PRELIMINARY HYDROLOGY REPORT

ALCAN PIPELINE ROUTE

DELTA JUNCTION TO CANADIAN BORDER

Prepared
For
Alcan Pipeline Company

By
R&M CONSULTANTS, INC.

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SUMMARY

Following is the preliminary report presenting an overall hydrologic assessment of the proposed gas pipeline route between Delta Junction and the Canadian Border. The work to date has consisted of a field reconnaissance of the route, both aerial and on-the-ground, as well as a preliminary office review.

The office review has entailed a literature search, analysis of the aerial photography, delineation of all drainage basins, and determination of the computational method to be used in obtaining the design discharge values. Since no decision has been made concerning monitoring agencies for the proposed project, it has not been possible to formalize approval of the computational approach. However, informal discussions with the agencies presently responsible for the Alyeska project indicate that approval should not be a problem.

Work is presently beginning on the discharge computations for all drainage basins along the proposed route. These discharge computations will yield the total runoff to be expected from each drainage basin. Additionally, wherever possible from the aerial photography or the topographic maps, defined channels will be identified. Exact locations of all defined channels will require field verification and a survey.

GENERAL DISCUSSION

This report completes the first phase of the hydrologic study for the proposed gas pipeline route between Delta Junction and the Canadian Border. A qualitative assessment has been made of the route, and potential problem areas identified. All drainage areas along the route have been delineated on topographic maps, and sub-areas have been determined where necessary to isolate such specific hydrologic features as glaciers, lakes, etc. Computation of preliminary discharge values will begin immediately. Some points which must be considered during design and construction are discussed here.

Fish Streams

A number of fish streams are crossed by the pipeline route. Wherever a cross-drainage structure is installed in these streams, it will be necessary to comply with criteria established by the regulatory agencies concerning fish passage. Adequate hydrologic designs will be particularly critical in order to determine the proper cross-drainage structures for these crossings.

Hydraulic design criteria developed by R & M probably will be applicable to the Alcan Pipeline Route, but this must be verified with the appropriate agencies when it is determined how the regulation of the project will be administered.

Along the Alaska Highway between Delta Junction and the Canadian Border, the only two fish streams presently listed by the Alaska Department of Fish and Game are Scottie Creek and Berry Creek. Based on past experience, it is anticipated that a significant number of streams ultimately will be designated as important fish streams. We understand that an intensive field survey is presently being conducted of all streams along the Delta Junction--Canadian Border route. This survey, being conducted by other consultants for Alcan Pipeline Company, will acquire quantitative data on fish populations and distribution. The data will be utilized in identification of important fish streams.

Aggradation-Scour

Along some segments of the route, particularly in the Cathedral Rapids area, the pipeline crosses streams which aggrade actively. These streams carry a large bed-load from the steep upper basins, and deposit the material when the gradient begins to flatten. While no scour potential exists at these crossings, it should be noted that regular maintenance will be required to allow access and to maintain the capacity of any drainage control structures. In some locations it appears that if the alignment were even a relatively short distance further upstream, the regime could shift from aggradation to scour.

In streams where the gradient is steeper, or where the bed or bank materials are fine grained, significant scour potential will be present. Under design flood conditions in such large rivers as the Tok or the Tanana, scour depth will undoubtedly be the controlling factor for a buried crossing.

Outburst Floods

A number of the river systems which cross the proposed gas pipeline route have their headwaters in the permanent icefields of the Alaska Range and the Wrangell Mountains. These glacial environments require a number of special hydrological considerations. One problem unique to these regions is the hazard of outburst floods from glacier dammed lakes.

Large quantities of water can be stored in or under glaciers and can cause catastrophic flooding when ice dams fail. Outburst floods are most commonly associated with visible lakes blocked by glaciers and glacier clad volcanoes; however, many glaciers may produce outburst floods. The largest lakes with the greatest flood potential occur where glaciers block ice-free tributary valleys. Most common are small lakes which form at low elevations along the glacier margins and at the intersection with side glaciers. Once the depressions within the glaciers or along the valley walls are closed off, they begin to fill with meltwater and rain runoff from the surrounding basin.

The impounded waters rise until they can overflow at a saddle or cause flotation of the dam, with subsequent release under the ice. Occasionally a lake may drain with no flooding, but generally once a leak is established, melting and mechanical scouring combine to rapidly widen the opening, and the discharge rate accelerates to extremely high values. Because of this rapid draining, even small glacier dammed lakes have the potential for flooding conditions which can be locally hazardous.

The dumping cycle for ice dammed lakes is based upon a complex network of factors and is not predictable without detailed study and monitoring of the individual glacial systems. Flooding can be especially critical when the outburst floods coincide with peak discharges due to heavy rainfall or snowmelt.

Five river systems along the proposed gas pipeline route head in glaciers with small visible ice dammed lakes. These drainage systems were listed by Post and Mayo as: 1) Gerstle River, 2) Johnson River, 3) Bear Creek, 4) Robertson River, and 5) Nabesna River. All five were considered to have the potential for outburst floods.

No data are available to predict the occurrence or effect of outburst floods in these rivers, and the danger from outburst floods along the proposed route appears to be minimal except for the Nabesna River. The flood courses inferred by Post and Mayo are restricted to the upper reaches in all but the Nabesna River, and serious flooding is less likely to occur on the lower, broad floodplains at the proposed pipeline crossings. The outburst flood hazard of the Nabesna River, although not well documented, could be high at the site of the Tanana River Crossing.

Ground Water

Ground water occurs along the proposed route and is being used by some road houses and service facilities along the Alcan Highway. Large portions of the route are underlain by permafrost which would restrict ground water occurrences locally. Many of the communities in the area use surface water, which reflects the general unreliable nature of ground water sources.

Observations described below in the discussion of the reconnaissance of the route section from Delta Junction to Gerstle River indicate a source of the ground water and provide clues as to mode of recharge. Flowing streams in the Alaska Range become dry beds and in places disappear altogether before reaching the highway.

Reports from current drilling programs along the route indicate that ground water west of Tok is encountered at 10 to 15 feet in the Tanana Valley. At Tok it is reported to be deeper.

Surface observations of the eastern portion of the proposed route are indicative of a more widespread occurrence of permafrost in that area. This would control ground water occurrences and further restrict consideration of its use as a reliable construction or domestic source.

Further investigation of this possible water source is recommended. The current test drilling program is providing significant qualitative information on ground water sources. Quantitative information is required if ground water sources are to be utilized in the construction and operation of the pipeline. This would require a test well program involving drilling and pumping.

PROPOSED COMPUTATIONAL METHOD

The method to be utilized in the hydrologic design computations will be a modified version of a method developed by G. N. MacDonald for the U. S. Bureau of Land Management. This method, referred to as the Modified BLM Method, has been utilized by R & M in previous hydrologic design for small drainage basins. It is not applicable for large basins, and will not be used for the major rivers. It is basically a derivation of the Rational Method, with additional factors applied based on elevation, aspect and topography. The equation representing the method is:

$$Q = RF \times LF \times EF \times q \times A$$

where,

Q = design discharge in cubic feet per second,

RF = rainfall factor based on rainfall intensity taken from U.S. Weather Bureau Technical Publications,

LF = land factor related to land use and general basin slope,

EF = elevation factor based on mean basin elevation and relative exposure to orographic conditions,

q = unit runoff in cubic feet per second per square mile, and

A = basin area in square miles.

Based upon observations made during the preliminary reconnaissance, June 21 through June 24, it has been determined that further modification should be made in the application of the Rainfall Factor. This is due to the extreme variation in the weather pattern between the upper basins in the Alaska Range and the flatter areas of lower elevation to the north. The basins will be divided into sub-areas to allow more accurate discharge computations from areas of uniform hydrologic characteristics.

A number of the basins along this route head in glacial areas. The runoff characteristics in these areas differ markedly from other portions of the basins, and could significantly affect the total discharge from a basin if the glacial area is large enough. The major rivers are primarily the basins which will be so affected; e.g., the Gerstle River drainage basin is approximately 20% to 25% glacier, and the Robertson River basin is 15% to 20% glacier.

Two possible analytical approaches are presently being reviewed for the major rivers. One method is a regionalization approach utilizing available information from the Tanana, Chena and Chisana Rivers as the data base. The other method is the Corps of Engineers HEC-1 Flood Hydrograph package. Both methods are being reviewed for applicability.

FIELD RECONNAISSANCE

During the period of June 19 through 24, 1976, a preliminary hydrologic reconnaissance was performed along the proposed gas pipeline route between Delta Junction and the Canadian Border. This consisted of a brief field review of the major river crossings by Dr. Robert Carlson, Senior Engineer, on June 19 and 20, and a four-day aerial and on-the-ground survey by John Swanson, Senior Engineer, and Stephen Shrader, Staff Engineer. All identifiable basins were observed for runoff patterns and hydrologic characteristics.

Following is a segment-by-segment commentary on the conditions observed during the reconnaissance. All references to Alcan Pipeline Mileposts are approximate.

DELTA JUNCTION TO GERSTLE RIVER

The Alaska Range foothills are 6 to 8 miles away, with everything between there and the highway being extremely flat. In general, it seems that much of the runoff from the foothills becomes subsurface flow before reaching the highway. USGS 1:63,360 maps show a number of creeks coming off the Granite Mountains (Alaska Range), with only three major creeks (Granite, Rhoads and Sawmill) crossing the highway. Field reconnaissance revealed only one creek--Sawmill Creek--crossing the highway.

Reconnaissance along the base of the mountains showed all the creek beds to be mostly gravel and cobbles, most carrying water. Most of these apparently went underground in the sandy gravel after the channel gradient was substantially reduced in the lowlands between the mountains and the highway (Photos 1 and 2).

Just east of Delta Junction, in the area of Alcan Milepost 544 (MP 544) a significant amount of local ponding and marshy areas is present (Photo 3). Very few drainage channels are defined. This is fairly typical of most of the area for 15 to 20 miles east of Delta Junction. There are not many highway culverts, but wherever they are installed, small induced drainages cross the pipeline right-of-way, which is immediately downslope (north). None of these induced drainages appears to have any potential for creating problems, as most are probably dry the majority of the time.

Granite Creek is adjacent to Jarvis Creek, heads next to the Gerstle River in the Granite Mountains, and has a drainage area of about 35 to 40 square miles. The channel coming out of the mountains is steep, mostly gravel and cobbles, and was carrying water at the time of this observation. Shortly after leaving the mountains the channel splits, with much of the water running toward the Rhoads Creek drainage to the east (Photo 4). However, Rhoads Creek becomes undefinable before reaching the highway. The Granite Creek "channel" disappears midway to the highway (Photos 5 and 6), becoming little more than a marshy area in the vicinity shown on the map as the Granite Creek highway crossing.

The existing Haines Pipeline is on or near ground surface. The right-of-way appears to be well maintained despite the fact that it is no longer in service (Photo 7). Soil in open holes appears to be sandy gravel. Through this entire area, there appears to be little or no thermal degradation along the pipeline right-of-way, nor any longitudinal drainage. One likely reason for the absence of such problems is that the right-of-way probably was not stripped; the pipe was merely laid on the ground. Since this will not be the case with the proposed gas pipeline, the problems of thermal degradation and induced longitudinal drainage must be considered.

A number of private access roads in the area immediately east of Delta Junction cross the pipeline right-of-way to reach private residences. A buried cold pipe may very well induce icings on these roads, in view of the amount of subsurface drainage that is apparently present. This potential problem should be addressed.

Gerstle River has a wide, braided, sand and gravel channel with low banks and a relatively flat gradient. This river drains a large area which extends well back into the Alaska Range (Photos 8 to 11). At the headwaters, the basin sides are extemely steep, with large contributory flows from the upper elevations. At the time of observation, June 19, approximately one-half of the channel was being used.

Some representative measurements were made at an unnamed stream just east of the Gerstle River. This stream crosses the highway in a 12 foot wide double box culvert (Photo 12). Fairly heavy vegetation in the channel indicates that flows probably are very sporadic. The stream was dry at the time of this observation on June 22. High water marks in the box culvert (Photo 13) indicate that most flows probably do not exceed about 100 cfs.

Photo 1 - Granite Mountains from highway
bridge on the Gerstle River

Photo 2 - Granite Creek drainage (toward Highway)

Photo 3 - Granite Creek at Alaska Highway
Note culverts in embankment

Photo 4 - Granite Creek (toward highway) near
base of mountains

Photo 5 - Granite Creek Channel

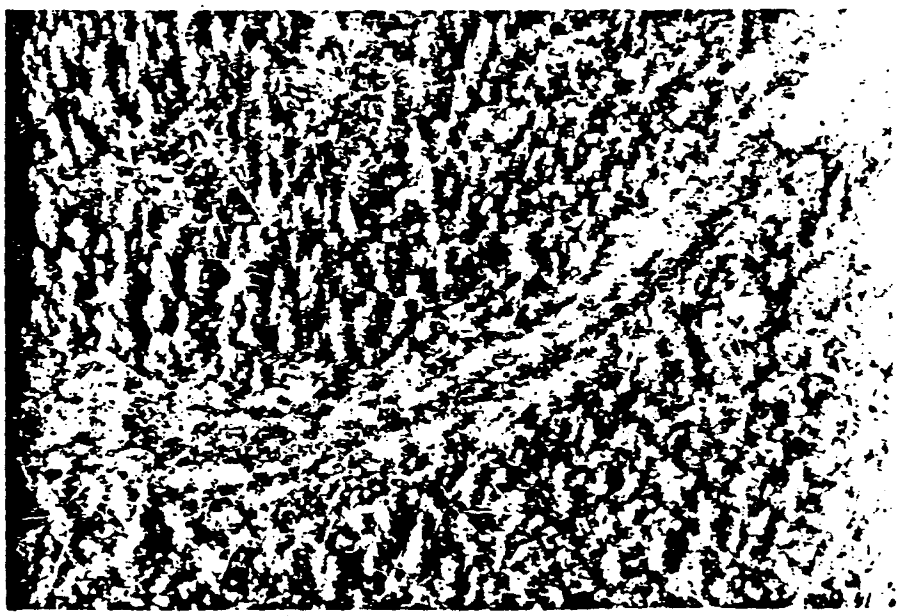

Photo 6 - Granite Creek Channel

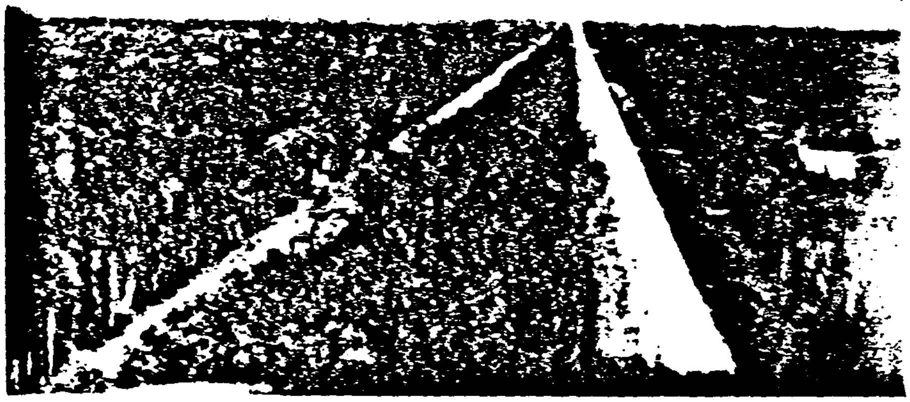

Photo 7 - SE along Haines Pipeline
near Delta Junction

Photo 8 - Gerstle River from Highway

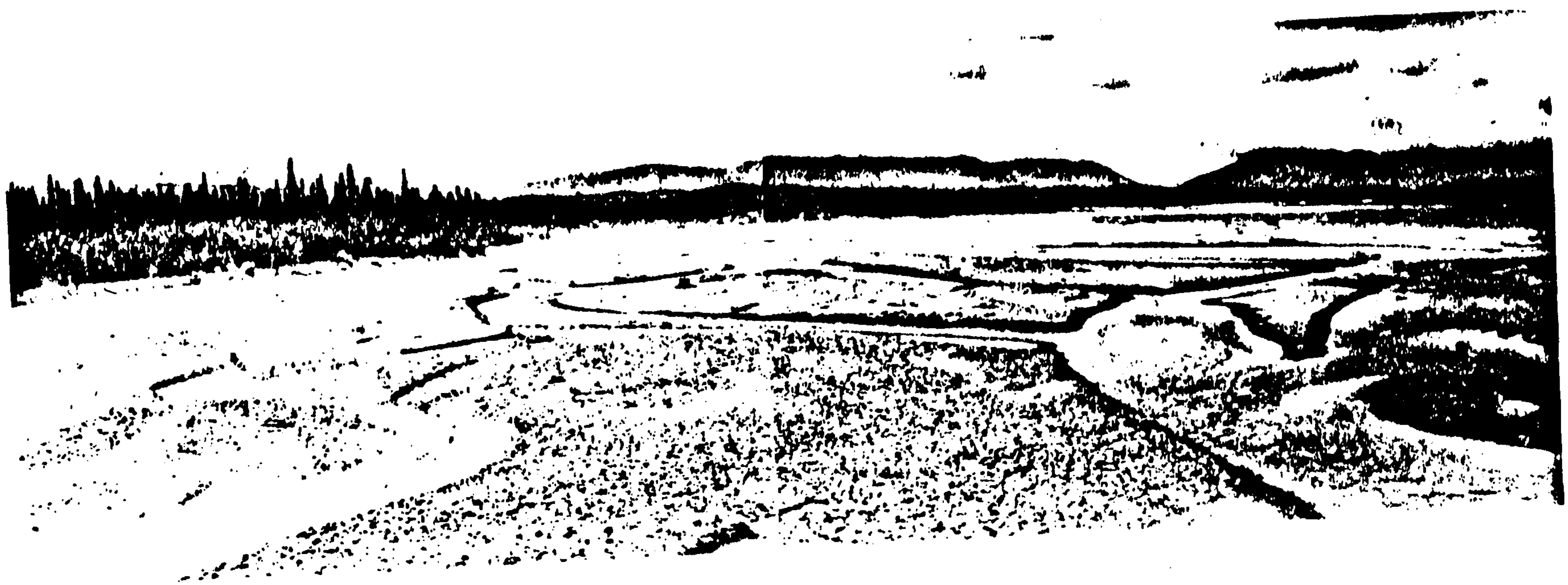

Photo 9, 10 Gerstle River upstream from highway

Photo 11 - Gerstle River (downstream from Highway)

Photo 12 - Dry stream bed near Gerstle River
(note overgrowth in channel).
Appears to be "overflow" channel
for Gerstle River.

Photo 13 - Box culvert in Gerstle River "overflow" channel (note apparent high water marks).

GERSTLE RIVER TO JOHNSON RIVER

Most of the drainage through this area is undefined, with only a few significant stream channels.

Little Gerstle River carries a fairly significant flow, but does not appear to present any major problems. The gradient is relatively flat, with very little apparent scour potential.

Just east of the Little Gerstle River, at MP 572.5, the Haines Pipeline crosses to the upslope side of the highway, approaching the base of the foothills. The potential for local ponding will be extremely high in this area, as the terrain is very rolling and numerous potholes are present. Most of this ponded water is trapped locally, and will probably cause dewatering problems during construction. Just west of Johnson River, in the vicinity of MP 577, extensive ponding is present.

Johnson River, with a drainage area of approximately 350 square miles, drains what appears to be a glacially eroded valley (Photo 14). The braided river bed runs northward and slightly eastward from Johnson Glacier (Photo 15). The river has an active full-width sand bottom with some gravel. The banks are steep alluvial bluffs. Once out of the lowlands, mountains rise on all sides in fairly sharp relief.

All the clouds seem to collect at the heads of drainages such as the Johnson (Photo 16). This seems to be generally true along this range of foothills. Rainfall data along the highway is not representative of the pattern in the foothills and upper basins. The rainfall pattern in the upper elevations seems to be a higher intensity, long duration precipitation. This will be considered in modifying the runoff computations.

Photo 14 - Johnson River (looking upstream)

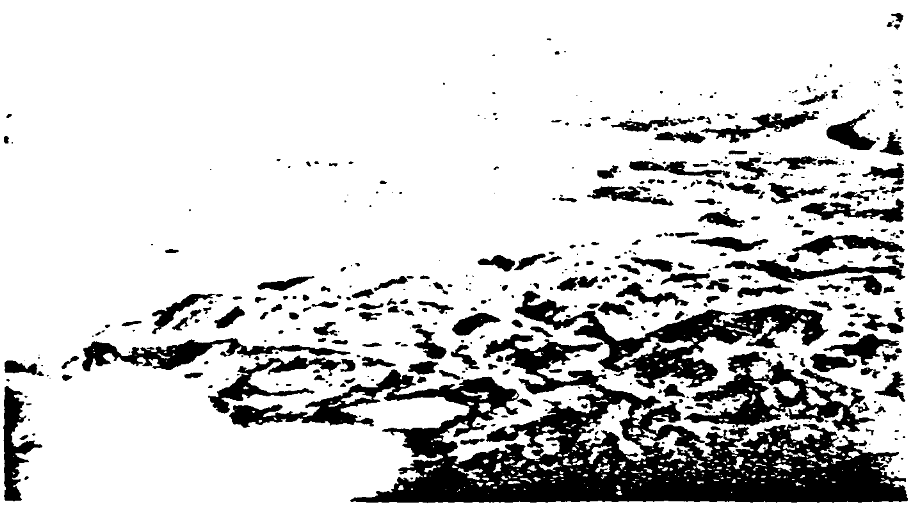

Photo 15 - Johnson River and base of
Johnson Glacier

Photo 16 - Johnson River (note clouds at head of basin).

JOHNSON RIVER TO DOT LAKE

After Johnson River, the highway and the Haines Pipeline (which is upslope from the highway) are near the base of the mountains. Dry Creek and Sears Creek are well defined channels. Basins in between are undefined or nearly so, with marshy areas at pipe crossings. Berry Creek is a significant basin with a well defined channel and a USGS gaging station at the highway. The drainage area north of Knob Ridge has a well defined channel with a box culvert at the highway.

Directly adjacent to the base of the foothills, most of these drainages are short and steep with no flat areas to buffer the flows as there are further west. These runoffs will be very "flashy", with most channels probably either completely dry or running full.

Dry Creek has a USGS crest stage gage installed at its crossing (Photo 17). This was investigated and measurements taken of a recently recorded stage. The date of the flow is unknown, but it probably occurred during spring breakup. It is likely that some ice was present in the channel during the recorded stage, but measurements indicate a flow of approximately 1000 cfs. At the time of this observation, June 22, the channel was dry but well defined, with vertical cut banks. Debris in overhanging brush at or above the top of the bank (Photo 18) indicates that this stream definitely has carried some significant flow. This data will be checked with the USGS for correlation with their records.

There appears to be a very high potential for ground water seepage and icing problems throughout this entire area. Aufeis build-up along this segment will cause major access problems, but should not be any danger to pipe integrity or highway structures.

Sears Creek is a well defined channel crossing the highway under a small bridge (Photos 19 and 20). Bed material appears to be fine grained sands and gravels. Channel bottom width is approximately 20 feet, and the stream gradient is approximately 1 to 2 percent. Laid-over vegetation in the channel indicates a recent flow depth of 3 to 4 feet. The flow has been fairly recent, probably during spring breakup.

Berry Creek has a USGS gaging station between the highway and the pipeline (Photo 21). At MP 475, the Haines Pipeline is immediately adjacent to the road. This situation probably will require widening of the shoulder and extension of the existing two culverts if the Haines pipeline right-of-way is used.

Photo 17 - Dry Creek

Photo 18 - Dry Creek (note log and debris
in brush on top of bank).

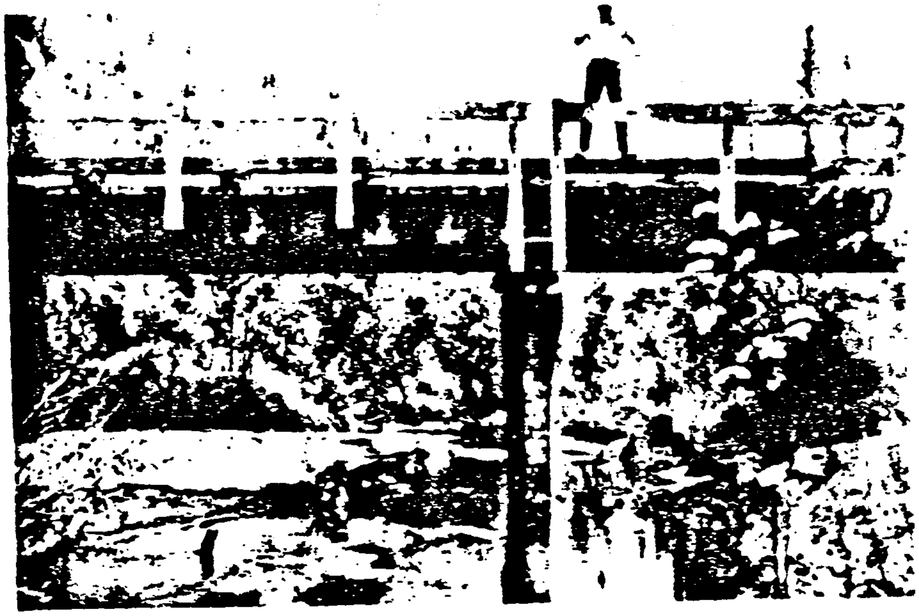

Photo 19 - Sears Creek (looking upstream)

Photo 20 - Sears Creek (looking downstream)

Photo 21 - Berry Creek just upstream of highway (USGS gaging station in lower left corner).

DOT LAKE TO ROBERTSON RIVER

Chief Creek flows under a small highway bridge. There do not appear to be any particular drainage problems, but there is a residence that seems to be located on the right-of-way which may indicate a "people problem".

Bear Creek is located at approximately MP 600.5. The basin drains about 70 square miles and extends well back into the Alaska Range foothills. It appears to carry a significant flow (Photo 22). A meander bend exists at the Haines Pipeline crossing which will undoubtedly cause difficulty during construction, as well as erosion potential during operation. It might be beneficial to realign this reach at the beginning of construction. Two miles west of Robertson River, the Haines Pipeline crosses the highway to the upslope side at MP 608.

Robertson River is located at MP 610. The Robertson is similar to the Johnson and Gerstle Rivers: wide and braided, with a long, relatively flat sand and silt channel before it enters the steeper mountainous portions of the basin. In the vicinity of the Haines Pipeline crossing, the river has three main channels, extensive mud bars, and high, steep alluvial banks. The weather pattern appears to be essentially the same as for the Johnson and the Gerstle, with clouds accumulating at the head of the basin and little or no weather activity a few miles away (Photo 23). The day of this observation, June 23, the sky was mostly clear along the Haines Pipeline although a rainstorm was occurring in the upper basin. Judging by the logs and lack of growth on the bars, it appears that this river flows over its full width at a dominant discharge with some regularity in frequency.

Three or four miles east of Robertson River, the foothills recede and the terrain along the Haines Pipeline again becomes flat and locally rolling. Some local drainage exists, but channels are poorly defined (Photos 24 and 25).

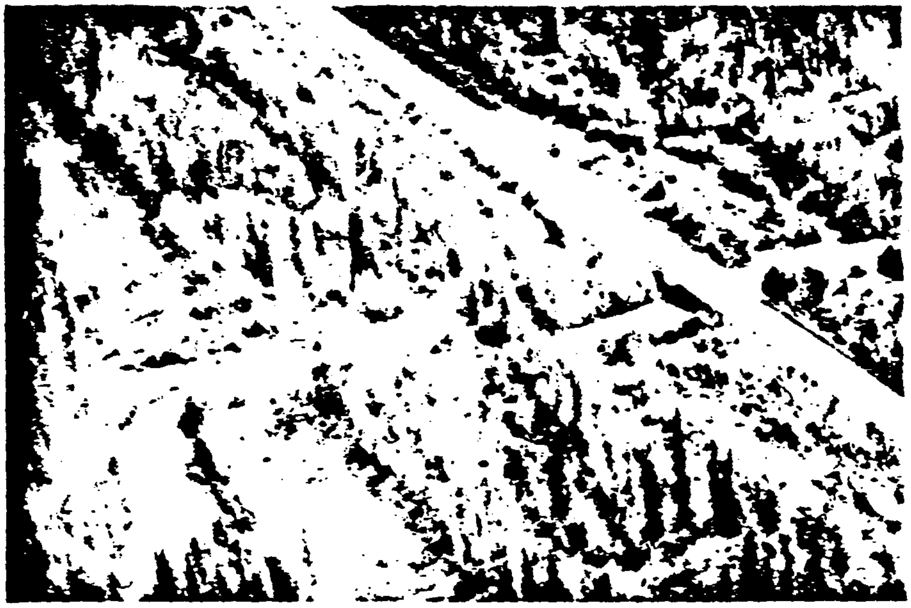

Photo 22 - Bear Creek near Dot Lake
Haines Pipeline is
downstream of Alaska Highway

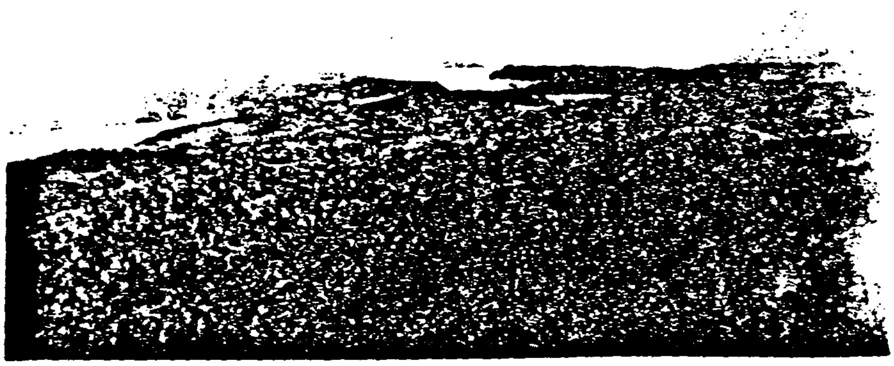

Photo 23 - Robertson River from Alaska Highway
Note rain near mountains.

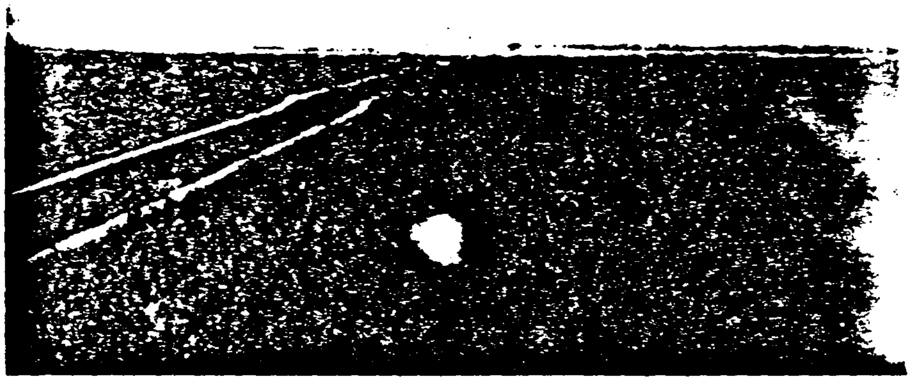

Photo 24 - Lowlands east of Robertson River
Hainies Pipeline is south of highway.

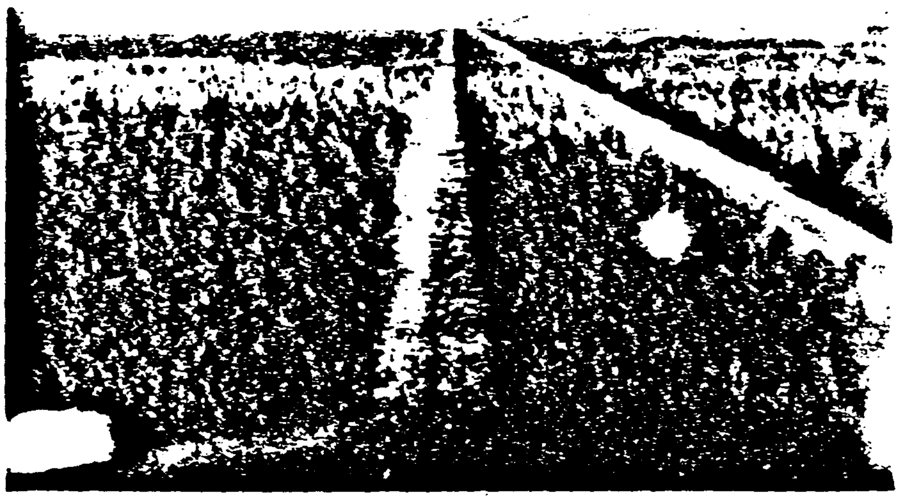

Photo 25 - Haines Pipeline R/W toward
the SE, east of Robertson River

ROBERTSON RIVER TO TOK

Between Robertson River and Sheep Creek there are no distinct drainage patterns. USGS maps, Tanacross (B-6) and (C-6), indicate two streams that were not observed. However, a wet, marshy area was noted just uphill from the highway embankment.

Sheep Creek is located at MP 615. It appears to have the potential for carrying fairly significant flows, with some possibility of scour. The bed material is quite fine and the stream gradient is relatively steep.

Cathedral Rapids Creeks (three streams) have steep upper reaches producing a large bed-load, with significant aggradation in the vicinity of the right-of-way (Photos 26 and 27). Several small streams in this area around Cathedral Rapids have essentially the same characteristics. Any line shift upslope in this area could very well result in serious scour potential, but where the right-of-way is located it appears that all streams are aggrading.

A USGS crest stage gage is installed at an unnamed creek near Highway Milepost 1369 (Photo 28). Measurements taken from the gage indicated a recent flow of approximately 50 to 60 cfs. This probably occurred during spring breakup. Observed flow at this time, June 22, was approximately 5 cfs.

A box culvert at Highway Milepost 1341 was observed to be almost completely plugged by gravel and cobbles (Photo 29). Another 6-foot box culvert at approximately Milepost 1339 had about 2 to 3 feet of clearance remaining.

This is very typical of the maintenance problems in this area created by aggrading streams.

As the pipeline approaches Yerrick Creek, the overall cross-slope is still relatively steep, although the actual foothills are approximately 1 mile to the south and the highway approximately 1 mile to the north.

Yerrick Creek is located at MP 623. Two channels exist: one main channel approximately 40 feet wide and an overflow channel approximately 20 feet wide. The day of this observation, June 23, the main channel was carrying approximately 30 to 40 cfs and the overflow channel was dry (Photos 30 and 31). The stream gradient is fairly flat at the pipeline crossing, although it appears to steepen considerably a short distance upstream. The stream carries a significant bed-load and appears to aggrade actively at the pipeline crossing.

Going east from Yerrick Creek, the pipeline crosses several fairly significant drainages approximately 1/2 to 3/4 miles upslope from the highway. The pipeline crosses the highway to the downslope side at approximately MP 626.

From the highway crossing to approximately 5 miles west of Tanacross, the foothills are adjacent to the highway, with the pipeline downslope from the highway. Several small, well defined channels exist in this area. Channels pass through highway structures before reaching the pipeline. Most of these channels terminate in a large, marshy area immediately downslope (north) from the pipeline. This marshy area may present a potential ground water seepage problem during construction.

From approximately 5 miles west of Tanacross, the foothills recede and the drainage pattern becomes very flat and poorly defined (Photos 32 and 33). Although there are no defined channels, significant amounts of ponded water exist along the pipeline. Some of this ponding is the result of material sources (probably from the original Haines Pipeline construction) which have filled from ground water seepage. No significant drainage channels exist between this point and Tok.

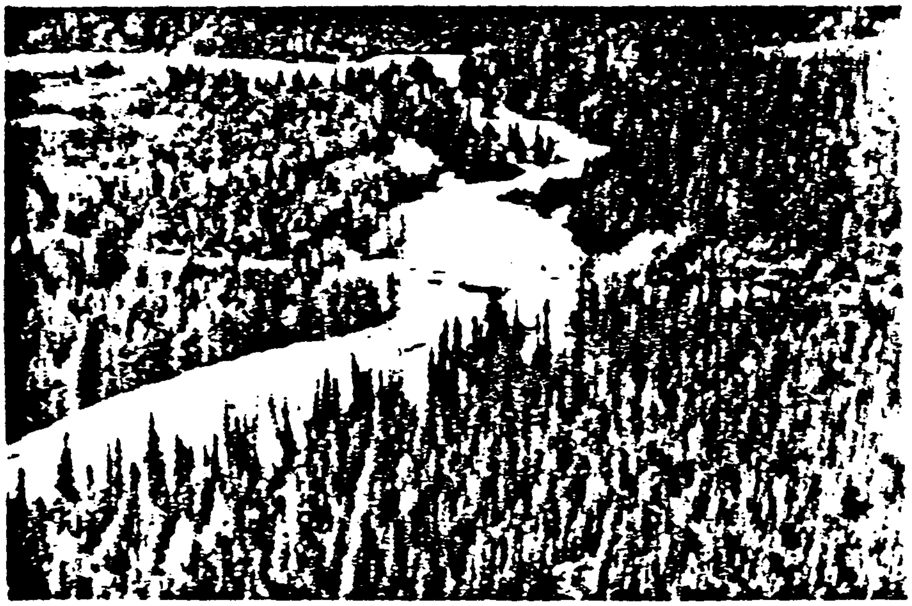

Photo 26 - Cathedral Rapids Creek #1
(looking downstream).

Photo 27 - Cathedral Rapids Creek #1
looking upstream from highway
bridge. Note cobbles in channel.

Photo 28 - USGS crest stage gage installed at an unnamed creek near HWY Milepost 1369.

Photo 29 - Standard box culvert at MP 1341 near Sheep Creek.

Photo 30 - Yerrick Creek (looking upstream)

Photo 31 - Yerrick Creek at Haines Pipeline Crossing

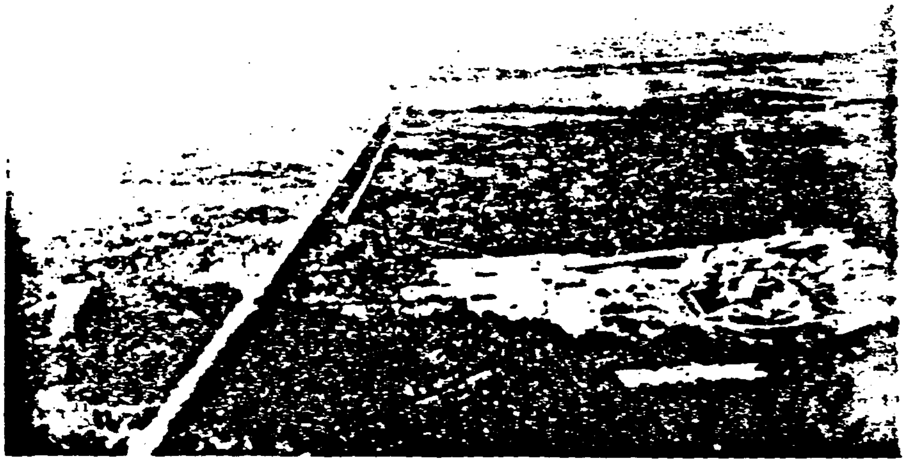

Photo 32 - Lowlands 5 miles west of
Haines Pipeline Tok Junction
near Pump Station.

Photo 33 - Lowland area west of
Tok Junction. Note ponded water

TOK TO TANANA RIVER

Immediately east of Tok, several borrow pits and waste disposal areas exist either on or adjacent to the right-of-way. These may cause local drainage problems during construction.

The 11-mile stretch from Tok Junction to the Tanana River is characterized by flatlands with no distinct drainage channels. Vegetation is typically spruce and birch. The only channel is the Tok River (Photo 34).

<u>Tok River</u> has a drainage area of about 900 square miles, but has a relatively small 50-foot wide channel. This river has entirely different stream characteristics than the large streams which head in the Alaska Range (Photo 35). The Tok is more a meandering river, with steep dirt cut banks and the bottom mostly armored with coarse sand and gravel.

<u>Tanana River</u> is a somewhat braided, meandering river draining an area of approximately 6800 square miles. The river bottom is mostly silt with some sand, and steep bluff sides at the bridge. Bedrock is present at the east bluff. Upstream from the bridge, the river widens considerably. From a standpoint of river hydraulics, this crossing will probably present the most difficulty on this portion of the route.

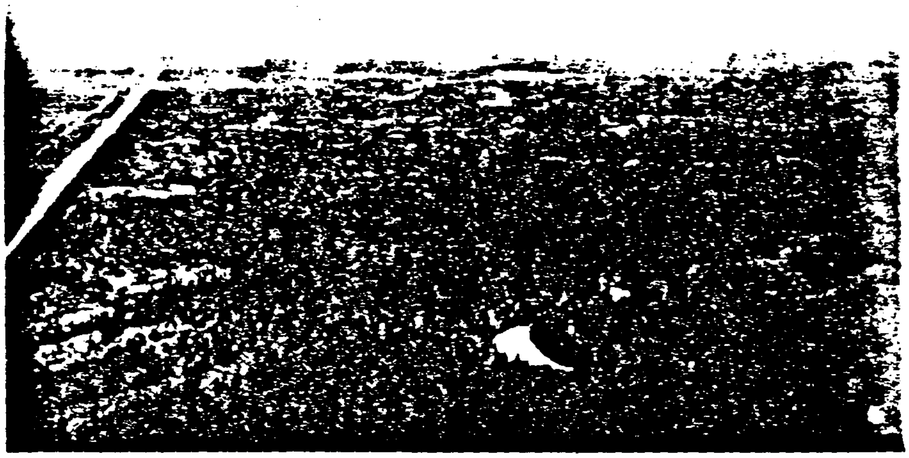

Photo 34 - East toward Tanana River
from Tok River

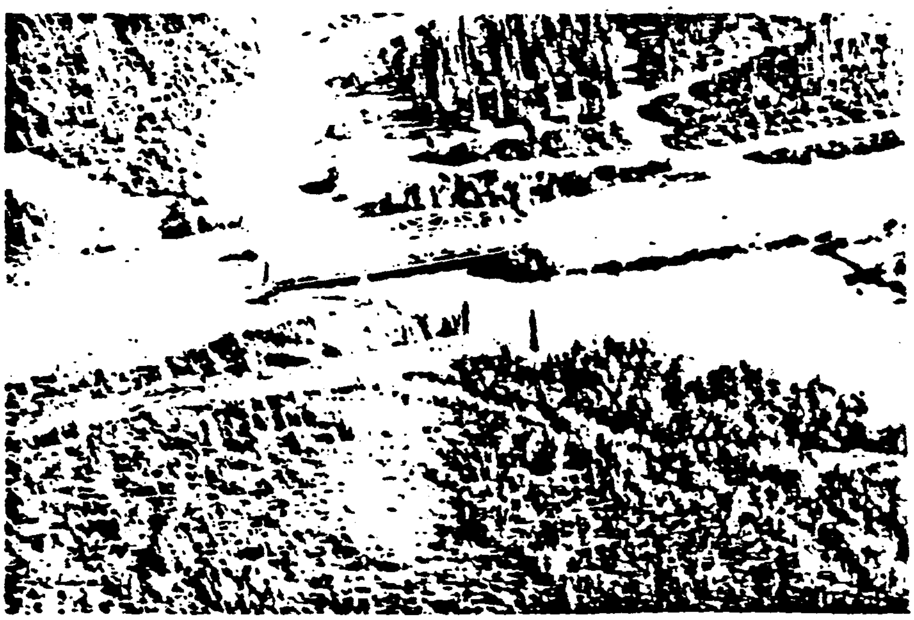

Photo 35 - Tok River

TANANA RIVER TO CANADIAN BORDER

East of the Tanana River, the road traverses the base of the foothills (Photo 36). The Haines Pipeline is upslope. These are local, south-facing rolling hills (Photo 37), not associated with a mountain range as was the case with all the foothills between Delta Junction and Tok. These slopes appear to be drier, with less surface runoff. A fairly significant amount of local ponding still exists, but not to the extent of that in the Alaska Range foothills. Except for the two major rivers, no significant drainage channels exist between Tok and the highway crossing at approximately MP 668 where the Haines Pipeline crosses back to the downslope (south) side. It crosses to the upslope side at approximately MP 672. A few more defined drainage channels are present in this reach, but they are not significant. Most of the streams shown on the maps were not observed.

The Haines Pipeline crosses back to the downslope side at approximately MP 673, and runs more or less parallel to the Tanana River. A major slope failure exists on an abandoned section of the Alaska Highway in this reach at approximately MP 674 (Photos 38 and 39). The failure is the result of severe headward erosion in a small stream channel which runs into the Tanana River. The abandoned highway embankment is downslope from the Haines Pipeline right-of-way. It appears that the headward erosion may still have the potential for reaching the right-of-way (Photo 40). The significance of this particular site is the potential for this type of occurrence throughout large portions of this region. R & M has documented a number of such cases, and their importance from the standpoint of pipeline integrity should not be underestimated.

The Haines Pipeline crosses again to the upslope side at approximately MP 675. A few defined channels exist here, but it is mostly rolling terrain with local ponding. One deep canyon is located at approximately MP 676, where the Haines Pipeline makes an aerial crossing over Bitters Creek (Photo 41). Some of the longitudinal slopes in this rolling terrain are fairly steep and several hundred feet in length. The potential exists here for severe longitudinal drainage problems and subsequent erosion during construction (Photo 42). Drainage control during the construction phases and a good post-construction revegetation program will be essential. A short downslope segment exists between approximately MP 684 and 685. Since this segment runs fairly close to the Tanana River, the long term possibility of channel migration on the Tanana should be at least considered.

Beaver Creek is located at MP 687. This stream drains a significant area. It is a meandering stream, with the Haines Pipeline crossing just upstream from its confluence with the Tanana. The flow is significant but velocities appear to be quite low (Photo 43).

Just east of Beaver Creek, a large materials site is being worked, probably by the Department of Highways, just at the edge of the right-of-way. This could cause local drainage problems during construction.

The Haines Pipeline crosses to the downslope side of the highway at approximately MP 693.5 Through this reach, the pipeline is between the highway and a series of pothole lakes. There is probably a very high potential for ground water seepage into the open trench during construction.

Gardiner Creek drains a fairly large area which is somewhat difficult to define on the topographic maps due to the low relief of its boundaries. The boundaries were verified during the field reconnaissance, and the area is now adequately defined. This site has a history of periodic icing problems, according to Department of Highways maintenance personnel. This should be considered during the design phase.

Scottie Creek is similar to Gardiner Creek in that it drains a fairly large area, but much of this area is flat lowlands. A large amount of storage is available. Both Scottie Creek and Gardiner Creek are slow and meandering at the highway crossings (Photos 44 and 45).

There are no other significant drainage features between Scottie Creek and the Canadian Border.

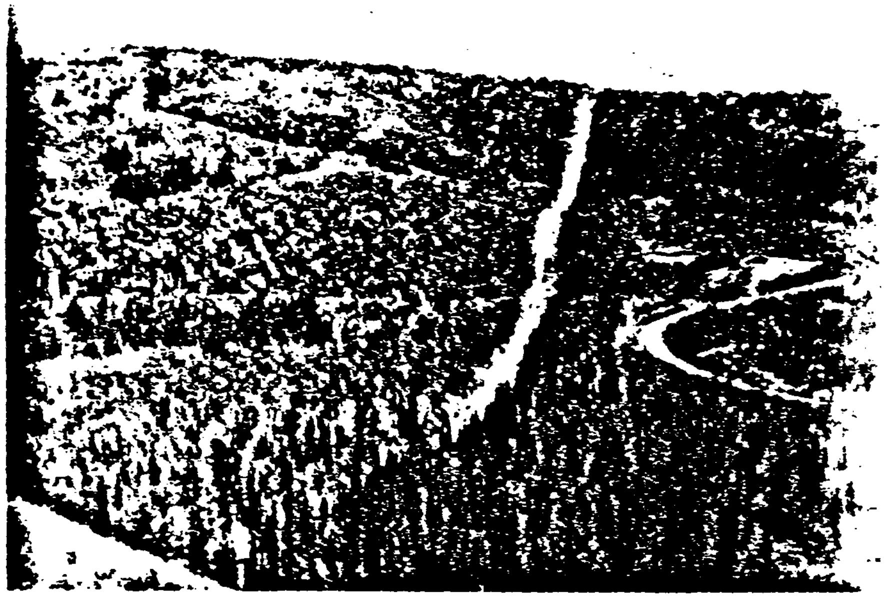

Photo 36 - East of Tanana River near Midway Lake. Typical drainage area with no distinct drainage channel.

Photo 37 - Same drainage area as Photo 36

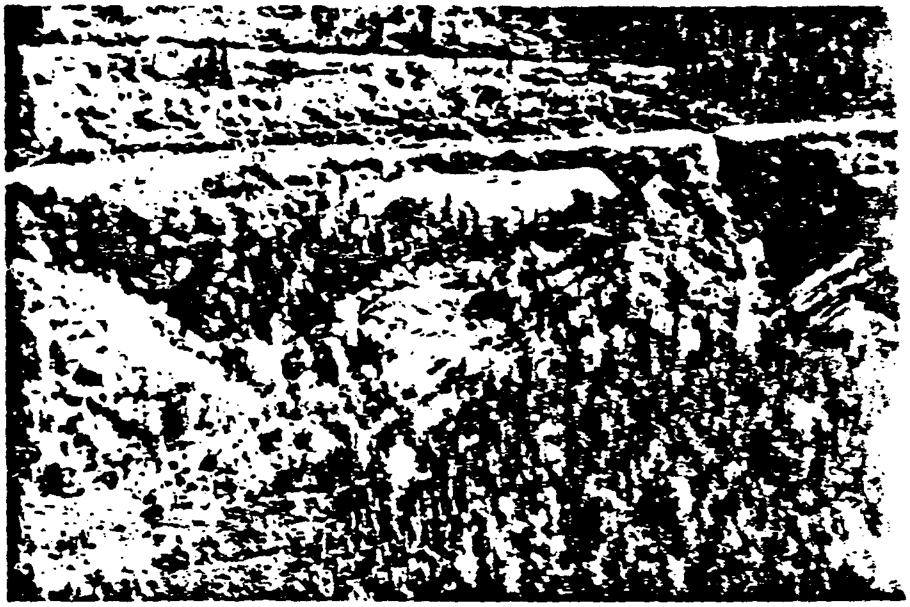

Photo 38 - Headward erosion on abandoned embankment of Alaska Hwy. Near Riverside Lodge

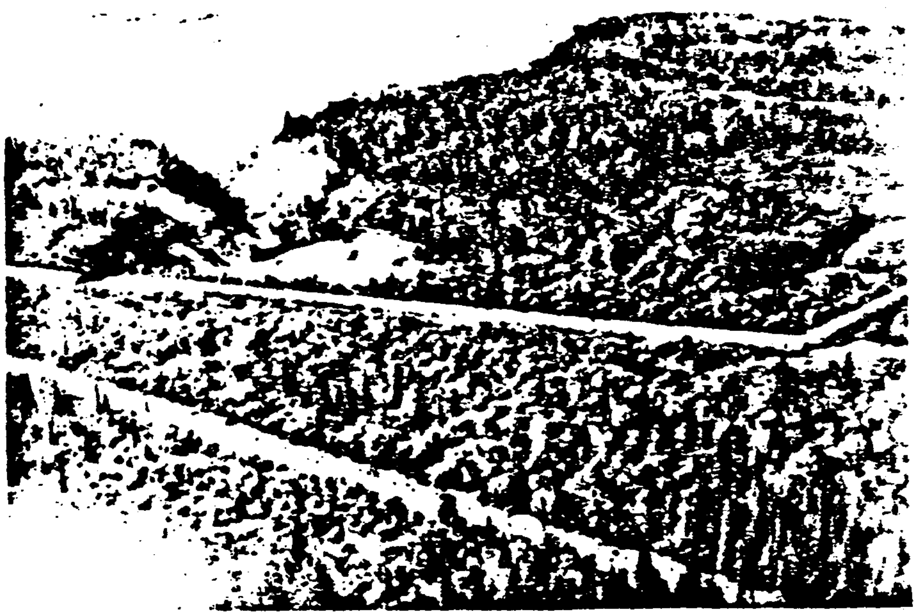

Photo 39 - Same as Photo 38

Photo 40 - Headward erosion near Riverside Lodge (photos 38, 39)

Photo 41 - Aerial crossing of Haines Pipeline over Bitters Creek

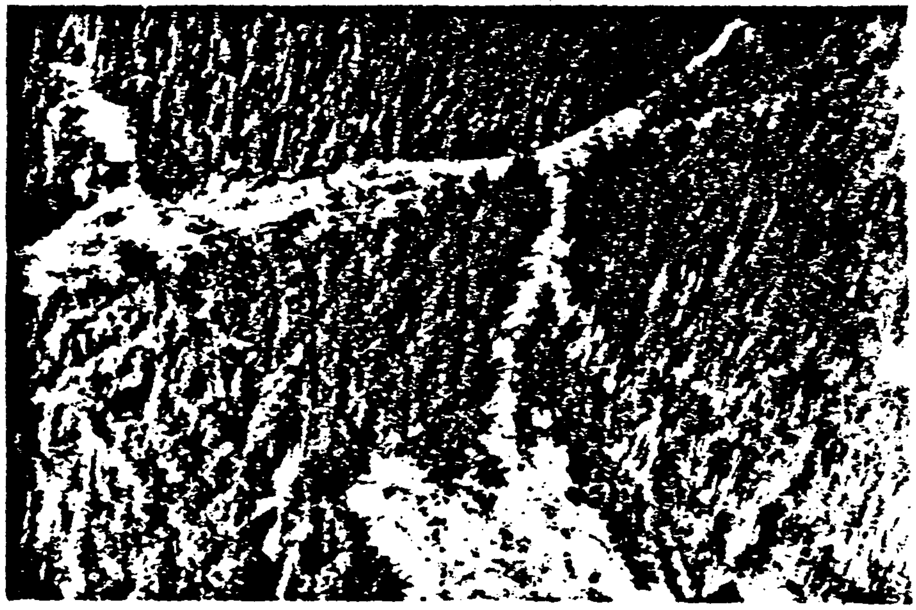

Photo 42 - Typical poorly - defined area east of Bitters Creek. Note failure downslope.

Photo 43 - Beaver Creek

Photo 44 - Gardiner Creek

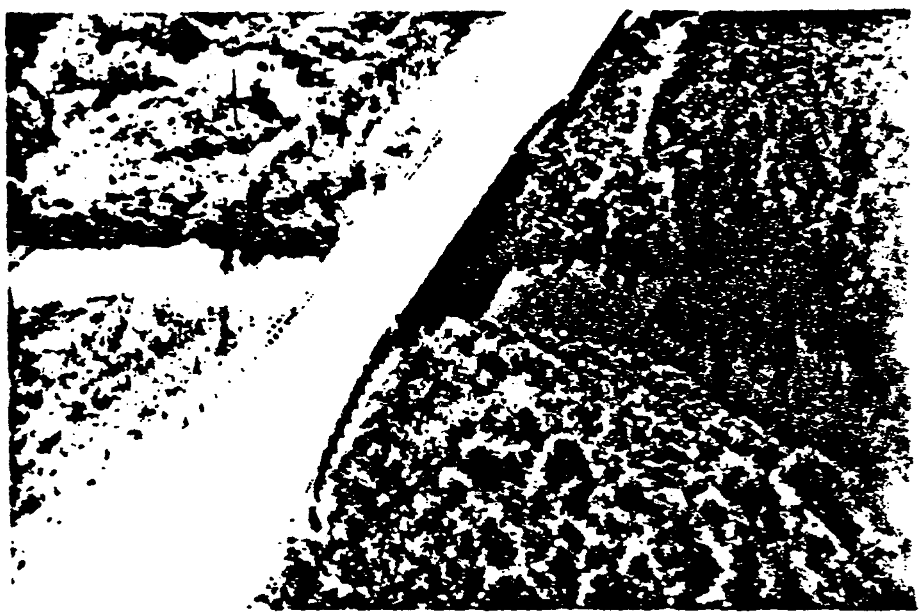

Photo 45 - Scottie Creek

conditions. It appears that a large amount of ground water seepage occurs on those steep slopes most of the time, and a buried frozen pipe will very likely create a "frost dam" which will bring the seepage to the surface as aufeis. Access along the right-of-way will be extremely difficult under such conditions. Additionally, serious erosion could result during spring breakup if runoff is forced out of the natural channels by ice accumulation.

Cathedral Rapids Area: The streams in this region all exhibit the same characteristics: extremely high bed-load transport and active aggradation in the vicinity of the right-of-way. While no danger to pipeline integrity exists from the standpoint of stream scour, maintenance of access will be a major problem. If maintenance is not performed, the characteristic habit of these streams is to leave their channels and flow overland until another channel is formed. This could result in erosion and loss of workpad, with subsequent downslope siltation problems.

Major Crossings: All five major rivers on the route (the Gerstle, Johnson, Robertson, Tok and Tanana) have the potential for large flows, channel migration and significant scour. For this reason the major rivers will present problems from the standpoint of both design and construction. It will be essential to obtain sufficient field data to perform computations for high water elevations and scour potential.