the bottom of the slope on the left of the photo (MP 110-111). The eastern edge of the landslide can be seen on left edge of the photo. This landslide may have flowed down to Boulder Creek. September 2, 2005.

FIGURE 18

PROPOSED MOOSE CREEK CROSSING REALIGNMENT



Caribou Creek that DOT&PF has recently reconstructed, and a second area west of Hicks Creek that may have fatal geotechnical flaws. This alternative may need to pull away to the north in several areas due to steep unstable lopes and other topographic concerns.

The area where the Glenn Highway crosses Caribou Creek is steep and ice-rich frozen soils have been encountered on these slopes. Failures have also occurred on the approaches to the old bridge. It would be very difficult to cross Caribou Creek Canyon at this location. An acceptable crossing may require moving the pipeline alignment away from the road for a considerable distance.

The Glenn Highway alignment crosses the toe of a large landslide in an area west of Hicks Creek. It appears that any pipeline alternative would need to move a significant distance downhill of the highway to cross through this area. There are other small areas of unstable bedrock and soils along this portion of the road that may require keeping the pipeline away from the road. The results of these reroutes would be to move much of the pipeline alignment away from the highway, minimizing one of the principal advantages of using the Glenn Highway Corridor.

The slope stability issues in the Caribou and Boulder Creek drainages generally appear to be easier to deal with than those along the Glenn Highway. At present, unless more difficult conditions are encountered along the present alignment through Chitna Pass, it would be the geotechnically preferred alignment.

Between Kings River and the EOP, it does not appear that there are any significant geotechnical differences between the Glenn Highway realignment and the present alignment to the north. However, a Glenn Highway alignment may provide a more simple crossing point of Moose Creek.

5.3 Stream Crossings

It is understood that proposed stream crossings are currently being evaluated by others. Table 5 presents a summary of our conclusions regarding the geotechnical conditions found at the 21 separate stream crossings identified in our statement of work. More detailed information gained from our site reconnaissance efforts is provided on the Field Site Description sheets found in Appendix B. Further, we understand that site-specific subsurface investigations may be required at certain stream crossings as part of the final design.

5.4 Material and Disposal Sites

5.4.1 Potential Material Sites

Potential sites for material extraction have been selected and the general locations shown on the RSC sheets. A tabular summary of potential material sites is also provided in Table 6. Selection was based on existing reports, geologic maps, aerial photographs and aerial reconnaissance. *On the ground reconnaissance was not performed, but would be necessary to determine whether these sites contain sufficient quantities of suitable*

TABLE 5

SUMMARY OF STREAM CROSSING CONDITIONS

Stream Name	Milepost	Boulders	Anticipated Soils	Bedrock
EF Moose Creek	0.93	None observed	Fine- to coarse-grained	Not anticipated
Moose Creek	3.85	None observed	Fine-grained	Not anticipated
Tolsona Creek	15.95	Probable	Coarse-grained	Not anticipated
Duram Creek	18	None observed	Fine-grained	Not anticipated
Little Woods Creek	20.09	None observed	Organic soils overlying coarse-grained deposits	Not anticipated
Atlasta Creek	23.9	None observed	Coarse-grained	Not anticipated
Tex Smith Lake Drainage	26.76	None observed	Coarse-grained	Not anticipated
Woods Creek	34.51	None observed	Organic rich fine-grained	Not anticipated
Mendeltna Creek	35.8	None observed	Fine-grained	Not anticipated
Cache Creek	41.22	None observed	Generally fine-grained	Not anticipated
Startup Creek	64.77	None observed	Fine-grained	Not anticipated
Caribou Creek	75.68	Anticipated	Coarse-grained	Shallow
Chickaloon River	110.5	Anticipated	Coarse-grained	Shallow
Kings River	117.94	Anticipated	Coarse-grained	Shallow
Little Granite Creek	124.29	Anticipated	Coarse-grained	Shallow
Granite Creek	126.01	Anticipated	Coarse-grained	Shallow
Eska Creek	128.01	Anticipated	Coarse-grained	Shallow
Moose Creek	134.32	Anticipated	Coarse-grained	Shallow
Carnegie Creek	138.53	None observed	Coarse-grained	Not anticipated
Wasilla Creek	144.6±	None observed	Coarse-grained	Not anticipated
Spring Creek	147.24	None observed	Organic rich fine-grained	Not anticipated

General Notes:

1. Mileposts are based on the March, 2005 alignment (Baker, March 31, 2005).
2. See Field Site Descriptions presented in Appendix B, Volume 2, of this report for more detailed geotechnical information regarding proposed stream crossings.

TABLE 6

SUMMARY OF POTENTIAL MATERIAL SITES

Mile-post	Offset	Terrain Unit	Access	Comments	References
16.7	----	L/Gt (GFe)	Existing Road	Existing Pit on West Side of Tolsona River DOT 42-3-010-5 (MP171.9)	DOT&PF, Material Site Report, Glenn Highway Paving, Mile 152 to Mile 172, Mendeltna Creek to Tolsona Creek, 1979 DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway – Tolsona Creek 10 Miles West Reconstruction and Surfacing, 1966
18.7	200 ft. south of CL	GFe	Existing Road	Existing Pit on west side of Duram Creek DOT 42-3-008-5 (MP169.7) DOT 42-3-020-5 (MP169.8)	DOT&PF, Material Site Report, Glenn Highway Paving, Mile 152 to Mile 172, Mendeltna Creek to Tolsona Creek, 1979 DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway – Tolsona Creek 10 Miles West Reconstruction and Surfacing, 1966
20.2	100 ft. north of CL	L/Gt (GFk)	Existing Road	Existing Pit on West Side of Little Woods Creek DOT 42-3-017-5	N/A
24.1	2,000 ft. north of CL	GFk	Existing Road	Existing Pit DOT 42-3-015-5 (MP164.1)	DOT&PF, Material Site Report, Glenn Highway Paving, Mile 152 to Mile 172, Mendeltna Creek to Tolsona Creek, 1979 DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway – Tolsona Creek 10 Miles West Reconstruction and Surfacing, 1966
29.0	1.1 miles north of CL	Gt+C/Gt	Existing Road	Existing Pit at about 1.1 miles on Lake Louis Road DOT 809-001-5.	Materials Report, Glenn Highway, Mendeltna – Tolsona, 1962
30.6	100 ft. north of CL	Gt	Existing Road	Existing Pit DOT 42-3-007-5 (MP157.8)	DOT&PF, Material Site Report, Glenn Highway Paving, Mile 152 to Mile 172, Mendeltna Creek to Tolsona Creek, 1979 DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway – Tolsona Creek 10 Miles West Reconstruction and Surfacing, 1966
33.7	1,000 ft. north of CL	Gt	Existing Road	Existing Pit on East Side of Woods Creek DOT 42-3-014-5	DOT&PF, Material Site Report, Glenn Highway Paving, Mile 152 to Mile 172, Mendeltna Creek to Tolsona Creek, 1979 DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway – Tolsona Creek 10 Miles West Reconstruction and Surfacing, 1966
36.8	800 ft. north of CL	L/Gt (GFk)	Existing Road	Existing Pit on West Side of Mendeltna Creek DOT 42-3-013-5 (MP151.3)	DOT&PF, Centerline Soils and Materials Investigation, Mendeltna Creek, 11 Miles West, Pages 46- 51, 1971
38.6	700 ft. north of CL	Gt (GFk)	Existing Road	Existing Pit DOT 42-3-006-5 (MP149.6)	DOT& PF, Glenn Highway Phase II, Mile 127 – Mile 135.8, Page 141-145, 1992 DOT & PF, Centerline Soils and Materials Investigation, Mendeltna Creek, 11 Miles West, Pages 38- 45, 1971
42.7	600 ft. south of CL	GFk	Existing Road	Existing Pit DOT 42-3-019-5 (MP145.7)	DOT & PF, Centerline Soils and Materials Investigation, Mendeltna Creek, 11 Miles West, Pages 52- 58, 1971

(continued)

TABLE 6 (continued)

SUMMARY OF POTENTIAL MATERIAL SITES

Mile-post	Offset	Terrain Unit	Access	Comments	References
47.2	100 ft. south of CL	GL (GFo)	Existing Road	Existing Pit DOT42-3-004-5 (MP141.1)	DOT&PF, Supplemental Material Site Investigation, Material Site 42-3-004-5, 1975
					DOT & PF, Centerline Soils and Materials Investigation, Mendeltna Creek, 11 Miles West, Pages 33- 37, 1971
52.4	1,000 ft. north of CL	Gt	Existing Road	Existing Pit east of Little Nelchina River Crossing DOT 42-3-018-5	DOT& PF, Glenn Highway Phase II, Mile 127 – Mile 135.8, Pages 115-144, 1992
					DOT& PF, Glenn Highway Phase I, Mile 118 – Mile 127, 1991
					DOT & PF, Centerline Soils and Materials Investigation, Mendeltna Creek, 11 Miles West, Pages 33- 37, 1971
55.4	100 ft. south of CL	Gt	Existing Road	Existing Pit Between the Little Nelchina River and Eureka Lodge DOT 42-3-022-5 (MP132.5)	DOT& PF, Glenn Highway Phase II, Mile 127 – Mile 135.8, Pages 109-114, 1992
					DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway, Mile 132 to Mile 134, Pages 18-23, 1975
57.4	100 ft. north of CL	Gt	Existing Road	Existing Pit west of Eureka Lodge DOT 42-3-001-5 (MP130.4)	DOT&PF, Centerline Soils and Materials Sites Investigation, Glenn Highway, Mile 132 to Mile 134, Pages 18-23, 1975
67.5	CL	Ffg	----	New Site on north side of Squaw Creek	N/A
68.7	CL	Ffg	----	New Site on north side of Squaw Creek	N/A
70.4	CL	Ffg	----	New Site on north side of Squaw Creek	N/A
71.3	CL	Ffg	----	New Site on north side of Squaw Creek	N/A
78.6	100 ft. north of CL	Fp/Bx	----	New Site on south side of Caribou Creek in Floodplain	N/A
84.7	100 ft. south of CL	Ct/Bx	----	New Site on south side of Caribou Creek on Talus Slopes	N/A
89.0	CL	Ffg	----	New Site on Alluvial Fans in Chitna Pass	N/A
93.2	CL	Ffg	----	New Site on Alluvial Fan along Boulder Creek	N/A
96.3	CL	Ffg	----	New Site on Alluvial Fan along Boulder Creek	N/A
101.7	500 ft. north of CL	Fpt	----	New Site on River Terrace along Boulder Creek	N/A
104.2	200 ft. north of CL	Ffg	----	New Site on Alluvial Fan along Boulder Creek	N/A
110.1	2,000 ft. north of CL	Fpt	----	New Site on East Side of Chickaloon River	N/A
110.5	3,000 ft. north of CL	Gfo	----	New Site on West Side of Chickaloon River	N/A
114.9	5,000 ft. south of CL	Gfo	----	New Site East of Fish Creek	N/A

(continued)

TABLE 6 (continued)

SUMMARY OF POTENTIAL MATERIAL SITES

Mile-post	Offset	Terrain Unit	Access	Comments	References
116.9	100 ft. south of CL	GFo	----	New Site on East Side on Kings River.	N/A
121.0	200 ft. south of CL	Fpt	----	New Site on West Side of Kings River	N/A
125.8	2,000 ft. south of CL	El Gfo	----	New Site on East Side of Granite Creek	N/A
126.9	200 ft. south of CL	El Gfo	----	New Site on West Side of Granite Creek	N/A
129.1	200 ft. north of CL	El Gfe	----	New Site on West Side of Eska Creek	N/A
130.8	300 ft. south of Cl	El Gfe	----	New Site Near Correction Center	N/A
133.2	100 ft. north of CL	El Gfo	----	New Site on East Side of Moose Creek	N/A
135.6	CL	El Gfe	----	New Site on West Side of Moose Creek	N/A
141.5	200 ft. east of CL	El Gfo	----	New Site Near Walby Lake	N/A
142.8	1,200 ft. east of CL	Gfk	----	Existing Privately Operated Pit on South Side of Palmer-Wasilla Highway	N/A
144.4	CL	GFe	----	Existing Privately Operated Pit on West Side of Trunk Road	N/A

General Notes:

1. Spur line mileposts are based on the March, 2005 alignment (Baker, March 31, 2005).
2. Glenn Highway mileposts are based on DOT&PF reports.
3. See Section 3.1.1 for terrain unit descriptions.

material to warrant further exploration. The ultimate disposition and intended use of a specific material will be the primary factor governing the quantities of acceptable material which may be mined at a particular site. The sites were laid out with an approximate five-mile spacing, with closer spacing where possible, to allow for loss of sites due to insufficient quantities or poor material, and environmental/land issues. Other sites might be considered should any of these sites not ultimately be available.

The Copper River Basin (Glennallen to Startup Creek, MP 0 to MP 65) is generally underlain by fine-grained glacial lake and glacial till deposits, which are generally unsuitable for construction purposes. There are a limited number of ice-contact and river terrace deposits along the alignment in this area. Many of the potential sites selected for this project are located along the highway and have been mined in the past. The quantity and quality of remaining material is unknown. There are sources further away from the alignment that may be considered if significant amounts of material are required. These sources include ice-contact deposits such as kames and eskers to the north of the highway and along the Lake Louise Road and river terraces along the Nelchina River. There are no known sites along the pipeline alignment between Glennallen and Tolsona Creek at about MP 16 and any material required here would necessarily need to be obtained from private and state sources in the area between Gulkana and Glennallen. Limited bedrock exposures exist between Slide Mountain and the Little Nelchina River Crossing. However, these exposures are of soft, poorly indurated bedrock that may be unsuitable for construction purposes.

Between Startup Creek (MP 65) and Simpson's Cabin on Boulder Creek (MP 104), the spur line alignment essentially follows stream valleys. There are no existing material sites within this segment. The principal potential sources of material in these valleys consist of alluvial sands and gravels in floodplain, terrace, and fan deposits. It should be noted that shallow bedrock (<5 feet deep) is interpreted to underlie many of the floodplain deposits. However, much of the bedrock in this area is mapped as fine-grained mudstones that may not be suitable for some construction purposes.

Between MP 104 and MP 128 (Eska Creek) the alignment crosses fine-grained glacial tills and colluvium overlying bedrock, interspersed with river valleys. The available construction materials along this portion of the alignment consist of alluvial floodplain, terrace and fan deposits. There are existing material sites within the area along the Glenn Highway but these sites are generally too far away from the alignment to be economically feasible.

From Eska Creek (MP 128) to the EOP (MP 148), the alignment crosses areas covered with glaciofluvial deposits overlain by eolian silts and sands. Sand and gravel is generally plentiful. Land ownership and regulatory issues may be more problematic than availability of material along this stretch of the alignment. Additionally, there are numerous privately owned material sources within this area.

During construction, the less competent bedrock units (i.e. shales, coal, and highly weathered or sheared rocks) may be rippable, whereas, the more competent bedrock (conglomerates, sandstones and igneous rocks) may require blasting. Bedrock best suited for use as general construction materials include most of the fine-grained igneous units, but any of the competent bedrock may be used.

Future materials investigations should include a field reconnaissance study that takes into consideration estimated quantities and quality of material required, lands and ownership issues and environmental concerns. A reconnaissance plan showing how the sites would be accessed should be prepared for review by ROW personnel. The reconnaissance may include use of hand tools (i.e. shovels, hand augers, etc.) and visual observations to determine if the areas contain sufficient quantities of suitable material. Due to the distance of many of the sites from the highway, helicopter access will be required.

Based on the results of the field reconnaissance, an exploration plan should be prepared, showing the exploration area, proposed access for equipment, test hole locations, testing requirements, and outlining any clearing required for the field work. For sites in close proximity to the highway, tracked backhoes can be used to test the materials. Small helicopter-slung backhoes can be used to reach the sites further from the highway. These helicopter portable backhoes normally excavate to between five and eight feet in depth. With considerable extra effort (benching, etc.) they can reach 10 feet or more. Track-mounted drills can be used for drilling in frozen ground and in places where greater depth is required. *Upon completion of the field work, a report containing site maps, test hole logs, laboratory testing results, access and mining guidelines, and estimated quantities should be prepared.*

5.4.2 Proposed Disposal Sites

Proposed sites for material disposal were selected and the general locations shown on the RSC sheets. Additionally, Table 7 presents a tabular summary of the proposed disposal sites. Selection was based on existing reports, geologic maps, aerial photographs and aerial reconnaissance. *On the ground reconnaissance was not performed and would be necessary to determine whether these sites are satisfactory.* These sites were laid out with an approximate five-mile spacing and placed in such a manner as to minimize siltation into water bodies. Other sites may be considered should these sites not be satisfactory or are not ultimately available.

5.5 Design-Level Investigations

5.5.1 Detailed On-the-Ground Geotechnical Survey

A detailed on-the-ground geotechnical survey should be performed which would consist of walking the alignment and making observations of geotechnical conditions. This survey would allow for geologic hazards to be identified early in the design phase. Trafficability of the native soils could also be evaluated. Hand tools, including shovels and hand augers, could be utilized to examine shallow subsurface conditions. Access to the alignment could be mostly from the road, but a helicopter would be required to reach

TABLE 7

SUMMARY OF PROPOSED DISPOSAL SITES

Milepost	Offset	Terrain Unit
0.2	200 ft. North of CL	GL
2.6	200 ft. North of CL	GL
7.6	150 ft. North of CL	GL
12.4	100 ft. North of CL	GL
17.9	150 ft. North of CL	GL
22.1	400 ft. North of CL	L/Gt
27.7	300 ft. South of CL	L/Gt
33.6	200 ft. South of CL	L/Gt
37.7	200 ft. North of CL	L/Gt
43.5	200 ft. South of CL	C/GL
47.6	100 ft. North of CL	GL
52.1	100 ft. North of CL	Gt
58.0	600 ft. South of CL	Gt
62.4	300 ft. North of CL	Gt
66.6	100 ft. North of CL	Cs/Gt
72.3	200 ft. North of CL	Gt
78.5	400 ft. South of CL	C/Gt
82.6	200 ft. South of CL	Bx
89.6	100 ft. North of CL	C/Bx
94.8	200 ft. South of CL	Fpt
101.2	100 ft. North of CL	Fpt
105.7	100 ft. South of CL	Gt
109.9	100 ft. South of CL	$\mathrm{Bx} + \frac{\mathrm{C}}{\mathrm{Bx}}$
114.8	200 ft. South of CL	Gt
120.6	400 ft. South of CL	Fpt
124.3	200 ft. South of CL	$\frac{\mathrm{Gt}}{\mathrm{Bx}}$
130.2	200 ft. South of CL	$\frac{\mathrm{El}}{\mathrm{Gfe}}$
135.7	100 ft. North of CL	$\frac{\mathrm{El}}{\mathrm{Gfe}}$
141.2	200 ft. South of CL	$\frac{\mathrm{El}}{\mathrm{Gfo}}$

General Notes:

1. Spur line mileposts are based on the March, 2005 alignment (Baker, March 31, 2005).
2. See Section 3.1.1 for terrain unit descriptions.

many of the locations along Boulder and Caribou creeks, and in areas in which the access crosses private land. The helicopter could also be used for aerial reconnaissance to identify features not apparent on the ground. Hand probes could also be performed in bogs to determine peat depths. Methods of access for exploration equipment could also be evaluated and a route soils exploration plan could be prepared.

5.5.2 Slope Stability Study

There are various slope stability concerns along the pipeline alignment, primarily between MP 64 and 110. *A detailed slope stability study should be performed prior to selection of the preferred alignment. This study should determine which existing landslides are active and which can be crossed by the pipeline with minimal risk. The study should also evaluate those areas that do not have discernable existing failures and conclude what, if any, risk there is of failure in the future.* This study may be the decisive factor on which side of the creek the pipeline is placed in the Boulder and Caribou Creek valleys. Due to the distance from the road, the high elevation of the scarps and the extent of the known and suspected landslides, a helicopter would be required to perform most of this work.

5.5.3 Avalanche Studies

Avalanches may occur along portions of the alignment and could endanger the safety of construction and maintenance personnel. *Potential damage to shallow buried pipe may also be a possibility and should be considered. At a minimum, an avalanche study should be performed in the area between MP 64 and 104 to determine the probability of avalanches and potential avalanche paths. If between MP 104 and 116, the pipeline is realigned further north and closer to the mountains, then avalanche studies should be extended into these areas.*

5.5.4 Exploration for Route Soils Characterization

Shallow test holes including test pitting and drilling should be performed to characterize the soils along the centerline. The holes could range from about five to 10 feet in depth. The test hole spacing would need to be adjusted so as to cover all of the terrain units crossed by the alignment, with wider spacing in large units and closer spacing in areas with small units. Test pitting would be the preferred method of excavation as it would allow pipeline trenching requirements to be characterized. In places where backhoes cannot excavate due to frozen ground or other hard conditions, drilling may be appropriate. Additional test holes with closer spacing may be required at stream crossings, in floodplains, areas where shallow bedrock is suspected, areas where workpad cuts are anticipated and other areas where more detail is required.

Equipment for this program might include both wheel and track-mounted excavators in areas readily accessible by road and trail and helicopter-slung backhoes and drills in more inaccessible areas. Track-mounted drills may be used in areas with poor trafficability. Laboratory testing should be performed on selected samples.

Deeper test holes, ranging from say 10 to 50 feet deep, may be required in site-specific areas with slope and thaw stability concerns, deeper cuts at some river crossings and in other areas where deeper subsurface information is required. These test holes would most likely be achieved using track-mounted drill rigs.

5.5.5 Geophysics

Geophysical studies should be implemented as they are an excellent method to extend subsurface data between widely spaced test holes. However, there are numerous geophysical methods, some that work best in one set of conditions and others that will work best in other sets of conditions. Thus, any geophysical studies would need to be aimed at resolving specific conditions, using the best method or methods to obtain the required information. The two methods that may be of most use along the pipeline alignment are resistivity and conductivity for determining the presence of permafrost, and seismic refraction for determining depth to and rippability of bedrock.

Electrical resistivity/conductivity methods are effective methods for economically characterizing soil conditions over large areas. They are useful for determining the presence of permafrost. They are also one of the better methods to use for landslide studies.

Seismic refraction surveys may be performed to evaluate depth and or continuity of bedrock. This may be useful along portions of the alignment underlying the floodplain of Caribou and Boulder creeks where shallow bedrock is anticipated. Rippability studies in selected areas may also be useful for evaluating trenching difficulty.

5.6 Summary of Recommendations

As a convenience to the reader, Table 8 provides a summary of the salient geotechnical recommendations presented in Section 5.0. Please note that the key portions of these recommendations were highlighted in italics in the preceding text.

TABLE 8

SUMMARY OF SALIENT RECOMMENDATIONS

Page	Section Name	Recommendation
49	Milepost 13.3 to 15.2	This area should be accessed only during winter conditions when the ground is sufficiently frozen to support equipment. Any realignment in this area should take the presence of these mud volcanos into consideration.
49	Milepost 16 to 16.8	Consideration should be given to possible realignment of the spur line to the old gravel pit access road lying north of the highway. Drainage should be directed to minimize the concentration of water flow along this road. Detailed subsurface exploration should be performed to determine site-specific conditions.
51	Milepost 40 to 57	The alignment may need to be moved slightly north of this disturbed area.
51	Milepost 42.3 to 50	Should the alignment need to move, we recommend that it be moved south of the existing highway, and not uphill to the north.
51	Milepost 48.7 to 51.1	Both bedrock stability and highway embankment deformation should be investigated.
51	Milepost 64.3 to 64.7	The alignment should be moved north; away from these scarps and geotechnical investigations should be performed to determine whether there is any potential for further such failures elsewhere in the area.
51	Milepost 65 to 73	It may be advantageous to move the alignment uphill to avoid some of these frozen ground degradation problems. Further study and exploration should be performed to determine the extent of this hazard and the feasibility of any proposed solutions.
51	Milepost 69.1 to 69.8	The alignment should not be moved northward (uphill) at this location. Further investigations should be performed to determine whether these landslides may affect the present alignment.
52	Milepost 82.2 to 84.3	Further evaluation of these slides should be performed.
52	Milepost 84 to 93	These reported landslides should be analyzed as part of any future slope stability study.
52	Milepost 86 to 88	These two slides should be further evaluated.
52	Milepost 91.2 to 91.9	We recommend that the alignment be moved out of this area. See Section 5.2.1.

(continued)

TABLE 8 (continued)

SUMMARY OF SALIENT RECOMMENDATIONS

Page	Section Name	Recommendation
52	Milepost 92.4 to 92.8	Further evaluation of this slide should be performed, or the alignment should be moved to the south side of the creek.
52	Milepost 94.6 to 94.8	The likelihood of movement of the glacier should be evaluated.
53	Milepost 95.3 to 98.5	Further evaluation of these fans should be performed. Relocating the alignment across the creek, where there are fewer colluvial fans, may be appropriate.
53	Milepost 107 to 109	The alignment in this location should be moved south at least 1,000 feet.
53	Milepost 110.5	It is recommended that the alignment be shifted to avoid steep bedrock bluffs. See Section 5.2.2.
53	Milepost 117.6 to 118.6	The stability of this ridge should be evaluated.
53	Milepost 134.3	It may be advisable to move the crossing either downstream or upstream to a location with a wider floodplain, or more gentle slopes. See Section 5.2.3.
55	5.2.1 Chitna Pass Realignment	We recommend that the proposed northern realignment, as shown in Figure 15, be given further consideration.
55	5.2.2 Chickaloon River Crossing Realignment	We recommend shifting the alignment either up or downriver to a move advantageous crossing location.
58	5.2.3 Moose Creek Crossing Realignment	We recommend that consideration be given to moving the crossing either upstream as shown on Figure 18 or downstream to a location between the Glenn Highway and the Matanuska River.
61	5.4.1 Potential Material Sites	On the ground reconnaissance was not performed, but would be necessary to determine whether these sites contain sufficient quantities of suitable material to warrant further exploration.
67	5.4.1 Potential Material Sites	Future materials investigations should include a field reconnaissance study that takes into consideration estimated quantities and quality of material required, lands and ownership issues, and environmental concerns. A reconnaissance plan showing how the sites would be accessed should be prepared for review by ROW personnel.

(continued)

TABLE 8 (continued)

SUMMARY OF SALIENT RECOMMENDATIONS

Page	Section Name	Recommendation
67	5.4.1 Potential Material Sites	Based on the results of the field reconnaissance, an exploration plan should be prepared, showing the exploration area, proposed access for equipment, test hole locations, testing requirements, and outlining any clearing required for the field work. Upon completion of the field work, a report containing site maps, test hole logs, laboratory testing results, access and mining guidelines, and estimated quantities should be prepared.
67	5.4.2 Proposed Disposal Sites	On the ground reconnaissance was not performed and would be necessary to determine whether these sites are satisfactory.
67	5.5.1 Detailed On-the-Ground Geotechnical Survey	A detailed on-the-ground geotechnical survey should be performed which would consist of walking the alignment and making observations of geotechnical conditions.
69	5.5.2 Slope Stability Study	A detailed slope stability study should be performed prior to selection of the preferred alignment. This study should determine which existing landslides are active and which can be crossed by the pipeline with minimal risk. The study should also evaluate those areas that do not have discernable existing failures and conclude what, if any, risk there is of failure in the future.
69	5.5.3 Avalanche Studies	Potential damage to shallow buried pipe may also be a possibility and should be considered. At a minimum, an avalanche study should be performed in the area between MP 64 and 104 to determine the probability of avalanches and potential avalanche paths. If between MP 104 and 116 the pipeline is realigned further north and closer to the mountains, then avalanche studies should be extended into these areas.
69	5.5.4 Exploration for Route Soils Characterization	Shallow test holes including test pitting and drilling should be performed to characterize the soils along the centerline.
70	5.5.5 Geophysics	Geophysical studies should be implemented as they are an excellent method to extend subsurface data between widely spaced test holes.