TAPS OWNERS COMMENTS ON SUPPLEMENT TO APPLICATION FOR RIGHT-OF-WAY GRANT FOR THE ALASKA SEGMENT ALASKA NATURAL GAS TRANSPORTATION SYSTEM

July 25, 1980
Washington, D.C.

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July 25, 1980

The Honorable Guy R. Martin
Assistant Secretary
Land and Water Resources
Department of the Interior
Room 6616
Washington, D.C. 20240

Dear Mr. Martin:

The owners of the Trans-Alaska Pipeline System ("TAPS") were requested by Mr. William M. Toskey's letter of July 3, 1980 to submit by July 25, 1980 our comments on the Northwest Alaskan Pipeline Company ("NWA") supplement to its right-of-way application. We have conducted as thorough a review as possible during this brief period and our comments are contained in the attached document, "TAPS Owners Technical Comments On Supplement To Application For Right-Of-Way Grant For The Alaska Segment, Alaskan Natural Gas Transportation System."

Our comments are presented in seven sections; Section I is an introduction which briefly reviews the background and events leading to preparation of this document. Section II summarizes the major concerns associated with the alignment proposed by NWA. Section III discusses NWA's response to Enclosure B, "Assumptions and Conclusions," of your June 13, 1979 letter to Mr. Edwin Kuhn. NWA's response to Enclosure C, "Working Group Questions/Concerns," of that same letter is discussed in Section IV. Section V addresses Exhibit Z-9 of the July 1, 1980 NWA filing with the Federal Energy Regulatory Commission. Section VI comments on the civil construction -- the typical construction zone cross-sections and their application -- proposed by NWA. Finally, Section VII is a mile-by-mile analysis of the NWA proposed project. Our concerns are caused by the proximity of the proposed NWA alignment to TAPS. Were the alignment nowhere near TAPS, and no adverse effects were possible, deficiencies in the right-of-way application would not concern us.

The adequacy of the NWA right-of-way application must be judged against the general requirements of Section 28 of the Mineral Leasing Act of 1920, as amended, 30 U.S.C. §185. Some of those more general requirements were translated into the specific technical requirements contained in your June 13, 1979 letter to Mr. Edwin Kuhn.

Enclosure A of the June 13 letter is a memorandum written by the Chairman of the Working Group reviewing the NWA submission. This memorandum indicates that, "With the limited technical data available from [NWA], this type of evaluation was possible only because of the technical expertise of the Working Group members who are, by and large, experienced in the Arctic and on the TAPS line." Thus, we feel that the recommendations of the Working Group members should be given great weight in making your decision on the NWA right-of-way application. Of particular concern should be the report of the geotechnical group, which concluded:

> [T]he geotechnical uncertainties in predicting the consequences and attendant risks of co-location are so large that the only prudent course is complete separation of the two pipelines. We recognize that isolated reaches exist where co-existence may be feasible, however, we feel that these are the exception rather than the rule and that NWA should direct their exploration and design efforts toward an independent alignment. These conclusions are based solely on geotechnical issues and are not influenced by the substantial legal questions still to be resolved by the parties.

Enclosure B of your June 13, 1979 letter contained "a number of important working group assumptions and conclusions" that needed to be "ultimately validated by additional information and analysis." As Associate Solicitor John Leshy indicated in his October 30, 1979 memorandum, "the final determination [of compatiblity or incompatiblity] cannot be made until sufficient data confirming working assumptions and hypotheses [contained in the June 13, 1979 letter] have been obtained." These assumptions and conclusions have not been confirmed or validated in NWA's recent supplement.

The NWA "Comments on Basic Assumptions and Conclusions" in Volume V of the NWA "Supplement to Application for Right-of-way Grant" are largely a paraphrase of the assumptions and conclusions coupled with NWA's concurrence. For example, the Working Group summarized assumption number 4 as follows: "[e]nvironmental and technical standards for the NWA project will be compatible with the standards for TAPS." NWA's response is "Concur. The standards set for TAPS are of a high order, and NWA is in agreement with this concept." Likewise, assumption No. 2 states: "Outstanding environmental and technical concerns will be resolved prior to construction. . . ." The NWA response reads in part "Concur. Substantial progress has been made in resolving environmental and technical concerns to the point that there is a reasonable basis for confidence that there are no environmental or technical concerns that cannot be resolved fully before construction commences." These responses by NWA are merely illustrative. In order to validate the Working Group's Assumptions and Conclusions, NWA must do more than merely concur in and, in some cases, restate the assumption or conclusion. NWA's assurances simply do not eliminate the need for confirmation of the listed assumptions and conclusions.

Even the few assurances given by NWA in its application are not consistently applied. For example, according to Exhibit Z-9.1, Section 1.1 Pipeline Route Selection Criteria and Route Description, NWA intends to "locate the pipeline downslope of TAPS or the haul road." Yet, this would be violated by the alignment presented by NWA in at least 61 locations. NWA also says that the number of crossings of TAPS and other pipelines will be minimized. Presently, 23 crossings of TAPS are shown on NWA alignment sheets. Thirteen of these crossings, for geotechnical reasons, are unacceptably hazardous to TAPS and probably to ANGTS.

Enclosure C of the June 13, 1979 letter listed 12 "questions/concerns." Again, as was indicated in your letter, these "specific technical issues [raised in the questions/concerns] .... require resolution prior to a final right-of-way issuance .... [and] must be answered prior to a final decision ...." NWA has not answered or resolved the 12 "questions/concerns." Instead, NWA redefines the question and indicates what sort of data will be needed to answer it. In some instances, NWA indicates that the question will be answered in the future. What NWA has done might be a useful first step in attempting to formulate an answer, but cannot be confused with an answer.

The technical issues presented in the June 13, 1979 letter must be resolved before the Department of the Interior can determine whether the NWA proposal satisfies not only Section 28(p) of the Mineral Leasing Act, but also whether NWA satisfies Section 28(j) of that Act. Section 28(j) provides that the Secretary may grant a right-of-way only when he is satisfied that the applicant has the technical capability to construct, operate, maintain, and terminate the project for which the right-of-way is requested. At this point there has been no demonstration of what the technical requirements for ANGTS may be and, thus, it is impossible to determine whether NWA, or any other entity, has the technical capability to construct the project as proposed.

Section 28(p) provides that a right-of-way in common shall only be required "to the extent practical" and "for compatible uses." The data submitted indicates that the project proposed by NWA is not compatible with TAPS and it would not be practical to utilize a right-of-way in common with TAPS.

Use of a right-of-way in common should not be confused with the use of existing corridors. NWA has repeatedly cited portions of the President's report favoring the use of existing corridors. As Associate Solicitor John Leshey pointed out in his October 30, 1979 memorandum to you, "Congress divorced the establishment of utility corridors from the joint use provision." The use of common corridors is referred to in Section 28(s) and the use of rights-of-way in common in Section 28(p) of the Mineral Leasing Act. A common corridor with TAPS could be utilized by NWA without use of a joint right-of-way or a right-of-way in common.

Section 28(g) of the Mineral Leasing Act requires that the Secretary impose requirements for the operation of the pipeline or related facilities that will protect the safety of workers and the public from sudden rupture and slow degradation of the pipeline. In this instance, there are two pipelines and two sets of related facilities that the Secretary is obligated to protect from sudden rupture and slow degradation -- TAPS and ANGTS. The use of the TAPS work pad as proposed by NWA will not protect TAPS against suddden rupture or slow degradation.

Furthermore, under Section 28(h)(2) of the Mineral Leasing Act, the Secretary is required to impose requirements designed to control or prevent damage to the environment, to public or private property and hazards to public health and safety. It has not been shown that this statutory standard will be met if a right-of-way were to be issued as proposed by NWA.

There are, of course, other problems presented by NWA's proposal. These include the TAPS owners' ownership of the work-pad, the exclusive right of the TAPS owners to use the portion of the Yukon River bridge that NWA proposes to use, and the manner in which NWA and its owners would indemnify and hold harmless the TAPS owners for NWA's activities in the vicinity of the TAPS right-of-way.

The NWA proposal is unique. The presence of TAPS even in the same general vicinity -- not to mention an alignment proximate to TAPS in many areas -- would merely heighten the need for deliberate decision-making by the Department of the Interior in deciding the location of NWA's right-of-way. At the time of execution of the Agreement and Grant of Right-of-Way for TAPS on January 24, 1974, the alignment for the pipeline had been carefully fixed, all major design criteria had been developed, and all basic design and construction planning documentation had been submitted to the Department of the Interior. In the case of NWA's proposed natural gas pipeline an alignment equally definitive must be established and the same degree of design and construction planning completed because now the safety and integrity of TAPS also must be considered.

We trust that the attached comments as well as all of the earlier comments we have submitted will assist you in your review of NWA's application.

Very truly yours,

J. F. McPhail
Manager
ANGTS TASK FORCE

JFM:rr

Enclosure

cc: See Distribution List Attached

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SECTION I

Introduction

The Owners of the Trans Alaska Pipeline System (TAPS) have analyzed the Supplement to Application for Right-of-Way Grant filed with the Department of the Interior (DOI) on July 1, 1980, by Alaskan Northwest Natural Gas Transportation Company (NWA). These technical comments have been prepared to assist the DOI in determining whether sufficient data are available to support the grant of the right-of-way as proposed or whether the grant should be deferred either until essential missing information is supplied or until the proposal is modified to avoid unacceptable consequences.

The primary concern of the TAPS Owners is that the proximity of the gas pipeline during its construction and operation will adversely affect TAPS. The need for adequate separation between the two pipeline systems has been expressed by the TAPS Owners as early as December 1976. Since that time, as more studies have been made and more information developed, that need has been confirmed. The TAPS Owners have made their views known to the DOI and other appropriate governmental agencies, as well as to NWA, through the submission of comprehensive analyses and extensive discussions over the past three years.

As the DOI well knows, TAPS is a unique project. The successful construction and operation of a hot oil pipeline in the arctic environment, with its permafrost, mountains, rivers and floodplains is an achievement in which the Owners take great pride. The resultant benefit to the nation dictates that every precaution be taken to prevent damage to TAPS and interruption of its operation.

The validity of the concerns expressed by the TAPS Owners has been recognized by the governmental working group established by Assistant Secretary Martin to assess the technical aspects of the proposed gas pipeline. The report of the Chairman of the working group, whose members "are, by-and-large, experienced in the Arctic and the TAPS line," was attached to Assistant Secretary Martin's letter of June 13, 1979, which set forth the requirements to be satisfied by NWA before a right-of-way could be granted.

The technical comments which follow were prepared by the most experienced and talented professional experts available to the TAPS Owners. While they point out that the DOI requirements have not yet been met, the information and analyses contained in these comments should prove valuable in designing and constructing a safe and efficient gas pipeline.

SECTION II

Summary Of Taps Owners Major Concerns Regarding TAPS/ANGTS Compatibility

Parallel construction on steep slopes will subject TAPS to the high potential of damage by construction activities.

Parallel construction on steep slopes will subject the aboveground and belowground portions of TAPS to the hazard of being struck or exposed to high wheel loads by construction equipment. TAPS aboveground zig-zag configuration increases the risk. Control on grades which are dry can become difficult at about a four percent slope. The problem is intensified in the spring, when snow softens the pad and provides uncertain footing for equipment on steep slopes; but it is most severe during winter and early spring months, when snow and icing reduce traction on these slopes.

This hazard is not limited to vehicles. Loose boulders and joints of pipe can be propelled downslope by construction activities. These are fully as destructive as heavy construction equipment.

The potential for damage to TAPS by NWA construction activities cannot be overstressed. Every precaution must be taken to protect TAPS from damage and disruption of flow. Due to lack of response to this concern by NWA, the following protection requirements for areas where NWA is parallel and in close proximity to TAPS are proposed:

- No construction activities will be allowed within a zone described as 15 feet clear horizontal distance from any above or belowground portion of TAPS, including related facilities. The only exceptions to this will be at designated gas pipeline crossings of TAPS where a detailed design and construction procedure must be submitted for review and subsequent approval by the TAPS Owners. No encroachment of the 15-foot safety zone will be allowed without prior submittal, and TAPS Owners approval, of design and construction procedures. A construction schedule will also be required at pipeline crossings to allow quality control and appropriate monitoring by the TAPS Owners during construction.

- No vehicular traffic will be allowed over the belowground portions of TAPS except at designated belowground crossings. New crossings of the belowground portions of TAPS will be allowed only where the TAPS Owners can be shown that a crossing can be designed and implemented which ensures the integrity of TAPS. Such crossings shall be kept to a minimum number. Construction-related traffic under the aboveground portion of TAPS will be allowed only where an established crossing exists and only after a TAPS-approved barrier, which protects the oil pipeline and vertical support members (VSM) at these crossings, is installed.

- A continuous barrier will be required between TAPS and its related facilities and NWA construction activities. The barrier shall be constructed in advance of workpad restoration, repair, and extension activities and shall be constructed in such a way as to preclude damage to the insulated and structural work pad. The barrier shall not jeopardize the integrity of TAPS, i.e., channelization of surface water flow or concentration of aufeis.

- Where longitudinal workpad slopes are less than 4 percent, the barrier shall be designed to prevent construction equipment in the immediate area from violating the 15-foot safety zone discussed previously. The momentum of runaway equipment should not be a problem in these areas, but vehicle extensions such as booms, counterweights, buckets, etc. shall be considered when designing barriers.

  Where longitudinal work pad slopes equal or exceed 4 percent, the barrier must be capable of stopping the heaviest piece of loaded construction equipment and its loads and extensions while it is moving in a runaway condition on the specific slope. The barrier must be designed to either stop or deflect the runaway equipment without encroaching more than 5 feet into the safety zone. Impact force should be assumed to be such that the unbraked vehicle is accelerating down the slope from an initial speed at the crest of 20 miles per hour at the crest. The barrier should extend past the toe of the slope a distance calculated to slow the unbraked design vehicle to a speed of 10 miles per hour. Barrier design must be approved by the TAPS Owners and barrier construction must be monitored by the TAPS Owners.

The barrier shall be removed as the last sequence of construction activity within a given segment and, in all cases, prior to commission of the gas pipeline.

The effects of production blasting along both the aboveground and belowground segments of TAPS could have a substantial effect on the integrity of TAPS.

Ground motion and flyrock from blasting proximate to the aboveground and belowground segments of TAPS pose a substantial threat to the integrity of TAPS. Blasting could also affect the stability of the now thawed material beneath the TAPS workpad. The result could compound the problem of trafficability and reduce the capacity of the pad to support heavy construction traffic.

The present NWA criteria do not assure the safety of TAPS. These criteria were based on non-production type testing in 1977 near Fairbanks. These tests were not done in soil types representative of the entire line and, therefore, are inadequate and inapplicable to the majority of the proposed route. In fact, the effects of blasting proximate to TAPS aboveground and belowground segments in various soil types, frozen and unfrozen, have not as yet been considered by NWA. These effects are very complex and until the proper testing is completed and acceptable criteria developed, large safety margins for blasting proximate to TAPS must be required.

Alyeska has offered recommendations for blasting criteria for different distances from the existing oil pipeline. These criteria are, however, different from those proposed by NWA. More recently, Alyeska has recommended that a detailed blasting analysis and site supervision be required for NWA blasting from 0 to 60 feet from TAPS.

NWA should be required to submit to TAPS a blasting plan which would include:

1. Maximum charge/delay
2. Type of explosive to be used
3. Total charge
4. Total holes/blast
5. Time schedule
6. Depth of excavation
7. Probable soil type

Although TAPS agrees that the problems associated with site-specific blasting can be solved with a proper testing and monitoring program, production blasting along long segments of TAPS is more difficult to control and, therefore, is of much greater concern. TAPS does not agree at this time that production blasting can be conducted safely by NWA in close proximity to TAPS. Blasting accidents, resulting in damage to TAPS from lack of quality control, overloading of blast holes, or incomplete placement of flyrock containment devices, constitute a real hazard to TAPS which must be addressed by NWA in its application.

In order to insure the integrity of TAPS during construction blasting, a series of detailed fail-safe procedures must be developed and implemented on a foot-by-foot basis. The effect of applying these procedures may protect the integrity of TAPS but will also slow production blasting progress below rates which could be achieved when blasting is conducted from a remote separate workpad.

Based on TAPS construction experience, it is much easier to maintain ditch production by slightly over-shooting rather than by risking under-shooting and having to redrill and reshoot. This tendency to over-shoot must be controlled during gas pipeline construction. This tendency likely will be greater for NWA than it was for TAPS, because NWA has the additional time constraint of shoulder month construction to avoid ditch stability problems.

Gas pipeline crossings of TAPS are areas of high potential for damage during construction operations.

Gas pipeline crossings must be designed and constructed to minimize potential damage to TAPS during construction and operation. All crossings must be designed to eliminate any adverse effects during operation, such as adverse changes to the thermal regime.

Specifically, NWA construction equipment may damage TAPS by breaking the cathodic protection zinc ribbon, damaging pipe coating, denting, puncturing or overstressing the pipe. Construction equipment may damage the aboveground VSM. NWA excavations may remove support from VSM either as a result of excavation or thermal degradation of the ditch wall during construction and prior to startup.

To reduce the risk of these types of damage, the number of crossings should be held to an absolute minimum. Fewer crossings will benefit NWA by reducing the risk of TAPS damage and will provide for longer spreads where constructon cadence can be maintained. Accordingly, the TAPS owners are proposing a reduction in the number of gas pipeline crossings of TAPS. By further detailed study, NWA should find that an even smaller number of crossings are possible which would reduce the hazard to TAPS.

All crossings of TAPS by NWA will require a site-specific work plan, including a protective barrier design, to be reviewed and agreed to by Alyeska prior to commencement of work.

The greatest possibility for adverse thermal effects is the gas pipeline construction disturbance.

Disturbance of the thermal regime during gas pipeline construction may cause slope instability, liquefaction, and workpad trafficability problems. The trench will be opened in ice-rich soils avoided by TAPS through the use of an elevated construction mode. Construction cannot occur in all areas where trench stability problems exist during the shoulder months and even in the shoulder months, thermal erosion may occur quickly when large amounts of surface water are available. Further, several years will elapse between the time the first pipe is buried and the time the entire gas pipeline becomes operational. During this time, the ameliorative effects of gas pipeline cooling will not be available, and significant thaw may develop around the gas pipeline. Frequent maintenance may be required near the gas pipeline to prevent erosion, especially where ditch spoil is used as backfill. Even after pipeline startup, permafrost degradation may continue to either side of the pipeline if the average gas temperature is just below 32°F. NWA has discussed some of these problems, but an adequate design has not yet been developed.

Trench stability field tests are proposed for 1980 and 1981. These tests will investigate several different methods of maintaining trench stability. Until they are completed, the ability to effectively install buried pipe in ice rich permafrost is questionable.

NWA has proposed to place slab insulation across the ditch and above the pipe to prevent permafrost degradation during the dormant period. Directionally, this may be an acceptable solution, but more analysis is needed to see if it is effective and practical. For example, insulation which is wider than normal may be needed. On the North Slope, the insulation should extend across the ditch and under the workpad extension and be tied into the existing insulated pad or haul road. Additionally, the possibility of groundwater flow through the ditch backfill should be considered by NWA as this condition may make the slab insulation ineffective.

The freeze bulb associated with a chilled gas pipeline can be expected to block groundwater flow, creating areas of saturated soil and aufeis which will result in problems with slope stability, liquefaction, drainage, and trafficability.

The freeze bulb associated with a chilled gas pipeline can be expected to block groundwater flow, creating an area of saturated soil on the uphill side of the gas pipeline. Any excess groundwater can be expected to flow over the freeze bulb creating frost boils, when the surficial layer is frozen and/or aufeis, when the air temperatures are below freezing.

When the gas pipeline is on the downhill side of the workpad the underlying soils could become saturated, resulting in problems with slope stability, drainage, and trafficability.

If the gas pipeline is located on the uphill side of the workpad, the freeze bulb may divert underground flow to the surface causing aufeis growth on the workpad during periods of freezing weather. The aufeis growth may create problems with structural integrity of aboveground portions of TAPS, drainage patterns, and trafficability.

A proximate location to TAPS may have a direct adverse effect on the gas pipeline. Over much of its route, the gas pipeline will be buried in soil which was frozen when TAPS construction began. However, thaw has now occurred beneath uninsulated workpad and around the buried oil pipeline. The freeze bulb generated by the gas pipeline will extend into these newly thawed areas. Consequently, the potential for frost heave may be increased by additional water being available at the growing freeze bulb.

Before the gas pipeline can be permitted to cross TAPS or to be located relatively close to TAPS in special design areas, such as the Atigun Pass, the adverse effects of direct thermal interaction between the two pipelines must be satisfactorily resolved.

Damage to the TAPS insulated workpad north of the Brooks Range could compromise the integrity of the adfreeze vertical support members (VSM) and hinder maintenance operations by reducing trafficability.

North of the Brooks Range, in cold permafrost, an insulated workpad was designed and constructed as an integral part of the TAPS aboveground design. The insulated pad limits the active layer depth near the adfreeze VSM, and thus allows the use of shorter VSM embedment lengths.

The insulation thickness was chosen to maintain the thaw depth above the bottom of the insulation during TAPS construction. After construction and away from the VSM, the thaw depth was allowed to increase. The thaw could be below the insulation but had to remain above the bottom of the naturally occurring preconstruction active layer. The increase was allowed because of the anticipated insulation damage caused by heavy construction.

Although the insulated workpad is presently capable of supporting light traffic for TAPS monitoring and maintenance purposes, the adequacy of the pad to support additional heavy construction traffic is highly questionable. The construction of a second pipeline was not considered in the workpad design, and if the expected thaw has occurred, the reduced support for the insulation could result in extensive damage under heavy wheel loads. Even if the soil is still frozen, the layer of gravel above the insulation may have been reduced by maintenance grading and now be too thin to adequately protect the insulation. There are already known areas where the traffic lane of the workpad has deteriorated.

The thermal disturbance resulting from further damage to the insulation could compromise the integrity of the VSM by increasing the active layer near the VSM or by causing a general warming of the permafrost. Either could reduce the VSM load-carrying capacity. The length of pipeline affected will be dependent on the amount of insulation damage, soil properties, and local thermal conditions. It is logical to assume, however, that the area affected by new construction traffic could involve a considerable length and that the damage would not be limited to isolated occurrences.

Adverse impact on the VSM may be limited by the 15-foot safety zone and protective barrier. However, trafficability of the workpad could be severely reduced, and this would impair TAPS maintenance operations. TAPS must be assured of continuous access for maintenance, especially due to the potential risks posed by construction of the gas pipeline.

A comprehensive field program is required before the insulated workpad can be used by NWA to construct the gas pipeline. The field program must confirm that the soil is still frozen below the insulation and that the gravel overlay is adequate to protect the insulation. If either condition is not satisfied, NWA must either apply corrective action or construct a new and separate workpad.

NWA does plan to conduct a workpad field assessment program this summer. Unfortunately, NWA has not yet developed criteria for rehabilitation and reuse of the workpad. Draft criteria would be very useful in planning the field work and assuring that all needed data is collected.

Because of the above concerns, it may be more desirable for NWA to relocate the 53 miles of gas pipeline located adjacent to TAPS in insulated workpad areas. A relocation of the gas pipeline to the haul road or an alternate location would eliminate TAPS concerns regarding insulated workpad damage.

The gas pipeline may adversely affect the integrity of TAPS at stream crossings and in floodplain areas.

TAPS stream crossings and floodplain segments were designed to insure the integrity of the line under naturally occurring design flood conditions, bank migration, scour, aufeis and the effect of existing adjacent works. They were not designed for the effect of an adjacent parallel chilled gas pipeline.

The TAPS owners are concerned about the impact of the NWA line and construction activity on TAPS river crossings and floodplain areas. The general concerns are:

1. Scour,
2. Bank migration,
3. Water levels during open water conditions,
4. Ice and water levels during aufeis and early spring breakup conditions, and
5. Flow attack on bridge piers, guidebanks and abutments.

Reducing the length of a gas pipeline river crossing relative to that of TAPS (by means of revetments, spurs and guidebanks) or construction of workpad bridges in the vicinity of TAPS could increase scour at the TAPS crossings. This concern includes buried or elevated TAPS crossings both upstream and downstream of NWA crossings.

Bank migration at TAPS crossings is generally affected by the river behavior in the immediate vicinity, both upstream and downstream of the crossing. Natural behavior and characteristics were considered in locating the sagbends on the TAPS crossings.

The construction of access roads and bridges, material sites, and clearing of additional right-of-way by NWA could alter stream behavior to the degree that the integrity of TAPS crossings on floodplain segments are jeopardized.

In floodplain areas protected by main channel spurs, additional clearing by NWA may result in an increased probability of attack on the structures and thus increased maintenance requirements. Where TAPS is protected by overbank spurs, the clearing by NWA may require the upgrading or modification of existing structures or additional protection. In areas of minor natural overbank flow during PDF conditions, NWA's additional clearing could result in the need for extensive new overbank structures to prevent the development of flow channelization down the cleared right-of-way. If TAPS is elevated, working around and under the oil pipeline to do the necessary work will significantly increase the risks to TAPS.

A very significant problem that may be created by the gas pipeline is the generation of new or increased aufeis. The freeze bulb around the line will create an impervious barrier to subsurface flow. Insulated pipe as proposed by NWA, chiefly intended to reduce frost heave, will no doubt decrease the potential impact on TAPS. Since design criteria for the insulation were not presented, the magnitude of this decreased impact is not known. TAPS is particularly concerned about minor and unclassified crossings where the burial depths will be only four feet and 2-1/2 feet respectively. At deep buried crossings having significant subsurface winter flow, the gas pipeline probably has little or no effect. Where the gas pipeline is located downstream of either buried or elevated TAPS crossings, the design flood levels and overbank flow could be increased by aufeis development. Even an upstream location of NWA relative to TAPS would result in similar concerns.

It is extremely doubtful that NWA can develop criteria for aufeis levels. Icings vary from year to year depending, among other factors, on weather conditions. Site specific impacts of NWA are indeterminate. For example, during an extremely cold, low - snowfall winter, the water forced to the surface by the chilled gas pipeline freeze bulb would freeze almost immediately creating increased ice levels near the gas pipeline. During a milder year, this same water forced to the surface would not freeze for some distance downstream. The relative location of TAPS facilities to the NWA line would determine the impact on TAPS.

Other concerns related to icings or the development of a freeze bulb are:

1. Flow channelization over TAPS as a result of the freeze bulb or a berm-type frost heave mitigative measure.
2. "Locking" of pipeline shoes by aufeis in aboveground pipeline areas thus preventing TAPS line from responding to seismic and/or thermal loading.
3. Frost heave could destroy the integrity of TAPS river training structures containing fine grained fill

material, e.g., the Middle Fork Koyukuk River area. To avoid this, the disturbed area would have to be replaced by non-frost susceptible material. Proper winter compaction is difficult, if not impossible. If work is done in the winter, the structure should be proof-rolled in the summer and brought up to required grade. Tie-ins, particularly into permafrost banks must be carefully restored.

Where permanent hydraulic structures such as bridges or culverts could affect TAPS, the design criteria for the structures should be the Pipeline Design Flood (PDF) equal to or larger than that computed by TAPS. For temporary structures, which could impact TAPS, the recurrence probability of the design flood during the life of the structure should be equal to or less than the probability of the PDF during the life of the pipeline.

TAPS structures breached during construction should be repaired immediately following pipe laying operations. If critical structures are breached during open water periods, it may be necessary to construct a temporary diversion dike in accordance with the above design criteria. Where NWA additional clearing necessitates new or modified structures to ensure the integrity of TAPS, it will be necessary to: 1) construct the necessary structures immediately after clearing and breach them only during pipe laying, or 2) construct temporary works in accordance with the criteria outlined above.

Construction of the NWA workpad over the fuel gas line could jeopardize the integrity of this facility.

The design criteria for the fuel gas line (FGL) included the maintenance of frozen soil above the bottom of the ditch to prevent thaw settlement and frost heave. Due to its size, the FGL operates at ambient soil temperatures and provides no significant soil cooling. Therefore, the desired configuration of frozen soil was maintained by placing insulation across the trench at the bottom of the active layer in the area disturbed by trenching operations and by protecting the tundra on each side of the trench with a snowpad during construction. The construction and use of a three-foot thick gravel workpad adjacent to the haul road and over the FGL as planned by NWA will result in thaw of the ice-rich soils surrounding the FGL. This thawing will create a lack of restraint in the soils around the FGL could result in failure of the FGL with a corresponding temporary shut down of TAPS.

The deterioration of structural workpad in many areas along TAPS has made it unsuitable for supporting heavy construction traffic. The rehabilitation of the workpad could result in extensive modification and an inordinate amount of additional fill to support the construction of another pipeline.

Structural workpad design was used for TAPS construction where the permafrost subgrade could not be maintained in a frozen condition or where thaw-stable soils were encountered. The design criteria for the structural workpad assumed a limited life embankment capable of bearing a finite number of repetitive wheel loads. The long-term permafrost degradation due to the construction thermal disturbance and the buried hot oil pipeline were not considered. Therefore, where the workpad is reused by NWA, few problems are expected where the soils are free-draining and ice-free, but problems are likely to occur in areas where the workpad was constructed over high ice content and/or high moisture content, fine-grained soils. In these areas, thawing of ice-rich soils and pumping of water and fines into the workpad material may result in trafficability and stability problems. These problems occurred during the latter phases of TAPS construction.

Three years have passed since construction was completed from the TAPS workpad. The effects of construction and operation of the warm oil line have caused the expected thermal degradation beneath the workpad. Maintenance crews have experienced trafficability problems in many areas even with light wheel load vehicles. Additionally, maintenance crews have witnessed partial breakup and moderate to severe settling in the TAPS structural workpad especially south of the Brooks Range.

Considerable rehabilitation with additional workpad material may be required prior to reuse of the structural workpad in permafrost areas. NWA, in its Right-of-Way Application and its FERC filing, has not (according to Civil drawings) taken into account the substantial quantity of material which would be required to rehabilitate the TAPS workpad.

Since construction of the gas pipeline is still several years away, assessment of the structural workpad must address not only its present condition but also its continued deterioration. Undoubtedly, trafficability and stability problems associated with thermal deterioration of the structural workpad will increase with time.

The TAPS workpad could present a hazard to the gas pipeline. The TAPS workpad was only designed for marginal static stability and the workpad was designed to fail away from both the above- and belowground portions during a seismic event. NWA, however, is faced with a different situation with the workpad uphill. There is a need for NWA to evaluate the seismic stability of the uphill TAPS pad and determine what effects its failure might have on the gas pipeline.

Where the TAPS structural pad has deteriorated beyond reasonable repair, NWA will have to construct a new workpad. This alternative should be restricted to a pad downhill of TAPS because an unstable NWA structural pad uphill of TAPS constitutes a hazard to TAPS, especially in the aboveground configuration. Along most of the aboveground pipeline, the TAPS workpad was located downhill to avoid this problem.

Although one of the NWA route selection criteria is location downhill of TAPS, their Right-of-Way Application includes at least 61 areas where NWA would be uphill of TAPS. The NWA typical cross-section drawings also indicate configurations showing the pad to be uphill when adjacent to TAPS.

Because an adequate frost heave design has not been developed, the gas pipeline must be routed well away from the oil pipeline to prevent damage to TAPS.

Maximum frost heave of the gas pipeline is expected to be approximately three feet. This could cause surficial drainage blockage and the formation of ponds or new drainage channels along TAPS. Hydraulic erosion caused by these conditions could jeopardize TAPS integrity.

Raised ground water levels resulting from ponding would increase the potential for slope failure. For these reasons, the frost heave problem is of concern to the TAPS Owners.

NWA has developed tentative frost heave design criteria for use in its filings with FERC and DOI, but the conservativeness of these criteria is uncertain. NWA acknowledges in its Right-of-Way Application that the degree of conservatism for total and differential heave in the design is questionable. In referring to the criteria, NWA states (Page N1-18), "The basis for these assumptions ultimately rests on engineering judgment; rigorous justification for any reasonable number is not possible with the current state of frost heave understanding." NWA also states (Page, N1-18) that "potentially excessive heave behavior has been observed in the lab for nearly all soil types."

The fact that the frost heave design is uncertain is more important to TAPS than the causes of the uncertainty. If the pipelines are in close proximity, frost heave of the gas pipeline will directly affect TAPS. Therefore, as long as the frost heave design is uncertain, prudent engineering practice dictates that the gas pipeline be located well away from TAPS. If the gas pipeline is located in close proximity, the possibilities of an elevated construction mode or extensive remedial work on a buried pipeline present unacceptable risks to TAPS.

The freeze bulb which forms around the NWA line can cause problems for TAPS even if it does not cause excessive differential heave of the gas pipeline. The freeze bulb could still affect groundwater conditions near TAPS, causing slope instability and liquefaction problems.

While it may be appropriate and acceptable for NWA to assume risk and use its engineering judgment in designing its gas pipeline, TAPS must be satisfied that a gas pipeline located near the oil pipeline poses no short or long-term risks to its safety.

An extensive laboratory and field testing program is planned to further develop the frost heave design. It must be emphasized that this work is for design development and <u>not</u> merely design confirmation. The success of this work is not certain because it will require a significant advancement in the current state-of-the-art for frost heave predictive techniques. The schedule on page N1-29 of Volume V indicates that assessment of the ultimate success of this procedure will not occur until July, 1981. Before that time, NWA will have to overcome a number of very difficult problems. Among them are:

1. Both CRETC and TAPS have previously raised questions about the details of the laboratory frost heave test procedure. Major concerns are the appropriateness of the constant temperature boundary condition to model field conditions and the number of tests needed to develop a correlation. NWA itself is now questioning the need to run the tests to steady state.

2. No guarantee can be given that an adequate quantitative correlation between frost heave and soil index properties can be developed, or that it even exists. At a CRETC meeting, NWA stated it has already attempted and failed to correlate the CRREL frost heave data, the largest body of experimental frost heave data currently available.

3. NWA is having problems locating sites for the new full-scale frost heave tests. As explained by NWA, at a CRETC meeting, one reason is that sites with uniform soil conditions cannot be found, and the complex soil conditions will make the data difficult to analyze. TAPS sympathizes with the desire for uniform soil conditions. However, if a well-instrumented field test cannot be analyzed, it is questionable that an adequate pipeline design can be developed.

4. The field tests may have to run for several years to collect adequate data. Comparing frost heave predictions based on the laboratory work with only one year of field data may not be enough to verify the long-term accuracy of the prediction method. After one year, the freeze bulb around an uninsulated pipe is only about 25 percent of its 30-year value. The amount

of field data needed will not be known until the first comparisons of lab and field data are made and the disparity determined. Even if the comparison is good, questions about long-term accuracy may remain.

Several years of field data may be especially important for insulated pipe. This is due to the slower frost bulb growth and the increased influence of seasonal effects. Some minimal freeze bulb must be obtained before the consistency and representativeness of the data can be evaluated. Due to the difference in freezing rate, the heave measured at an early time for a given size freeze bulb around an uninsulated pipe may not be applicable to the same size freeze bulb around an insulated pipe at a later time.

5. Developing an adequate data base to quantify soil index property variability and to locate all frozen/thawed transitions is extremely difficult. Some method for field verification during construction will be required but has not yet been developed. Simple visual ditch logging may not be adequate.

Hopefully, soil testing conducted so far has included all the needed index properties. CRETC has warned NWA that the clay size fraction may be an important correlation variable. Nevertheless, NWA has used the combined silt and clay fraction in its preliminary criteria and, apparently, the clay size fraction is not usually determined.

6. To estimate differential heave, it may not be adequate to conservatively estimate total heave. A soil which heaves less than anticipated mixed with a soil which heaves as much as anticipated causes greater than anticipated differential heave. Having to accurately predict total heave rather than just conservatively predict total heave makes the problem much more difficult.

NWA has suggested that several mechanisms for pipeline/soil interaction may reduce the frost heave problem by reducing the ice segregation rate, by reducing pipe restraint, or by smoothing differential heave. Examples include the increase in effective overburden pressure caused by the uplift resistance of the pipe, the spread of heave forces through the freeze bulb, creep of the freeze bulb, and the relaxation in pipe restraint allowed by thawing of the active layer each summer. All these mechanisms appear qualitatively plausible but have not yet been quantitatively evaluated by NWA. The analysis to do this will be much more complicated than that necessary for TAPS.

7. The mechanical and thermal models used in the frost heave design will not be directly coupled. The freeze bulb growth will be calculated using soil thermal properties based on an assumed ice segregation ratio. The calculated freeze bulb growth will then be used in the mechanical analysis. However, as just discussed, the mechanical analysis will include mechanisms which reduce the ice segregation ratio. If the ice segregation ratio decreases, the frost bulb increases due to the lower latent

heat and higher conductivity. The net result of a larger freeze bulb with a smaller ice segregation ratio is not clear. NWA has not indicated how it intends to account for the coupling.

8. The current heave mitigation measures proposed by NWA depend on the use of six inch thick pipe insulation. This thickness is beyond current industry experience. NWA has not yet developed any details of the insulation design. The reliability of this insulation is of utmost importance because even short sections of damaged or deficient insulation may cause excessive heave.

Material sites mined by NWA, including the extension or deepening of existing TAPS sites, could have a substantial effect on the integrity of TAPS.

The design and construction of the TAPS river crossings and floodplain segments considered the effect of [TAPS or other] all pre-1976 floodplain material sites whether or not TAPS related. New sites to be mined by NWA, or the extension or deepening of existing sites, could have a substantial effect on the integrity of TAPS. The actual mining, as well as temporary disturbances, such as channel diversion berms, stockpiles, and access roads, can alter stream hydraulics. TAPS problems at M.P. 25.5-27.5 in 1977, as a result of these kinds of temporary disturbances, attest to the potential impact. This is the very same area where NWA is proposing Material Sites 5-2, 5-3B, and 5-3A and access roads 5-APL/ASY-2, 5-APL/AMS-3 and 5-APL/AMS-4.

The effect of a material site cannot be determined by assessing the impact only in the immediate vicinity of the site. Stream changes can occur for considerable distances upstream and downstream. TAPS was able to, and did on several occasions, change the pipeline design and/or design of river training structures as a result of material sites. Impacts caused by NWA will be much more difficult to remedy. Obviously, the TAPS line cannot be changed and alterations or additions to TAPS existing river training structures could be difficult to accomplish next to an operating pipeline.

Problems that may be created by material site selection include:

1. <u>Site downstream from buried or elevated TAPS line.</u>
   Lowering of the river bed level through mining can result in general degradation (bed scour) at a buried crossing or at bridge piers and abutments.
2. <u>Site upstream from buried or elevated TAPS line.</u>
   A deep mining site upstream can result in near-total bedload deposition resulting in short-term degradation at TAPS crossing as a result of "clear water scour."
3. <u>Site near "overbank" TAPS design.</u>
   A material site could increase flows from overbank to main channel along a section of TAPS.
4. <u>Site near "main channel" TAPS design.</u>
   A material site could increase the severity of flow attack on spurs, revetments, and dikes.
5. <u>Temporary construction berms, stockpiles or roads.</u>
   These works can increase severity of attack and water levels on structures and the TAPS line. TAPS experiences at M.P. 25.5-27.5, as previously mentioned, attest to this real concern.

The selection process for a material site must include a detailed assessment of the impact on TAPS. Mining must be strictly limited to the approved mining depths and extents. The vast material quantities required and the cost of hauling can easily result in overmining of a particular site. During the construction of TAPS, significant design changes were required as a result of material sites. NWA has not documented how they propose to avoid similar problems.

Deficiencies in the proposed ditch types may lead to significant remedial work and may pose a long-term risk to TAPS.

The NWA proposed ditch types are designed for either frozen or thawed soil conditions and are not compatible at frozen/thawed transition zones. Additionally, the proposed ditch types may not satisfy design requirements for all soil conditions.

Ditch Type IIB is designed for use south of the Brooks Range in initially frozen, thaw-unstable soil. Ditch Type V is designed for use in initially thawed, frost-susceptible soil. These two ditch types are incompatible with each other and neither can be used to cross a frozen/thawed soil transition. NWA has not addressed this problem.

Insulated pipe cannot be used in initially frozen ground because the cold pipe is needed as a heat sink to offset the construction thermal disturbance and prevent permafrost degradation. Uninsulated pipe cannot be used in initially thawed ground because the large freeze bulb generated makes frost heave likely. The situation is aggravated at a frozen/thawed interface because of the initial soil thermal regime. Where the soil is just barely above or below 32°F, the worst case exists for frost heave or thaw settlement respectively.

NWA has not specified the maximum allowable average gas temperature. Even when uninsulated pipe is placed in initially frozen ground, stable permafrost is not guaranteed. The average gas operating temperature must still be maintained several degrees below 32°F to prevent permafrost degradation near the pipe. The permafrost directly beneath the pipe may not thaw, but the pipe may become perched on a narrow pedestal of frozen ground which could be unstable. The gas temperature might have to be further reduced if groundwater flow is a problem.

North of the Brooks Range, transition problems can also occur between Ditch Types IIA and V. A possible solution may be to extend the insulated pipe well into the permafrost and use slab insulation above the insulated pipe to prevent permafrost degradation; groundwater flow must also be considered.

A problem similar to the transition problem occurs when the permafrost is relatively thin or the permafrost table is relatively deep. If deep burial cannot be used either to get below the thin permafrost or to get into the deep permafrost, both heave and settlement can occur. Neither Ditch Type IIB or V may be adequate to overcome these problems.

Ditch Type V uses six inches of pipe insulation. As noted *supra*. page 25, this insulation thickness is beyond current industry experience and details of the insulation design have not yet to be developed. Minimum required mechanical and thermal properties of the insulation and protective jacket, application procedures, and pipe bending procedures have not been established. The conductivity of 0.015 Btu/hr-ft-°F used by NWA in some calculations is inadequately justified. Also, insulation degradation due to moisture absorption or mechanical damage has not been addressed.

Applicable industry experience for buried pipe insulation is very limited. Insulation is normally used for temperature control of the fluids inside the pipeline, so some insulation damage is acceptable and usually unnoticed. For the gas pipeline, where a short length of damaged insulation can cause excessive heave, the need for 100% reliability in the insulation system is much greater. The NWA method to achieve such high reliability is unknown.

Ditch Types IIA and IIB use slab insulation to reduce the permafrost degradation during the dormant period. The general concept is good, but NWA presented no calculations supporting the proposed insulation widths and thicknesses. The possibility that groundwater flow in the ditch backfill could significantly increase thaw and make the slab insulation ineffective is not addressed.

North of the Brooks Range, the slab insulation should extend beneath the entire work pad. The insulation should be tied into the existing TAPS insulated pad or the haul road. This will ensure the original permafrost table is maintained or raised.

It is not clear if the proposed slab insulation thicknesses include an allowance for mechanical damage. A workpad material gradation to reduce such damage has not yet been specified.

Even when thawed soil is non-frost-susceptible, Ditch Type I may not be appropriate. The large freeze bulb generated may not cause heave, but it may affect groundwater flow and cause slope instability or liquefaction problems.

Frost heave effects associated with the chilled gas pipeline may create a linear area of uplifted ground parallel to the workpad resulting in the alteration of existing drainage patterns and the loss of integrity due to erosion by surface water along and across the TAPS line.

A belowground segment of TAPS can be considered a buried restrained column with an axial load sometimes as high as 3 million pounds (resulting from temperature differential and internal pressure). As a free column, the straight portions of the buried pipeline would be unstable and buckle in lengths greater than about 80 feet. The pipeline derives its stability from the lateral restraint provided by the surrounding soil. Therefore, any erosion of the surrounding soil within the influence zone of the pipeline would jeopardize the integrity of TAPS. Similarly, the TAPS aboveground support VSM could be jeopardized by thermal and/or hydraulic erosion caused by uncontrolled surface water.

This stability problem in the belowground pipe is accentuated at bends, because the vectorial sum of the axial compressive forces in the pipeline has an outward radial component and the influence zone for side bends is enlarged laterally by several (12-15) pipe diameters (50-60 feet). Soil in this influence zone is highly stressed and disturbance by erosion or excavation would create a hazard to the integrity of TAPS.

NWA design criteria allow up to three feet of total heave, but the nominal depth of cover over the pipeline is only 2-1/2 feet. This could lead to exposure of the gas pipeline.

The drainage alteration caused by heaving of the gas pipeline will be difficult to predict. Conditions may change from year to year or season to season. It is, therefore, necessary that considerable monitoring and maintenance for this condition be required.

NWA construction activities could disturb TAPS erosion control facilities and alter drainage patterns.

The TAPS restoration efforts at the termination of construction activities included regrading, stabilization of cut and fill slopes, revegetation of all disturbed areas and preparation of visual impact sites at selected locations. Drainage structures were modified for long-term stability by the installation of transverse levees, siltation basins, ditch checks, diversion levees, and let-down structures. In numerous locations, culverts were upgraded by the installation of additional culverts, the installation of larger culverts, or replacement with low-water crossings.

Where NWA construction is planned in close proximity to TAPS, many of these TAPS structures or stabilization procedures will be removed or buried. Further, inadequate rehabilitation of TAPS workpad may lead to damaging other structures and to creating erosion problems unforeseen by TAPS.

The documentation submitted does not show a complete set of typical drainage structures, slope stabilization procedures, nor how and when these structures and procedures will be implemented. The protection of TAPS integrity requires close attention to these details and prompt implementation of erosion control and drainage techniques to prevent thermal and hydraulic erosion.

SECTION III

Specific Comments On Supplement To Application For Right-Of-Way, Volume V, Enclosure M, Comments On Basic Assumptions And Conclusions

Assumption 1, Page M-1

> "The Pipeline will be a cold buried line (chilled below 32°F)."

It has not been clearly established that a chilled, buried gas pipeline is the best construction mode at all locations. NWA should perform an analysis of alternate modes. A buried pipeline operating just above 32°F or an elevated pipeline may be a better solution to geotechnical problems. An evaluation of the effect of these alternative modes on TAPS should also be made. These modes may not require any advancement of the state-of-the-art as is required for frost heave mitigation.

Assumption 2, Page M-1

> "Outstanding environmental and technical concerns will be resolved prior to construction in accordance with DOI and State of Alaska R/W Grant requirements and procedures."

It may be difficult to resolve all technical concerns related to frost heave prior to commencement of construction. An acceptable design will require a major advance in the state-of-the art.

Assumption 3, Page M-2

> "Stipulations will be complied with, which prevent adverse effects on fish passage and wildlife movement."

No Comment.

Assumption 4, Page M-2

> "Environmental and technical standards for the Northwest project will be compatible with the standards for TAPS."

Where design features and construction of NWA could impact TAPS, the application of the environmental and technical standards by NWA must result in design magnitudes for seismic, floods, drainage works, slope stability, etc., equal to or greater than the magnitudes used by TAPS.

Conclusion 1, Page M-2

> "A nominal 80-foot Centerline(CL) of oil line to CL of gas line spacing is acceptable. A nominal 70-foot CL Highway to CL of gas line is acceptable; however, there shall be no aboveground structure or appurtenance within 30-feet of the highway shoulder. Workpad requirements and construction modes within Enclosure No. 2 to Northwest Alaskan Pipeline Company letter dated April 30, 1979, to Guy R. Martin are acceptable, with the exception that the spacing of the M9 and M10 drawings should be increased to 80-feet and M1 and M2 drawing spacing should be decreased to 44-feet."

Evaluations by TAPS indicate that a minimum separation of 200-feet between TAPS and the NWA pipeline is required to provide sufficiently low risk of damage to TAPS from construction and operation of the natural gas pipeline. Similar conclusions were reached by the DOI-Technical Working Group in May 1979. This separation would generally eliminate the heavy construction traffic along the TAPS workpad and therefore will generally eliminate the need for providing a barrier and safety zone along TAPS. Furthermore, providing drainage along and across the extended workpad would no longer be necessary. However, the risk of damage to TAPS where TAPS workpad is being used as an access road (e.g. GVEA alignment) should not be allowed without the installation of a safety barrier. Trench blasting activities would be less critical with a 200-foot separation with the primary concern being flyrock containment. TAPS opinion is that any separation less than 200 feet between the oil pipeline and the gas pipeline is unacceptable.

Furthermore, should the NWA design require an aboveground mode, either supported on structures or buried in a berm, the separation from TAPS aboveground must be increased to a minimum of 600 feet. Flame impingement studies conducted for TAPS indicate that separation distance less than 600 feet could jeopardize the integrity of TAPS.

<u>Conclusion 2, Page M-3</u>

> "Joint use of R/W is compatible with a 15-foot safety zone adjacent to all related facilities. No activities will occur within the safety zone."

No activities should be allowed within the agreed to 15-foot clear safety zone adjacent to all related TAPS facilities, including activities related to the construction of the protective barrier required to protect TAPS from NWA construction. Therefore, a "clear" 15-foot zone must be maintained between TAPS and the nearest point of the NWA safety barrier. The barrier must be removed subsequent to the completion of all NWA construction activities.

Conclusion 3, Page M-3

Conclusion 4, Page M-4

> "Use of the existing workpad in preference to the haul road may not result in:
>
> (a) Lower cost of construction
>
> (b) Increased potential for environmental protection unless construction mode alternative from Northwest's proposal is used
>
> (c) Reduction in commitment of natural resources (land, gravel, energy).
>
> However, a judicious route selection using both the haul road and workpad has advantages and complies with Section 28(p) of Mineral Leasing Act."

(Conclusion 4)

> "TAPS workpad will require extensive upgrading and widening to support the construction effort."

TAPS still maintains that the cost of constructing NWA will be reduced with a greater separation between NWA and TAPS. It has been stated by NWA that by constructing alongside TAPS and making partial use of the existing TAPS workpad the quantity of gravel saved will be approximately 37% where the TAPS workpad is found to be in good condition but will save only 10% in gravel quantity where the TAPS workpad is in need of significant rebuilding and repair. NWA has proposed a gravel berm barrier to separate their construction activities from TAPS facilities. We believe the construction of such a barrier is not reflected in the above gravel quantity estimates. When quantities for an appropriately designed and situated barrier are included, it can be shown that no reduction in gravel quantities is achieved by using the TAPS workpad. In fact, in many cases, larger quantities of gravel will be required to upgrade and widen TAPS workpad than to construct a new separate workpad.

In February, 1980 the TAPS owners made available to NWA, the Department of the Interior and the Office of the Federal Inspector an Exxon Pipeline Company study that compared the cost of construction along the existing TAPS workpad with construction of the gas pipeline alongside the haul road. This study, which used NWA assumptions, quantities, etc., indicated that cost of construction along the haul road would be no greater than construction along the TAPS workpad. Moreover, this study did not reflect the increased workpad deterioration that exists at this time, nor the other additional cost items listed below. NWA has not commented on this study.

TAPS is presently conducting field investigations to assess the present condition of the workpad. Although not yet complete, preliminary results indicate that the TAPS workpad is in a state of deterioration greater than that assumed in NWA gravel quantity estimates.

With appropriate adjustment for gravel quantities (required to construct the gravel barrier and widen and upgrade the existing workpad) and consideration of reimbursement to TAPS for use of the existing workpad, the cost of constructing the gas pipeline from the existing workpad could undoubtedly be greater than constructing from a new separate workpad. Other significant cost factors which will increase the cost of construction proximate to TAPS include: delineating a 15-foot safety zone; constructing an adequate barrier to prevent encroachment upon the safety zone; and enforcement measures to ensure no encroachment within the safety zone; monitoring of construction activity to assure that all proximity related standards are met; providing unobstructed drainage across and along the workpad; and close control of blasting which will reduce productivity and result in generally slowed construction progress.

<u>Conclusion 5, Page M-4</u>

> "Surface drainage can be accommodated by proper design and location."

NWA response is that "approved standard drainage structures will be installed. . . " and that "maintaining existing flow patterns and stream locations are prime criteria." The referenced details (response to Concern No. 12 and FERC Filing Exhibit Z-9.1) are not given in sufficient detail to allow an evaluation of the effectiveness of the NWA approach. The philosophy given does not address the key issue of handling surface drainage in a manner which will insure maintaining the integrity of TAPS.

Where a parallel workpad is constructed next to TAPS, drainage structures must be compatible with TAPS and ensure the integrity of TAPS. This applies to both permanent and temporary structures. During TAPS PDF conditions, the structures must not affect scour, bank migration and freeboard.

All temporary structures that could affect TAPS must have a design flood magnitude with the same probability of occurrence during the life of the temporary structure as the probability of occurrence of the PDF during the life of TAPS.

Conclusion 6, Page M-5

> "Winter construction from snow pads is a viable alternative and is expected to be used where desirable from environmental and construction scheduling standpoint."

No Comment.

Conclusion 7, Page M-6

> "Other than the Yukon River Bridge, the pipeline will not be installed on highway bridges."

As noted in the transmittal letter there is a problem with the use of that portion of the Yukon River Bridge to which there is an existing exclusive right of use.

Conclusion 8, Page M-7

> "Traffic can be controlled to use part of the haul road traffic surface for construction (e.g. TAPS Fuel Gas Line)."

No Comment.

Conclusion 9, Page M-7

> "Alignment as proposed and those recommended considerations for realignment are within the constraints of the Presidential Decision, Alaska Natural Gas Transportation System, Federal Land Policy Management Act and the Mineral Leasing Act of 1920, as amended."

TAPS interpretation of the Presidential Decision is that adjacent construction and co-workpad use is not a constraint of the Presidential Decision.

Conclusion 10 Page M-8

> "Controlled blasting will not adversely affect TAPS, but there are special cases where additional analysis is required. (For example, proximity to adfreeze VSM's, thawed and different geologic conditions were not considered in the specific study case.)"

Although TAPS agrees that the problems associated with blasting for special cases can be solved on a site-specific basis with a proper testing and a monitoring program, the major concern of production blasting along long segments of TAPS is more difficult to address and less likely to be solved. Damage to TAPS from lack of quality control, overloading of blast holes, and inadequate placement of flyrock containment constitutes a real hazard to TAPS which is not addressed by NWA.

Conclusion 11, Page M-8

> Requirements of 49 C.F.R. 192 have been incorporated into these conclusions and/or assumptions."

No Comment.

Conclusion 12, Page M-8

> "The Northwest proposal will not adversely affect the fuel gas line."

NWA must develop criteria for the strucutral workpad to ensure that excessive thaw depths at the fuel gas line do not occur. NWA should provide detailed analysis to ensure the criteria will be met.

Conclusion 13, Page M-10

> There are several generic site-specific conditions where there are insufficient data to determine compatibility between the gas line and other manmade structures. Minimum separation distances cannot be determined until compatibility is resolved. In these cases, the applicant must demonstrate their proposal is compatible. For example, the closer the gas pipeline is to highway (minimum 44' separation centerline highway to centerline gas pipeline) the better environmentally and technically."

NWA response states that the impacts of blasting, thermal interference, and possible damage during construction have been addressed. TAPS totally disagrees; NWA documents discuss the items mentioned but do not adequately address any of them in specific terms.

SECTION IV

Specific Comments On Supplement To Application For Right-Of-Way, Volume V, Enclosure N, DOI's Technical Questions/Concerns

FROST HEAVE, TAB 1

1.2.1, Page N1-1 -- Principal Issue

". . . Demonstration of satisfactory progress toward an acceptable . . ." frost heave design must include a high probability of ultimate success and development of acceptable alternatives should the primary design prove unworkable. Both are lacking in NWA documents made available to TAPS. The NWA design approach is based mainly on engineering judgment and cannot be quantitatively substantiated at this time. To do so will require a major advancement in the state-of-the-art for frost heave predictive procedures and mitigation measures.

1.3.1, Page N1-1 -- Frost Heave Susceptible Soils

No basis is given for the specified frost susceptibility criteria. Based on CRREL frost heave data, CRETC has recommended using the percent smaller than 0.02mm rather than percent passing the No. 200 sieve. NWA has previously stated a preference for the latter simply because it is easier to measure.

1.3.2, Page N1-2 -- Availability of Water

Water table information was used to determine frost susceptibility, but the effect of water table on freeze bulb size and frost heave is still being studied. This may lead to construction mode changes in the future.

1.3.3, Page N1-2 -- Depth to Permafrost

Burial a few feet above the permafrost table may not necessarily reduce heave as compared to burial in totally thawed ground. The permafrost will ensure a high watertable. For a high heave potential soil with an ice segregation ratio of 50 percent, only 3 feet of soil is required to obtain 3 feet of heave.

Assumption of a gradual transition between permafrost and non-permafrost areas is neither conservative or realistic. TAPS experience has demonstrated that at streams and at isolated islands of permafrost, frozen/thawed soil transitions can be quite sharp. A vertical interface between frozen and thawed soil must be assumed in areas where site specific field data is not available.

1.3.4., Page N1-3 -- Ground Temperatures

NWA has not addressed the problem of heave in partially frozen ground. Although this subject is controversial, it should not be ignored. TAPS used design permafrost temperatures of 30° and 31.5°F north and south of the Brooks Range respectively. At these relatively warm temperatures, heave in partially frozen ground may be a problem.

1.3.5, Page N1-3 -- Pipe Temperatures

The average gas temperature at any given location must be several degrees below 32°F to offset the thermal disturbance due to construction and prevent permafrost degradation. Apparently, NWA has not yet determined the appropriate gas temperature range to be used in the geotechnical design.

1.4.1, Page N1-4 -- Route Soils Data

The site specific location of frozen/thawed transitions is only indirectly addressed. Precise definition of frozen/thawed transitions is necessary, because the construction modes will change at the transitions. Field verification by ditch logging may be difficult as demonstrated by TAPS experience. During shoulder month construction, a deep active layer or rapid freezing of the trench walls after excavation may lead to inadvertently logging thawed areas as frozen. The inverse problem, logging frozen soil as thawed, may occur during the summer.

1.4.3, Page N1-5 -- Ground Temperature Data

NWA states 75 thermistor strings are being read monthly, but on page N3-10, item 3.4.2.3 states ground temperatures from 92 sites have been used and 34 other sites have recently been installed. The applicability and usefulness of the data cannot be assessed without more detailed information.

1.4.5, Page N1-5 -- Testing Program Data

Since the frost heave design is empirical, the two operating field test sites may not be adequate to address all the soil variables needed to substantiate the design.

1.4.5, Page N1-6 -- Verification of Structural Models

The frozen/thawed interface in test section 9 at the Fairbanks test site is gradual and is not representative of many transitions along the alignment. The frozen/thawed interface at the TAPS leak site at milepost 734 was nearly vertical.

1.4.6, Page N1-6 -- Laboratory Heave Tests

To predict frost heave, NWA is attempting to develop a quantitative correlation between standard measurements of soil index properties and laboratory measurements of heave. Several previous investigators have attempted to develop similar correlations; the results have been only qualitative indications of frost susceptibility. The planned NWA work is certainly the most sophisticated ever attempted. Nevertheless, there is as yet no indication that the attempt will provide a successful predictive method.

At the third CRETC meeting at Irvine on March 12 and 13, 1980, NWA representatives stated that an unsuccessful attempt had been made to correlate CRREL frost heave data. This is the largest body of experimental heave data currently available. Although the possible reasons for the failure were debated by the participants at the meeting, no consensus was reached. NWA did not provide any details on the correlation procedure.

The CRREL frost heave experimental procedure was designed to study seasonal heaving of roadways and not the long-term heaving of a chilled, buried gas pipeline. Therefore, the failure to correlate the CRREL data does not mean that an adequate correlation for pipeline design cannot be developed. However, it is an indication that the ability to develop an appropriate correlation is uncertain.

1.4.6, Page N1-7 -- Heave Tests

The frost heave laboratory test procedure should be verified by a parametric study. NWA is doing this but has not made any results available.

1.4.6, Page N1-8 -- Temperature and Heat Flux

NWA justifies the boundary temperatures to be used in their experimental work by stating that the heat flux range at the freeze front in the laboratory is the same as that in the field. However, it is not only the heat flux range but also the heat flux time history which is important. Therefore the results of the laboratory tests may not be applicable in predicting heave in the field.

Even assuming NWA is correct, there is an inconsistency in their application of the experimentally determined ice segregation ratios. Figures 1-3 and 1-4 indicate that, in the field situation, a given four inch thickness of soil freezes at a relatively constant heat flux rate. In the predictive analyses of the proposed laboratory test, the four inch soil samples freeze over a much wider heat flux range as shown in Figures 1-5 to 1-8. Since the heat flux ranges are drastically different, the ice segregation ratio should not be used in an incremental manner as shown in Figure 1-1.

For uniform soil conditions, one could argue that the ice segregation ratio should be applied to the entire freeze bulb and not incrementally. The heat flux range for uninsulated pipe is about the same as that occurring in the lab. However, the heat flux range for insulated pipe, the main method of mitigation, is much less than that in the lab, so there is again inconsistency in the NWA reasoning.

1.4.6, Page N1-10 -- Duration of Frost Heave Testing

NWA is seriously considering reducing the duration of their laboratory frost heave tests because they believe running the constant temperature tests to steady state over-predicts heave. Criteria are not given for determining the appropriate test length, but the NWA discussion can be interpreted as requiring several different test times with the results applied to separate portions of the freeze bulb. This may be an indication that the entire testing procedure needs to be revised as previously recommended by CRETC.

The alternative procedure recommended by CRETC is to use time dependent boundary temperatures adjusted to maintain constant soil temperature gradients. This would complicate the testing procedure but would also allow the laboratory tests to be more directly coupled with the freeze bulb calculations. Further, it may allow a reduction in test time, since the heave rate may be constant from the beginning to end of sample freezing. This general type of test procedure has been rejected by NWA.

1.4.7, Page N1-10 -- Laboratory Frozen Soil Uplift Resistance Tests

NWA is just beginning to study some aspects of pipe-soil interaction. NWA admits that the planned program to investigate uplift resistance forces is "inherently complex and, because there is no precedence for guidance, the program must have an exploratory aspect." Such comments indicate the lack of quantitative substantiation for the current design and the difficult problems to be overcome in proving the design.

1.5, Page N1-11 -- Semi-Empirical Model

The semi-empirical frost heave design approach is simple in concept. However, all the complicated frost heave design phenomena are lumped into the experimentally determined ice segregation ratio, and NWA has yet to demonstrate that appropriate values of this parameter can be determined. The method has been used to conservatively estimate total heave at the Calgary field test site. This is supportive but does not necessarily guarantee a conservative estimate of differential heave.

1.6.1, Page N1-14 -- Sensitivity Studies

See also comments on Exhibit Z-9.1 Section 1, infra.

The method used to combine the summer uplift resistance of 150 kips/ft and the winter uplift resistance of 30 kips/ft to obtain the effective continuous value of 50 kips/ft is not explained. These values differ from those given on Page 1-58 of Z-9.1. Figure 1-12 indicates there is a large difference in the allowable heave between 30 and 150 kips/ft. If excessive heave occurs and the pipe is over-stressed during the winter, any relaxation in the summer is inconsequential.

1.6.2, Page N1-15 -- Modeling of Pipeline Heave Forces

The appropriate mechanical boundary condition for modeling heave has not yet been determined. Calculations have been performed using both a uniform force and a uniform displacement boundary condition. Actually, force and displacement are interdependent. Displacement decreases as force increases. Thus, the curves representing allowable displacement versus span length cannot be used as design tools.

1.6.3, Page N1-16 -- Preliminary Design Basis

It is not clear that all the assumptions used in the preliminary analysis of pipe/soil interaction are conservative. The maximum expected operating pressure and maximum expected positive operating temperature difference (maximum gas operating temperature minus minimum pipe laying temperature) were used. However, until more work is done, the uplift resistance of 50 kips/ft and the load distribution shown in Figure 1-14 cannot be considered conservative.

Limiting the temperature difference to 30°F may require special backfill procedures. With a maximum gas temperature of 30°F, the minimum pipe laying temperature is 0°F. With the emphasis placed on shoulder month construction by NWA, pipe laying will occur at much colder air temperatures.

In some areas, concrete weights will be needed to prevent pipe buoyancy, especially for insulated pipe. The variable uplift resistance provided by these weights may cause differential heave. This possibility has not been addressed.

The mechanical analysis has not yet addressed the pipeline insulation system. The insulation system includes the insulation itself, the protective outer jacket, and the bonds between the jacket, insulation and pipe. The allowable frost heave may not be limited by deformation of the pipe but by deformation of the insulation system.

If insulated pipe is to be bent in the field, this must also be included in the analysis. Shoulder month construction could complicate field bending. The cold air temperatures may make the insulation materials brittle enough to crack during bending.

<u>1.7, Page N1-16 -- Design Criteria</u>

This section tabulates four "principles" used to guide development of criteria then refers to these principles as criteria.

<u>1.7.2, Page N1-18 -- Preliminary Ice Segregation Ratios</u>

It is qualitatively correct to assume that heave is limited by the pipe/soil interaction, however insufficient data exists to apply this phenomenon to design.

Differential heave can be more than half of the total heave. In the worst case, differential heave can equal the total heave. This could occur, for example, when pockets of silt are encountered within generally clean gravel in an abandoned floodplain.

An allowable differential heave of 18 inches over a span of 100 feet is presented as an example, and it was apparently used to develop the preliminary design. This is not consistent with Figure 1-12 which shows that only 16 inches of differential heave is allowable for an uplift resistance of 50 kips/ft and a span length of 100 feet. Figure 1-15 indicates that 18 inches of differential heave is allowable when the heaving soil is more than four feet below the pipe. Thus, four feet may be the maximum amount of over-excavation to be expected of NWA.

Using half the ice segregation ratio to estimate differential heave is only valid for uniform soil conditions.

NWA admits that the assumptions concerning ice segregation ratio and differential heave are based only on engineering judgment and cannot be rigorously justified.

The observations given in support of the frost heave assumptions are inconclusive. They are briefly discussed below.

1. The CRREL data indicates frost heave is extremely complex. Any empirical design procedure must be very thorough.
2. Small changes in soil properties could increase heave at the Calgary test site. Also, in July 1977, the differential heave for the control section was about 25 percent of the total. This is below the design value of 50 percent but is still surprisingly large

due to the relatively uniform soil conditions. The differential heave may be due largely to additional restraint provided by auxiliary piping, but this possibility has not been addressed by NWA.

3. The freeze plate data is supportive but not conclusive.
4. Increasing the effective overburden pressure will decrease heave but the extent is yet to be determined.
5. Reductions in heave due to lack of groundwater can only be claimed if based on site specific data.
6. The variability of soil conditions must be based on extensive field data.
7. It is likely that pipe bedding and padding are too thin to cause a significant reduction in differential heave.
8. Over-excavation can help smooth differential heave but the amount is uncertain.

NWA plans extensive field and laboratory work to substantiate their design assumptions. Unfortunately, much of this work is still in the planning stages. No update on the status of the work is provided in this submittal.

1.8.2, Page N1-20 -- Mode Geothermal Analysis with Varying Insulation

NWA does not provide calculation results to illustrate the performance of buried, insulated pipe with or without over-excavation.

1.8.2, Page N1-21 -- Results and Applications

If R is based on a uniform soil profile the equation given to determine the required amount of over-excavation is unconservative . The equation assumes freeze depth is independent of over-excavation; actually freeze depth increases with increasing over-excavation because of the higher conductivity and lower latent heat of the backfill material.

The discussion on N1-21 does not indicate how R is determined, but Figure Z-9.1-3-2 indicates R is based on a total ditch depth of 13.5 feet which should be conservative.

1.8.2, Page N1-21 -- Crossings

NWA states that the "effect of the chilled gas pipeline operating below major rivers will be minimal." No information is given to support this. The effect of the pipeline on minor stream crossings is not addressed.

The EPR program cannot model pipeline crossings. This is a three-dimensional problem.

1.8.2, Page N1-21 -- Insulation Analysis and Results

No references are given for the literature review of pipeline insulation conductivity. It is not clear what restrictions apply to the numbers quoted. The possibility of increased conductivity due to mechanical damage is not considered. The possible need for high density insulation is also not addressed.

NWA states, "Results of these tests show that the K-factor of this type of insulation can decrease with regard to insulative value during its design life depending on exposure." Obviously, "increase" was meant instead of "decrease."

1.8.3, Page N1-22 -- Soil Properties

No results are presented for the described study on the effect of ditch backfill. The soil thermal properties in Table 1-1 are not consistent with the assumed ice segregation ratios. For example, the silt dry density should be 112/2=56 lb_m/ft^3 and not 75 lb_m/ft^3. The sand dry density should be 130/1.2=108 lb_m/ft^3. Moisture content is also wrong, and dry density and moisture content are the major variables used to calculate the soil thermal properties. The method used to determine the parameters modeling unfrozen moisture below 32°F is not discussed.

A constant surface temperature does not necessarily give the same result as a periodic surface temperature variation. The difference depends on the depth of the active layer and the change between frozen and thawed soil thermal properties. This can be especially important when assessing the effect of the thermal construction disturbance on insulated pipe.

1.8.3, Page N1-24 -- Ground Temperatures

Using a ground surface temperature of 32.1°F is likely to be conservative when the pipe is insulated. A parametric study of surface temperatures should be investigated.

1.9, Page N1-24 -- Design Solution Process

The description of the design process is very general and of little value when trying to evaluate the preliminary design.

1.11, Page N1-28 -- Potential for Changes

The extent of frost susceptible soil may increase or decrease depending on the results of ongoing work.

It is good that NWA is considering new alternative construction modes. However, the possibilities are only stated. No details are given.

1.11, Page N1-29

According to the NWA schedule, it will be July 1981 before the probability of success of the proposed design can be assessed.

2.2.3.1, Page N2-2--Aufeis in Active Layer Groundwater Flow Areas

The problem is stated but no solution is given.

2.6.1, Page N2-10 -- Groundwater Classification Procedure

Little information is provided on the groundwater classification system. Its usefulness in the overall design process is not clear.

2.6.2, Page 2-11 -- Design Procedure for Aufeis in Discharge Areas

NWA states that "where aufeis conditions exist naturally, the presence of the chilled gas pipeline is not considered to appreciably aggravate the situation." NWA does not present documentation for this conclusion. The chilled gas line could concentrate the development of aufeis immediately downstream and reduce it a corresponding amount further downstream. If TAPS is elevated or protected by river training structures in the affected area, the gas pipeline could reduce freeboard. For example, access road 36-APL/AMS-1, material site 36-1 and temporary stockpiles and diversion dikes at the mining site could increase aufeis levels at TAPS river training structures and remote gate valve in the Dietrich River immediately downstream.

2.6.2.1, Page N2-11 -- Site Evaluation and Analysis

NWA states that the presence of aufeis will be included when determining scour during breakup, but they do not state how the magnitude of aufeis is calculated. There are presently no generally accepted analytical methods for estimating site specifically the amount of aufeis which can form.

2.6.2.2, Page N2-12 -- Design Alternatives

Alternate construction modes are merely stated. No criteria or typical drawings are referenced. Until design details are developed, the listed modes cannot realistically be considered alternatives. Satisfactory designs may not exist. For example, long-term reliability and frozen/thawed transitions are problems which will be encountered with heat tracing.

2.6.3, Page N2-12 -- Design Procedure for Aufeis on Slopes

No analytical methods are specified for the design procedure described. The objectives of the study are only summarized.

2.6.3.1, Page N2-13 -- Site Evaluation and Analysis

The gas pipeline route has been assessed and classified as having a low, moderate or high aufeis potential. The classification has little meaning as criteria for the three categories are not explained. Special study areas were apparently identified but are not listed.

2.6.3.2, Page N2-13 -- Design Alternatives

Alternate construction modes are merely stated. No criteria or typical drawings are referenced. As stated above, until design details are developed, the listed modes cannot realistically be considered alternatives.

2.6.4, Page N2-13 -- Design Procedure for Subsurface Erosion

NWA has not specified analytical methods for the design procedure described. Control of groundwater flowing in the ditch will be very important during the dormant period. Even after startup, groundwater near the pipe can cause permafrost degradation and increase the gas refrigeration load.

2.7, Page N2-13 -- Solution

NWA has provided no specific information. NWA admits that some problem areas will be difficult to identify.

2.8.1, Page N2-14 -- Ice-Damming Study

No specific information on the ice-damming study is provided. This is a major test. Proper site selection and instrumentation is critical because only one test site is planned.

2.8.3, Page N2-15 -- Standpipe Data

The location and monitoring frequency for the standpipes is not given. Data should be collected over at least one year to assess seasonal changes.

2.9, Page N2-15 -- Potential Changes

It is premature to state that no significant changes are expected. The design details have not been developed, especially the alternate construction modes to be used should problems be identified. Thermal/hydraulic analysis of groundwater flow around a buried pipeline is a difficult problem, and NWA has not described their analytical procedures. Further, the major field test has not even been constructed.

NWA has not considered the possibility of groundwater heated by the buried oil pipeline flowing down the gas pipeline ditch. This could greatly increase thaw during the dormant period and could significantly increase freezeback time after startup. It should not be a problem where the soil is initially thawed or is frozen but thaw stable. However, where the oil pipeline is deep buried or where the oil pipeline is uphill of the gas pipeline on a lateral or longitudinal slope, the problem may occur. An example of the latter, is where the oil pipeline is buried uphill and elevated downhill with the gas pipeline paralleling the oil pipe on the other side of the workpad. The gas pipeline will be on the edge of the combined pipeline/workpad thaw bulb which could be a source of heated water.

3.2, Page N3-2 -- Definition of Issues

The statement is made that "by itself, alteration of thermal conditions is not considered a significant stability issue". This statement is not correct. All soils (with the exception of very dry soils) become significantly weaker and less stable when changed from frozen to thawed. They resist less loading both statically and dynamically. Thus, stability conditions are adversely affected merely by causing or increasing thaw in an area.

3.3., Page N3-2 -- Categories

Additional categories should be added and discussed in this tab under 3.3.1 Geotechnical Terrain Stability. Some of these categories are:

- Thaw settlement,
- Ditch wall instability, and
- Work pad instability.

3.3.1.1, Page N3-3 -- Thaw Plug Stability

NWA states, "It is expected that any developing thaw bulbs will not be capable of adversely affecting pipeline structural integrity once a sufficiently large frost bulb builds up around the chilled line." However, no criteria are given to define "sufficiently large." Also, the time and temperature required to achieve such a freeze bulb are not discussed.

Where TAPS is deep buried and the gas pipeline is shallow buried, a thaw plug failure of overburden material could threaten the gas pipeline.

While it is likely that TAPS itself would not be located within the zone of thaw plug failure, these failures could remove cover from TAPS at critical locations.

3.3.2.2, Pages N3-4 -- Right of-Way Configuration

NWA needs to explain the process for including "actual and interpreted potential time dependent ground modifications associated with anticipated thermal degradation" in the assessment process.

3.4.1.4, Page N3-7 -- Groundwater Observations

The paragraph mentioned the sensitivity of liquefaction potential and slope stability to soil pore water pressure. NWA needs to describe the kind of data which is being obtained and explain the procedure for field measurements.

3.4.1.12, Page N3-9 -- Slope Assessment Data

NWA needs to assess the effect of their construction and operation on long and short term terrain stability.

3.4.2.2, Page N3-10 -- Laboratory Soil Tests

Laboratory test results should be incorporated in the project documents. None are listed at present.

3.4.2.3, Page N3-10 -- Ground Temperatures

Few results of the ground temperature monitoring are provided. North of Delta Junction no temperatures are given in the upper band on the geotechnical drawings.

3.5.1, Page N3-12 -- Thaw Plug Stability

NWA needs to include in their submittal the definition of "analytical qualification" and to explain further its application to the design process.

The five-inch displacement criteria is the same as used by TAPS; however, it was based on allowable pipe stress (lateral). The allowable stresses for the two pipelines resulting from detailed stress analyses are not likely to be identical.

The 1.1 factor of safety for nonintegrity thaw plug instabilities is from the Alyeska workpad criteria and it was qualified with a requirement for location of the pad such that dynamic failures were directed away from the oil pipeline. This means that in many places the TAPS pad will fail toward the NWA line during a dynamic event.

3.5.2, Page N3-12 -- Liquefaction

These criteria also need to address mass movement associated with liquefaction on sloping ground. This is by far the most significant concern associated with seismic liquefaction.

It is doubtful that NWA will find anywhere on their alignment where settlement due to seismic loading (seismic compaction) would approach 12 inches. This is primarily a dry soil phenomenon and should not be discussed under liquefaction.

No mention is made of liquefaction of disturbed and thawing permafrost.

Lateral loads due to liquefaction in the active layer on cross slopes is an important issue that needs to be addressed.

3.5.3, Page N3-12 -- Slope Stability

The statement given above about the five inch displacement criteria under thaw plug stability also applies here.

3.6.1, Page N3-14 -- Figure 3.1

A review of the workpad typical sections and their mile-by-mile applications indicates that the routing logic presented in Figure 3.1 has not been applied. Many potentially unstable configurations were noted during the mile-by-mile review.

3.6.1.1, Page N3-13 -- Geotechnical Data Base

The present format of the Route Soil Conditions Alignment Sheets does not present a convenient summary of geotechnical data. It is very difficult to read the boring numbers on the terrain unit maps and the subsurface profile is developed on a flat (ground zeroed) profile. For something as important as stability assessment, it is desirable to have more detailed information presented on those sheets.

3.6.1.2, Page N3-17 -- Initial Generalized Assessment

Comment on the adequacy of the proposed system of developing stability response typicals (SRT) to evaluate soil stability cannot be given until details and examples of the SRT system are provided. The concept of developing conservative analytical limits for various stability parameters was used by TAPS engineers to establish the non-criticality of large sections of the alignment and provided a basis for identifying potential problem areas. The development of the critical, limiting cases is the key to the usefulness of this concept; NWA's lack of specifics, therefore, precludes comment at this time.

The write-up seems to suggest, however, that SRTs encompassing all stability concerns (slope, thaw plug, erosion, liquefaction, etc.) will be developed. Attempting to address all of these factors in one model could lead to either a complex set of conditions which are difficult to evaluate or a very general model which will not allow rapid elimination of non-critical cases. The use of separate (but related) SRT's for the various stability concerns is suggested.

<u>3.6.1.3, Page N3-18 -- Site-Specific Detailed Analysis</u>

The site specific stability analyses proposed must be performed in accordance with specific procedures and to pre-established limits, neither of which have been presented to date by NWA. Without pre-determined limits and procedures, there could again be an inclination to develop criteria to satisfy design rather than developing designs to satisfy criteria.

The discussion concerning changed conditions is somewhat confusing when evaluated from a realistic viewpoint. In fact, the pipeline alignment will of necessity be set in stable terrain at an early stage of design (in order to avoid recycle). Any changes in conditions will likely be toward the less stable end of the spectrum necessitating redesign, reroute or special design. Discovery of more favorable conditions will be comforting but will generally not result in redesign. NWA's emphasis seems to be in an opposite direction.

3.7, Page N3-19 -- Solutions

"The initial route selection criteria and process provided considerable emphasis on the avoidance of areas of potential terrain instability." Refer to the attached mile-by-mile comments. There are many potentially unstable areas along the NWA alignment. Avoidance of potentially unstable areas has obviously not yet been achieved.

3.7.1, Page N3-20 -- Significant Potential Geotechnical Impacts

Detailed criteria, design procedures, and construction specifications must be developed for each of the mitigative solutions listed before any or all of them can be considered as an adequate solution to potential stability problem areas.

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BLASTING, TAB 4

Item 4.2, Page N4-1 Definition of Issue

TAPS does not agree that production blasting can be conducted safely by NWA in close proximity to TAPS unless:

1. Blasting criteria are in compliance with criteria and restrictions given in "Blasting Restrictions Near the Trans Alaska Oil Pipeline System" dated May 8, 1979 or revisions thereafter.
2. Blasting specifications are established by NWA which ensure the application of criteria established in the document named above.
3. Quality control procedures are established by NWA which guarantee the blasting is done in conformance with the specifications.
4. Quality assurance procedures are established that guarantee that all quality control procedures are addressed and applied in actual practice.
5. NWA is fully liable and able to pay for any damage to TAPS including damage due to lack of or diminished throughput caused by their blasting activities.

The major issue from TAPS viewpoint is not the technical feasibility of blasting, but rather, how can blasting be controlled to the point where pipeline damage would not occur under any circumstance. With due consideration to the large amount of blasting to be done, the possibility of encountering unanticipated soil conditions and the possibility of human error or sabotage, TAPS cannot determine whether or not blasting is safe until the procedures and criteria described above are developed and submitted by NWA.

4.3.2, Page N4-2 -- Adjacent Facility Configuration

When blasting adjacent to TAPS above-ground, flyrock containment will be required.

4.4.2.2, Page N4-4 -- 1977 Test Data

The 1977 test was not representative of production blasting techniques and therefore is of questionable value in justifying blasting procedures.

4.4.2.3, Page N4-5 -- SWRI Test Report

This section states that "some portions" of the SWRI Test have limited applicability. It would be more appropriate to state that most of the report has limited application to blasting along TAPS.

4.7.1, Page N4-8 -- General Solution

Particle velocity of eight inches per second is too high.

Alyeska has offered recommendations for blasting criteria for different distances from the existing oil pipeline. These criteria are, however, different from those proposed by NWA. More recently, Alyeska has recommended that a detailed blasting analysis and site supervision be required for NWA blasting from 0 to 60 feet from TAPS.

NWA should be required to submit to TAPS a general blasting plan which would include:

1. Maximum charge/delay
2. Type of explosive to be used
3. Total charge
4. Total holes/blast
5. Time schedule
6. Depth of excavation
7. Probable soil type

<u>4.7.2.1, Page N4-10 -- Ground Rupture Effects</u>

Depth of charge as a function of distance should be 1/5 (as specified by TAPS in the past) instead of 1/4 to 1/5.

<u>4.7.2.2, Page N4-10 -- Flyrock Control</u>

NWA has identified the problem of flyrock but has offered nothing specific on flyrock control. TAPS doubts that blasting mats will be sufficient.

<u>4.7.2.4, Page N4-11 -- Monitoring of Blast Effects</u>

This section contains only a general discussion by NWA of blast effects. If a criterion of six to eight inches per second is agreed to by TAPS and NWA there will be a need to monitor high frequency motions. NWA will therefore be required to measure more than the low frequency component.

<u>4.7.2.6, Page N4-12 -- Structural Responses of the Pipeline System</u>

NWA needs to monitor the test blasts with equipment sophisticated enough to measure vibration at different distances from the blast to define frequency ranges in which the motions are being sent out. These defined frequency ranges will be required to evaluate the tests.

4.7.2.8, Page N4-13 -- Sound Levels

NWA should consider sound levels caused by detonation of primer cord in addition to the blast itself.

4.7.2.10, Page N4-14 -- Quality Control and Inspection

NWA appears to be overly optimistic with regard to Quality Control during production blasting. NWA should address specifically the details of an adequate Quality Control Program.

RISK ANALYSIS, TAB 5

5.2, Page N5-1 -- Definition of Issues

The April 30, 1979 submittal by TAPS include an analysis of the construction related risk posed to TAPS by the gas pipeline. Yet the NWA overview of the risk analysis stated, "the concern is the probabilities for damaging the TAPS pipeline during construction or operation." There is no need to determine the probability of damage to TAPS -- the TAPS construction risk analysis has shown that damage will occur. Indeed, in NWA Center Point Justifications, it is acknowledged that there is a 100% probability of an accident occurring to TAPS.[1/]

An incident which occurred on March 10, 1980 confirms this. A tracked vehicle in a TAPS restricted area, encountered an area of aufeis, lost traction and skidded into the TAPS above-ground pipeline. The slope in the area was not extreme. This raises concern that many areas along the aboveground sections of TAPS will be subjected to significant risk of construction damage if the gas pipeline is constructed in close proximity to TAPS.

The above incident supports the validity of the earlier risk analysis, emphasizes our contention that NWA should not

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1/ Exhibit Z.7, Center Point Justification, Volume V, P4-30, FERC Submittal.

be located in close proximity to TAPS, and suggests that the proposed NWA risk analysis rather than discussing the probabilities of damage should, among other things, determine the realistic number of potential occurrences of damage to TAPS during construction of the gas pipeline. The Center Point Justification discusses the most likely case as being ten minor accidents where runaway equipment collide with VSM. No other types of accidents are included.

5.3.1, Page N5-2 -- Direct Oil Pipeline Damage
5.3.2, Page N5-4 -- Failure of the Oil Pipeline Associated Facilities and Equipment

Included in the analysis should be an assessment of risks to TAPS resulting from:

1) Temporary cofferdams, access roads, material sites and bridges in the river and floodplain areas in the event of a major flood.
2) The occurrence of a major flood prior to the completion of modifications to TAPS structures, and/or construction of new structures, and/or rehabilitation of a structure breached by NWA.

Regarding the first concern, the design of temporary works shall be such that the risks to TAPS are comparable to the probability of a PDF during the life of the line. Permanent structures shall be designed for the PDF if they can have an effect on TAPS.

Regarding the second concern, NWA's construction scheduling must ensure that there is an absolute minimum delay between time of impact (clearing new right-of-way or breaching a structure) and completion of remedial measures. A breached structure should be repaired immediately following laying of the pipe. This is particularly a concern where shoulder month construction is shown on the civil drawings whereas the environmental constraints indicate a June - August construction season. Examples are the Dietrich River segments from MP185.5 - MP186.0 and at MP186.7. In the case of a cleared right-of-way, the remedial measures may have to be done immediately following clearing and the new or modified structure breached only during the pipe laying period.

<u>5.4.2, Page N5-7 -- Pipeline Construction Statistics</u>
<u>5.4.3, Page N5-7 -- General Construction Statistics</u>

These sections indicate that existing pipeline data will be used for the risk analysis. Such data alone will be inadequate since literally no experience in Alaska is included. Yet it is imperative that weather, light, temperature, and terrain conditions existing in Alaska be considered in any adequate study of risk of damage to TAPS. By way of comparison, NWA should consider that about 30 percent of the total U.S. pipeline mileage is in Texas where construction and operating circumstances that might contribute to accident frequency rates are very different from those in Alaska. Equally imperative is the proper weighting of the construction of a second large diameter pipeline adjacent to an existing aboveground large diameter pipeline. To our knowledge there are no statistics available for this situation. Of course, there are numerous cases where an owner is looping his own belowground facility, but this is an inappropriate comparison.

5.6.2, Page N5-10 -- Oil Pipeline Structural Resistance Evaluation

The most disturbing part of 5.6.2 is: "The resistance of the oil pipeline, and its support systems, to the type of damage outlined in section 5.3 will be evaluated." This candidly acknowledges that aboveground facilities or portions of the aboveground pipeline will be impacted by projectiles, construction equipment, or other objects from adjacent construction that might damage the pipeline, interrupt throughput, and result in oil spillage and consequent damage to the environment.

6.5, Page N6-6 -- Design Criteria

TAPS reserves comment until criteria are developed. The seismic design criteria being developed by Dr. Nathan Newmark should be very similar to that used by TAPS. The federal and state stipulations mandate the same Richter magnitudes.

DITCH STABILITY, TAB 7

The entire issue of ditch stability is one of the most crucial design/construction issues which NWA will face. The results of their efforts, or lack thereof, in this area could have a direct impact on the integrity of the TAPS line in areas where they are proximate. The simplistic solutions proposed by NWA cause one to wonder whether a real understanding of the seriousness of the ditch stability issue exists.

The proposed solutions of shoulder month construction and the use of insulation over the pipe may or may not be adequate to handle ditch stability problems. No mention is made of the problem of ditching in saturated thawed soils nor of water control measures prior to, during, and after ditching. Comments previously made by TAPS concerning the need to protect insulated portions of the workpad north of the Brooks Range are likewise not addressed.

Comments presented by TAPS on the succeeding pages raise concerns which must be addressed by NWA at the very earliest if proximate construction is to be in any way acceptable to TAPS.

7.2.1, Page N7-2 -- Sloughing of the Ditch During Construction

Other problems which should be addressed by NWA are:

- Loss of pad material into the trench,
- Pipe bedding problems,
- Intersection of the TAPS thaw bulb which could cause thaw plug instabilities,

- Cross slope failures. (A ditch opened by TAPS just south of Delta on an 8 percent cross slope triggered a slope failure that resulted in progressive movement encompassing land 130 feet upslope of the ditch.)

7.2.3, Page N7-2 -- Thaw Prior to Startup

One major problem NWA must address with thaw prior to startup is thaw settlement during the dormant period and the resultant pipe deformation followed by frost heaving of saturated fine-grained soils after startup.

7.5.1, Page N7-4 -- Thermal State of the Soil

The statement that "only frozen soils were considered for evaluation of the ditch instability problem" is inconsistent with the first of the main issues given on Page N7-1. Active layer conditions and thaw bulbs as well as saturated thawed soils will create ditch stability problems and must also be considered by NWA.

7.6, Page N7-5 -- Design Procedures

The design process for ditch stability should not be separated from design processes for mass movements (thaw plug, slope stability, and liquefaction). Ditch stability must be evaluated on broader terms. The procedures outlined in this section take a limited look at the ditch wall without looking macroscopically at the whole slope. An analysis of the whole slope by NWA is necessary to assess the impact of NWA on TAPS.

7.6.1, Page N7-6 -- Alternatives from which Solutions were Selected

Alternative construction solutions are merely stated. Criteria and typical drawings should be referenced.

7.7.1, Page N7-6 -- Solution for the Construction Period Concern

Shoulder month construction can only be used to avoid some of the ditch stability problems. North of Delta Junction about 90 percent of the geotechnical alignment sheets indicate trench stability as being a problem. The remaining 10 percent are scattered. Therefore, construction spreads will continually be running into trench stability problems.

The construction periods indicated by NWA conflict in certain instances with allowable periods from an environmental viewpoint. For example, the Dietrich River area (A.S. 33) is shown as "shoulder month construction" whereas the environmental schedule indicates a requirement for June-August construction.

7.7.2, Page N7-7 -- Solution for the Dormant Period Concern

Thaw settlement associated with placement and removal of the spoil pile has not been addressed. Damage to the surficial vegetation could result in a deeper active layer which will melt the underlying soil. The thaw strain associated with the melting could create ponding and new drainage channels resulting in thermal and hydraulic erosion.

7.8.1, Page N7-9 -- Ditch Stability Field Tests

The success of ditching in frozen ground will not be known until the completion of the 1981 field tests. The planning for these tests still appears to be in the preliminary design phase. Only general descriptions are given.

<u>7.8.2, Page N7-10 -- Thermal Analyses</u>

Board insulation across the ditch may be an adequate dormant period solution. However, no calculations are provided to support the chosen insulation thicknesses and widths. Additionally, groundwater flow through the thawed ditch backfill has not been considered. This could significantly increase thaw and has been a problem for the TAPS fuel gas line.

<u>7.8.3, Page N7-10 -- Evaluation of TAPS Workpad</u>

TAPS has commissioned several reconnaissance overflights and is in the process of developing workpad reuse criteria. The 1980 NWA workpad field program startup at last report is at least three weeks behind schedule. TAPS encourages cooperation between NWA and TAPS to insure that a maximum amount of information is gained during this effort.

<u>TAPS CROSSING AND HIGHWAY CROSSING, TAB 8</u>

<u>8.3, Page N8-1 -- Categories</u>

The number of crossings of TAPS bears no relationship to the risks involved. NWA crossings of TAPS appear to be controlled only by a desire to increase design flexibility and to reduce investment costs.

<u>8.3.1, Page N8-1 -- Route Constraints</u>

NWA could pass north of TAPS Pump Station 1 and no crossings of TAPS would be required. There is no requirement that NWA utilize the Yukon River Bridge to cross that waterway. It would appear from the submittal that the secondary constraints are not substantive enough to require the 23 crossings proposed.

<u>8.3.2, Page N8-2 -- Geotechnical Constraints</u>

TAPS requires that NWA be downslope where the routes are proximate. NWA has included location downslope as one of their primary siting criteria. Decreasing the number of crossings does not <u>a priori</u> place NWA upslope of TAPS.

<u>8.3.3, Page N8-2 -- Hydrological Constraints</u>

A decrease in the number of TAPS crossings does not necessarily lead to less optimum river crossings. For example, the crossing at MP 174.5 can be eliminated by following west of TAPS in the active portion of the North Fork of the Chandalar River -- a realistic construction during the shoulder months. In other instances where a crossing cannot be avoided, the location selected by NWA is at times very questionable both from their viewpoint and potential impact on TAPS. The Middle Fork Koyukuk-Hammond crossings at MP 227.66 - 229.4 are examples, as detailed in the mile-by-mile analysis.

8.3.6, Page N8-2 -- Construction Constraints

This area of NWA concern appears to be the major reason for TAPS crossings. Specifically their desire is to reduce workpad construction costs by utilizing the TAPS workpad and to maximize accessibility to NWA and minimize haul and backhaul distance. The alleged decreased costs computed by NWA do not justify the increased risk to TAPS.

8.5, Page N8-4 -- Design Criteria

NWA in this submittal has violated in 61 locations their own siting criteria which states "the gas line will be located on the downslope side."

8.7, Page N8-5 -- Solution

See, mile-by-mile analysis, *infra*.

9.5.1, Page N9-6 -- Stipulations

3.4.3.1

The Federal stipulations do not adequately address the potential impact of the NWA hydraulic structures on TAPS. The following should be required of NWA:

Where culverts and bridges could affect existing works designed for "Standard Project Flood" conditions, the structures shall be designed so that they have no impact on these existing works during the Standard Project Flood.

3.4.3.2

The Federal stipulations do not adequately address the potential impact of the NWA hydraulic structures on TAPS. The following should be required of NWA:

Culverts installed which might affect flow conditions at existing facilities, shall be designed in such a manner not to affect such facilities during their design conditions.

9.5.3.2, Page N9-7 -- Scour and Minimum Cover

A minimum cover depth of 2.5 feet could result in impeding subsurface water flow which could cause increased aufeis. This could be a concern particularly where TAPS is elevated over a minor stream. NWA should be able to document that it is not a problem or increase the burial depth such that the line does not affect aufeis development.

9.5.4.1, Page N9-8 -- Criteria for Drainage Structures

Temporary drainage structures may be designed for the 5-year flood provided they do not affect TAPS. Where no effect on TAPS cannot be shown to be the case, the design flood magnitude should be selected so that the probability of its occurrence during the life of the structure is equal to the probability of occurrence of the PDF during the life of TAPS. Permanent structures must be designed for the PDF where they could affect TAPS during PDF conditions.

9.5.4.2, Page N9-8 -- Criteria For Drainage Structures

Where new access is required, structure selection should be based on an assessment of potential impact on TAPS as well and the appropriate criteria as outlined in Section 9.5.4.1.

Use of TAPS existing permanent structures by construction equipment may require extensive upgrading. This is particularly true for permanent workpad bridges, culverts, and low water crossings.

Significant rehabilitation of TAPS crossings will be required prior to reuse of these crossings. Where TAPS culverts are extended, the extension design must be compatible with TAPS and provision must be made for thawing the culverts. Low water crossings are the preferred method of crossing streams due to the lack of thawing requirements during operations.

FISH AND WILDLIFE HABITAT, TAB 10

No Comment

FISH AND WILDLIFE POPULATION, TAB 11

No Comment

EROSION CONTROL AND VEGETATION, TAB 12

12.6, Page N12-7 -- Design Procedures

NWA indicates that, "Application of erosion and revegetation design criteria has been included in the design in Enclosure B." If Enclosure B is intended to indicate the civil cross sections and alignment sheets, it should be noted that there are no criteria presented in these documents.

12.6.8, Page N12-11 -- Material and Disposal Site Design

Study of hydrologic data should include an assessment of the following on TAPS integrity:

1. Access roads and bridges or culverts,
2. Temporary diversion dikes, and
3. Mining extent and depth.

Material sites could result in:

1. Riverbed scour,
2. Channel switching,
3. Additional back migration,
4. Promotion of a channel cut off, and
5. Increased velocities and water levels at TAPS structures.

12.6.10, Page N12-12 -- Erosion Control During Construction

Plans prepared for stream diversions must include an assessment of the impact of the temporary works on the integrity of TAPS. NWA should select a design flood magnitude such that the probability of its occurrence during the life of the structure is equal to the probability of occurrence of the PDF during the life of TAPS.

SECTION V

Comments On FERC Application, Volume 7, Design Manual, Exhibit Z-9.1, Pipeline And Civil Design

1.0 PIPELINE DESIGN

1.1, Page 1-1 -- Pipeline Route Selection Criteria and Route Description

The fourteen criteria used by NWA in their route selection are not given the proper priorities. Minimizing the crossings of TAPS and maintaining a safe separation between the gas and oil pipelines should be the second and third most important criteria, respectively. NWA has made an attempt to reduce the number of TAPS crossings, but the number must be further reduced. The crossings are discussed in more detail later.

It is apparent from the submittal that NWA places too high a priority on using existing facilities. Whether use of existing facilities is cost effective is doubtful. TAPS has previously transmitted a cost analysis to NWA which showed no cost increase due to construction along the haul road compared to rehabilitating the TAPS workpad and constructing a protective barrier.

Building a new workpad will require additional soils exploration not included in the above cost estimate. However, the additional effort is justified because it would ensure the most technically feasible, safe, and economically viable route is selected. In areas where the gas and oil pipelines are close together and geotechnical problems exist, at a minimum, alternative routes should be investigated.

1.5, Page 1-14 -- Pipeline Ditch Design

The proposed ditch types do not adequately address all geotechnical problems. The ditch types are discussed in Attachment I as one of TAPS major concerns. No stationing is given for the different construction modes in the pipeline alignment sheets.

1.5.1, Page 1-16 -- Ditch Stability

Construction in all areas of potential ditch instability cannot be completed during the shoulder months. All but 10 percent of the alignments sheets north of Delta Junction have potential areas of ditch instability.

1.5.2, Page 1-16 -- Backfill Materials To Be Used In Pipeline Ditch

No procedures are given for placing backfill in a wet ditch. When non-frost susceptible backfill is needed, it is necessary to prevent the backfill from being contaminated with native soil. This may be difficult if the trench is undergoing thermal degradation and is not in good condition.

1.6, Page 1-17 -- River And Stream Crossings

Where NWA crossing of training structures could affect TAPS or where additional structures are needed to protect TAPS, the NWA computed PDF used to assess impact on TAPS must be equal to or larger than TAPS PDF.

Assumptions of a specific gravity of 1.0 and a negative buoyancy requirement of 5 percent seem low for silt-laden streams. If the pipe floats it will be a serious concern to TAPS if:

additional fill is placed over high pipe to obtain necessary cover depths;

the floating pipe causes blockage of subsurface flow and increased aufeis; or

the floating pipe results in local scour at TAPS -- where TAPS is located downstream -- as a result of flow over the obstruction.

A minimum cover of 2-1/2 feet at unclassified crossings could have effects upon TAPS similar to the conditions listed above.

1.8, Page 1-20 -- Other Pipeline Crossings

For pipeline crossings of TAPS buried line, NWA states that: " . . . the gas pipeline will cross above it (TAPS) as nearly perpendicular as practical and will be protected by an earthen berm." At buried crossings in the floodplain such as: Atigun M.P. 165.75 and Chandalar M.P. 172.5, the berm could result in local scour and flow channelization affecting TAPS.

1.8, Page 1-20 -- Design Criteria

The minimum clearance from "ditchline" to VSM is listed as 15 feet. However, several of the crossings shown on the mile-by-mile drawings are at such shallow angles that this clearance cannot be maintained. The term "ditchline" is interpreted as the edge and not the centerline of the ditch. In fine grained, frozen soils where trench stability is a problem, 15 feet of clearance from VSM to edge of initial "neat" excavation is insufficient.

The minimum separation clearance between TAPS and NWA which is listed as 12 inches is not acceptable to TAPS Owners. TAPS owners are concerned that excavation with construction equipment is too imprecise to permit such close positioning without excessive risk of damaging TAPS during construction. Such proximity will also pose problems for future maintenance.

The crossing angle criteria of 70° to 90° is reasonable. Calculations show that 70° is about the minimum possible crossing angle to provide acceptable clearance between the NWA ditch and the TAPS VSM. The crossing configuration shown on Figure Z-9.1-1-7 referenced herein does not, however, reflect the manner in which field bends are made in joints of pipe and how those joints are fabricated into a pipeline.

1.12, Page 1-23 -- Pipelines Spatial Position And Physical Condition Monitoring System

A system with very desirable capabilities is described, but there is no indication of how the system will be developed.

1.14.1, Page 1-29 -- Design Approach

NWA states that severe geotechnical loading conditions are not directly considered in structural stress analysis. The conditions include:

slope instability caused by construction or natural processes;

seismic liquefaction and subsidence;

erosion; and

thaw plug instability.

If these loading conditions are not considered, TAPS could be jeopardized where the two pipelines are proximate.

Vacuum is also not considered in the stress analysis. A vacuum condition can exist during dewatering after hydrotest.

Title 49 C.F.R. 192 does not specify levels of maximum stress as claimed; it does, however, provide a formula relating design pressure to yield strength, nominal wall thickness, nominal diameter, design factor, joint factor and temperature derating factor. From this equation a maximum permissible hoop stress can be implied.

<u>1.14.1, Page 1-32 -- Overburden</u>

Frost heave will also cause overburden to exert additional primary circumferential bending stresses as well as secondary longitudinal bending stresses. The circumferential stresses will be developed as a result of frost heave modifying the lateral restraint modulus of the padding and ditch wall.

<u>1.14.1, Page 1-34 -- Stress - Strain Relationships</u>

This section implies that there are only two widely accepted theories of failure. Actually, there are several. In addition, the hoop stress is not the major principle stress as implied by this section. A more precise statement of the Tresca effective stress is:

S_{eff} = MAX ($|S_1 - S_2|$, $|S_1|$, $|S_2|$)

S_{eff} = Maximum stress intensity

S_1 = Major principle stress

S_2 = Minor principle stress

If the von Mises criterion more closely complies with test results for other pipelines, then this data should be referenced or produced for review and evaluation.

If, as stated, the von Mises and Tresca criteria "do not indicate any of the inelastic stress and strain behavior beyond the proportional limit," then they cannot be considered as appropriate to "predict the onset of yielding." The proportional limit is significantly lower than the yield stress.

1.14.1, Page 1-36 -- Basis For Criteria

At the top of this page it is stated that bending stresses "may be added directly to the membrane stress" which implies that these stresses are of the same nature as membrane stresses. In the second paragraph of this section, it is stated that a higher factor of safety is applied to membrane stresses than to bending stresses due to the nature of the two stresses. This apparent discrepancy is a result of failure to differentiate between beam bending and wall thickness bending.

1.14.2, Page 1-39 -- Combined Membrane And Bending Stress

This section should also include increased hoop bending as a result of frost heave adversely affecting the lateral restraint modulus.

1.14.2, Page 1-39 -- Combined Membrane And Bending Strain

This section implies that bellows wrinkling is incipient at 0.35 percent compressive strain during construction. This hardly seems likely as it is well within the elastic region of the stress-strain diagram.

1.14.2, Page 1-41 -- Ovalling During Construction

NWA proposes to allow a maximum circumferential stress of 0.8 SMY due to overburden in the unpressurized case. The effects of construction traffic should also be added to this case.

1.14.3, Page 1-49 -- Structural Stability

No calculations are provided for stability considerations. Note that the equation for F_3 should be:

$$F_3 = -PA_p$$

If elastoplastic buckling is a likely mode of failure then the Euler formula will not serve as an appropriate prediction of failure.

The Euler formula for a column with restrained ends is:

$$F_{cr} = \frac{\pi^2 EI}{4L^2}$$

which can be transposed to calculate a critical length as:

$$L = \left[\frac{\pi^2 EI}{4F}\right]^{1/2}$$

There is a significant disagreement between this equation and the equation used by NWA.

<u>1.14.4, Page 1-52 -- Bend Design</u>

If NWA "bend design criteria are based on conventional practice established for unfrozen soil," NWA should be well aware that conventional practice for unfrozen soil is that bends are not designed, but placed in the ditch to satisfy route terrain and geometry. In as much as this assumption is at conflict with the remainder of this section, NWA appears to relate conventional practice to design methods developed by TAPS.

It may be that NWA bend design methods are based on procedures pioneered by TAPS, but this is hardly conventional practice. Little if any of TAPS bend design criteria are extendable to frozen soil; this is an area where <u>new</u> criteria are required.

<u>1.14.4, Page 1-53 -- Axial Restraint</u>

β in this equation is not defined nor is the value for beta of 20° substantiated as being reasonable or conservative. The value for should always be taken as the buoyant value to provide a conservative solution, as flooding in a thawed ditch can occur even on the slopes of an alluvial fan.

<u>1.14.4, Page 1-54 -- Sidebend Restraint And Overbend Restraint</u>

Again, γ should be taken as buoyant to provide for a conservative design. This requirement has been confirmed by TAPS as being required for all sidebends and almost all overbends, based on field experience.

1.14.4, Page 1-57 -- Frost Heave Interaction Effects

Uplift resistance should also include bond strength on the bottom half of the pipe. The method for determining the shear strength of frozen soil is not defined. The only definition of shear strength in Section 1.14.4 is the 25-year creep strength.

1.14.4, Page 1-58 -- Frozen Soil Uplift Resistance

The frozen shear strengths given by NWA are significantly lower than might actually occur.

1.14.5, Page 1-63 -- Elevated Pipeline

NWA indicates that "Stress Criteria (Elastic Analysis) as defined in applicable code" will be used. A more specific reference is required.

1.14.5, Page 1-65 -- Special Crossings

Specific criteria for special crossing situations should be developed prior to the need to design such crossings. Simultaneous development of criteria and design almost always result in criteria sufficient to justify design rather than design to satisfy criteria.

1.14.5, Page 1-66 -- Liquefaction

This section says that liquefaction potential will be determined, but does not describe design procedures or mitigative measures.

1.14.5, Page 1-67 -- Slope Instability

This section says that slope instability will be determined, but does not describe design procedures or mitigative measures.

Figure Z-9.1-1-12 -- Buried Pipe Cross Section

Only buoyant values should be used for .

Figure Z-9.1-1-15 -- Bending Of Pipeline Due To Differential Frost Heave

This drawing does not show the freeze bulb adhering to the pipeline.

2.0 CIVIL DESIGN

2.1, Page 2-1 -- Pipeline Construction Zone

NWA states that the preliminary design of the pipeline construction zone is presented and is derived from the design criteria. NWA has not presented the criteria. One particular omission is how TAPS workpad will be upgraded/rehabilitated. There are significant areas shown on the Civil Construction Drawings (4680-12-00-B-C series) with no proposed rehabilitation or widening of the TAPS pad.

In the design of the mile-by-mile cross sections, NWA states that special consideration will be given to ". . . appropriate clearances" for protection of existing facilities "such as the TAPS pipeline [and] fuel gas pipeline . . . ." NWA should define "appropriate."

2.1.2, Page 2-2 -- Clearing

Where clearing by NWA adjacent to TAPS results in additional flow (overbank) along the cleared right-of-way, it may be desirable to reduce clearing widths to an absolute minimum where the right-of-way exits from the main channel area. This will minimize the need for an extension of additional river training structures across the cleared right-of-way.

2.1.3, Page 2-3 -- Grading

The criteria referred to on drawings 4680-10-00-C-001 and 002 are not criteria but simply an explanation of the proposed workpad cross sections as proposed by NWA. Cut sections on the high side of TAPS could alter drainage patterns, create aufeis or create slope stability problems. Cut sections on the high side of the haul road could reduce the cover or expose the fuel gas line. Thermal integrity of the FGL or VSM could be jeopardized by these cuts.

2.1.3.1, Page 2-4 -- Excavation

NWA states: "Positive measures will be used to stabilize cuts where self-healing is not possible. These methods are included elsewhere." A more specific reference is needed. The information described could not be located.

2.1.3.2, Page 2-5 -- Embankments

NWA states: "The design of embankments will also assess the use of insulation board and engineering fabrics for reducing embankment thickness at appropriate locations." NWA should develop criteria for use of insulation, particularly over the fuel gas line and adjacent to insulated workpad.

2.1.4, Page 2-5 -- Disposal

NWA states: "Cleared timber and slash will be disposed of by burial in the workpad or access roads wherever compatible with design." TAPS design criteria permitted disposal under workpads only under certain conditions.

It is also noted that: "Excess materials may be spread along the workpad and access roads, as appropriate." TAPS needs criteria for materials to be spread along the workpad.

2.1.5, Page 2-6 -- Workpad Width

The requirement to maintain a 15 foot safety zone to TAPS has been omitted by NWA in the requirements used to establish the workpad reuse width.

2.1.5.4, Page 2-8 -- Location of Relative Facilities

NWA states: "a protective barrier will be placed to protect the TAPS when it is in the aboveground mode." A barrier will also be required when TAPS is in the belowground mode. Preliminary criteria for a barrier are given on Page II-1 of Section II.

2.1.5.5, Page 2-8 -- Cross-Sections Selection

Where NWA uses a stepped fill, a cut, or cut/fill section to maintain the geometric requirements, the design must ensure uninterrupted access for TAPS, and the integrity of TAPS' workpad and drainage structures. Deterioration of the latter could affect the integrity of TAPS. NWA must submit criteria and more nearly definitive drawings before the proposed designs can be properly reviewed.

2.1.6.1, Page 2-10 -- Workpad Thickness Design

The design procedure appears to be reasonable for new workpad construction, however, no procedures are presented for rehabilitation of the TAPS workpad. Methods for field modification of the workpad thickness should be considered. No standards for workpad embankment materials are presented.

2.1.7, Page 2-12 -- Erosion Control And Drainage

No mention is made of protection of TAPS facilities or compatibility with TAPS drainage structures. Erosion control techniques should be preventive rather than remedial in nature.

2.1.7.2, Page 2-14 -- Erosion Control Structures And Measures

No mention is made of compatability with TAPS structures. All of the NWA drainage structures must be (1) equal or better than TAPS structures; (2) must have alignment and location which is consistent with TAPS; and (3) equal or better hydraulic capacity. Alteration of drainage patterns by workpad extensions will require additional drainage structures which must protect TAPS facilities from erosion damage.

The extension of the workpad will result in increased drainage area which will require the construction of additional transverse levees across the workpad. Problems of blocked drainage due to frost heave of the chilled gas pipeline have not been addressed. Blocked drainage downstream of TAPS could produce serious integrity problems, because the increased water table could result in soil stability problems. Further, altered drainage patterns could produce serious thermal and hydraulic erosion.

2.1.7.3, Page 2-17 -- Culverts and Bridges

No mention is made of compatability with TAPS. In this section on drainage structures, NWA states: "Access will not be provided across channels where means of crossing exist (haul road or TAPS workpad)." Many of the TAPS structures are suitable only for light inspection and maintenance traffic. Significant rehabilitations and upgrading would be required prior to use by heavy construction traffic. Some culverts lack sufficient fill over the culvert to prevent crushing by heavy wheel loads. Additional low water crossings have been installed since the termination of construction activities. These may not be suitable for heavy construction traffic. No mention is made of procedures for rehabilitation and/or upgrading of these structures.

Where NWA structures could affect TAPS crossings and river training structures, the design should ensure that TAPS integrity is not affected. This may require a design flood for NWA culverts and bridges greater than the 50-year flood.

Temporary structures may require greater than a 5-year flood design where they could affect TAPS integrity. The design must be such that the probability of the design flood during the life of the structure is equal to the probability of the PDF during the life of the pipeline.

2.1.8.1, Page 2-22 -- Restoration

It appears that all fill slopes will be placed at 1:1 during construction and flattened out following construction. In permafrost areas this may increase thaw penetration due to terrain alteration at the toe of the slope, resulting in the establishment of new drainage channels.

2.1.9, Page 2-23 -- Site Specific Areas

TAPS crossings by the gas pipeline and access road should be included as areas warranting site specific designs.

3.0 FROST HEAVE

Detailed comments on frost heave are presented in the review of Tab N1 of Volume V of "Supplement to Application for Right-of-Way Grant" to the Department of the Interior. Almost all of the information presented in Section 3 is also contained in Tab N1. Comments presented here address only the new tables and figures presented in Section 3.

Figure Z-9.1-3-1 -- Frost Depth Below Pipe Bottom At 25-Years

This figure gives the only results of soil thermal calculations included in the submittals to FERC and DOI. Much more work has certainly been done but was not included for review.

Figure Z-9.1-3-2 -- Nomogram For Determination Of Total Excavation For Varying Gas Temperatures And Insulation Thickness

Methods used to develop this figure are not explained. Are the relationships conservative for all soil types?

Table 3-1 -- Criteria Used To Define Frost Heave Potentials

This table is less conservative than a similar table given in the NWA progress report on Enclosure C, dated February 29, 1980. The latter assigned a high heave potential to any soil with greater than 20 percent silt content. Now, for soils with greater than 12 percent silt content, the groundwater table must also be considered. Further, the limiting water table depth was 40 feet. Now, the table refers to a design frost bulb depth. No values of this parameter are given.

Table 3-2 -- Frost Heave Potentials Resulting From Geotechnical Conditions, States, And Confidence Limits

The right-hand side column headings should be "confidence level" and not "frost heave potential." No criteria for a reasonable confidence level are given.

Table 3-3 -- Geotechnical Assessment Criteria For Frost Heave Potential Determination

There are really only two confidence levels, high and low. High and moderate are always grouped together in Tables 3-1 and 3-2.

Page 3-28

NWA should not overrule field log interpretations of frozen soil without supporting data such as soil temperatures or resistance measurements.

The term "mixed frozen/thawed profile" is not explained. How much frozen or thawed soil must be present before the profile is referred to as mixed? Has a design active layer been defined?

Page 3-29

How high must the silt content be before the possibility of observing an accurate groundwater table is precluded?

NWA must assess not only the probability of a low silt content but also the probability of a high silt content. If 90% of a given segment has a low silt content but the other 10% has a high silt content, then the probability of differential heave is high.

4.0 GEOTECHNICAL CONSIDERATIONS

4.2, Page 4-1 -- Field Exploration Programs

While NWA has expended considerable resources drilling some 800 boreholes to date, as well as completing significant geophysical investigation programs, these programs fall far short of providing adequate design data for the gas pipeline.

The information developed to date by NWA supplemented by the data purchased from TAPS should provide a framework for preliminary route evaluation and geotechnical characterization. However, NWA will require several times as many borings as already drilled in order to develop and justify the final design for the gas pipeline.

4.3, Page 4-2 -- Laboratory Testing

The tests being run by NWA on route soil samples are described in general but no details of the criteria used for determining such tests are run on any sample are given. This information would be useful in evaluating the thoroughness and applicability of the laboratory testing program. Additional information on the sample testing basis is also required in order to assess the reliability of the program being used to develop landform engineering properties.

4.4, Page 4-3 -- Alyeska Pipeline Service Company Data

If as indicated, the TAPS data is just now being incorporated into the geotechnical design, the preliminary design of the gas pipeline presented by NWA must be considered suspect in all areas where the lines are in close proximity until the TAPS geotechnical data are included, reviewed, and evaluated. In addition in many areas, such as pipeline crossings, the thermal conditions have changed since TAPS began operations. Additional borings will be required to evaluate the impact these changed conditions have on the gas pipeline design.

4.5, Page 4-4 -- Geotechnical Data Presentation

The route soil conditions alignment sheets are a combination terrain unit map and topographic map. A longitudinal profile is shown, but commonly obscured by the vertical soil layer interpretations. A map showing boreholes on a profile section is needed to supplement the terrain or landform maps.

4.6, Page 4-4 -- Route Soil Conditions Alignment Sheets

It is implied in this section that the route soil conditions alignment sheets will be the primary tool of geotechnical design engineers. The sheets are very difficult for a design engineer to use. The data are cluttered and the sheets fail to provide an easily readable guide to the boring logs which are the primary geotechnical engineering data points.

Terrain Unit Concept: The NWA design philosophy seems to put far too much weight on the establishment or delineation of landforms and terrain units and their general characteristics. Coming up with general design modes for various landforms and terrain units is satisfactory for a preliminary design, but the variability of engineering properties for soils within a given landform preclude their use for final design. It is also important to go beyond the generalities of landform and terrain unit concepts when establishing new data location. To do landform interpretations, borings are added to a unit established by air photo interpretations, where little subsurface data exists. However, to undertake complete geotechnical design it is probably more important to gather engineering properties at the interfaces of landforms where a mode change may be required.

4.6.1, Page 4-5 -- The Terrain Unit Map Band

The actual Soil Condition Alignment Sheets do not yet include all of the data listed in this section. In particular, information has not been included concerning faults and fault crossings, liquefaction prone areas, landslide debris, potential soil instability and resistivity traverses. Where NWA is close to TAPS this data is available in a form that is easily asessed.

4.7, Page 4-7 -- Route Geotechnical Characterization And Classification

The RG2C process is described, but no results are given. According to the NWA design procedure, specific soil parameters are chosen to characterize each segment by RG2C. The selection of these parameters is a major step in the overall design. Developing specific parameters actually used in design from the general soils data on the route geotechnical alignment sheets requires significant engineering judgment and analysis. [It is certainly possible that different engineers could develop slightly different interpretations of the same data base.] Without much more detailed information on the RG2C, the adequacy of the current construction mode selection cannot be determined. Since NWA has chosen construction modes, this information should be readily available.

NWA states that: "For a given level of acceptable risk, the necessary conservatism of the RG2C data must increase in proportion to the geotechnical variability, data base limitations, and engineering sensitivity of the design solutions to nonconservative error in the RG2C input data." Where the gas pipeline might be near the oil pipeline, TAPS must have detailed documentaton on how NWA performed the RG2C.

4.8 Geotechnical Design Products

4.8.1, Page 4-11 -- Soil/Pipe Interaction

Neither this section nor the referenced Section 1.0 contains an adequate discussion of soil/pipe interaction, the factors involved or the manner in which they are to be handled.

As noted in TAPS comments on Section 1.14.1, NWA's present approach of not considering slope instability, seismic liquefaction, erosion or thaw plug stability in their pipeline stress analysis could jeopardize TAPS integrity where the lines are proximate.

4.8.2, Page 4-11 -- Terrain Stability

The last line states: "The geotechnical assessment process considered the influence of present and expected future field conditions on stability, including effects of TAPS proximity and chilled pipe frost bulb growth." The geotechnical assessment must also consider thermal disturbance due to construction activities, thaw during the dormant period, workpad instability directed towards TAPS as well as other effects generated by NWA construction activity.

4.8.2.1, Page 4-11 -- Liquefaction of Level Ground

The discussion of soil liquefaction addresses only seismic compaction and flotation and as such completely misses the major concerns for pipeline integrity due to potential liquefaction. Liquefaction as it affects the pipeline and environment is a major concern because of the potential for mass movement due to liquefaction on sloping ground.

The items addressed by NWA, *i.e.*, seismic compaction and flotation, are relatively minor problems in comparison to the issue of soils liquefaction on sloping ground. NWA has failed to consider a very significant problem, namely, the problem of liquefaction on sloping ground.

4.8.2.1, Page 4-13 -- Design Applications

Although not mentioned, it is assumed that the design parameters and procedures used to evaluate potential liquefaction hazards will be consistent with those used by TAPS. NWA must also indicate how it plans to maintain the integrity of TAPS in areas where analyses indicate potential liquefaction hazards due to the presence of the gas pipeline.

4.8.2.1, Page 4-15 -- Proposed Design Procedures

In Step 4 a detailed liquefaction analysis is referenced but a parametric analysis seems to be what is actually described.

NWA states that one of the criteria for determining which slopes will require mitigative designs is that "computed permanent displacements exceed five inches under design contingency earthquake loading. . ." The TAPS design process used an identical criterion for slope stability evaluations, however, the 5-inch limit was determined from pipe stress/deformation considerations specifically related to TAPS. Has NWA developed their criterion independently using their pipe characteristics and conditions or have they merely adopted the TAPS criterion which in this case may not be appropriate?

4.8.2.2, Page 4-17 -- Design Application

The evaluation of slopes and the selection of mitigative solutions by NWA must take into account the presence of the TAPS line in proximate areas. NWA must address the effect of potential slope instabilities and mitigative measures on the integrity of the TAPS line in these cases.

The statement "the most appropriate form of mitigation solution is arrived at on the basis of its efficacy and sufficiency. . ." is unclear as to its intent and should be clarified by NWA.

<u>4.8.2.3, Page 4-20 -- Thaw Plug Stability</u>

It is stated that "developing thaw plugs will not be capable of adversely affecting pipeline integrity once a sufficiently large freeze bulb builds up around the chilled line." NWA needs to determine how large a freeze bulb is required to resist thaw plug instability.

Once again, NWA proposed to use a displacement limit of 5 inches under design contingency earthquake loading. The origin of this limit is questionable. (See comment under 4.8.2.2, Page 4-16 - - Slope Stability).

<u>4.8.2.3, Page 4-22 Step 4</u>

The displacement equation presented was developed by Newmark for determining displacements of earth fill embankments during seismic loading. Using this for thaw plug displacements is stretching the equation past its intended use. The thaw plug soils which are going to be most problematic are fine-grained and saturated. They will undergo a significant loss of strength during seismic loading and may even liquefy in these areas, movement will not be measured in inches but in feet.

4.8.2.4, Page 4-23 -- Thaw Strain

This section states that particular landforms are analyzed according to the average thaw strain expected. Thaw strain estimates for landforms should be based on worst case or 90 percent confidence values rather than average values for preliminary design or a design based on landform interpretation.

It was stated that organic layer thicknesses had been estimated, but none of the estimates were included in the submittals. Organic layer thickness is a very important variable not only in assessing settlement but also in thermal analysis.

NWA plans to tie thaw strain into landform because site specific thaw strain would be impractical. Site specific thaw strain analysis was done by TAPS and should be required for the gas pipeline.

First complete sentence on page 4-23 cannot be understood.

4.8.2.5, Page 4-24 -- Ditch Degradation Potentials

The discussion presented by NWA and ditch degradation potential (DDP) is interesting and, if properly developed and applied, has potential for ameliorating construction difficulties and mitigating thaw during the dormant period. The discussion as presented is qualitative and as such does not present the criteria to be used to determine DDP nor does it indicate the use to which the DDP's will be put.

It is suggested that DDP be determined independent of the time of construction and that this variable (time of construction) be used as a potential mitigative measure in areas of high DDP in initially frozen sails.

The success of using DDP to mitigate ditch degradation problems will depend on acceptance and use of this concept by the construction contractors as well as the development of supplementary solutions to prevent ditch degradation in high DDP areas.

4.8.3, Page 4-26 -- Geotechnical Thermal Analysis

The discussion on geotechnical thermal analysis presents a general statement on various concerns pertaining to thermal considerations; however, the purpose of this discussion is not clear. How will the concerns stated be applied? What impact will they have?

The thermal and mechanical analysis of geotechnical problems are not always independent. Sometimes there are dynamic changes in geometry and soil properties which require that this coupling be accounted for. This may be the case for frost heave.

NWA is correct that for some problems a simple analytical solution can be an adequate thermal analysis. However, until documentation of design calculations is made available, it is not possible to verify the appropriateness of their application. For example, NWA is proposing the use of slab insulation in the ditch to reduce permafrost degradation during the dormant period. Since the insulation is relatively narrow, it may be necessary to use a two-dimensional computer program rather than a one-dimensional analytical solution to arrive at an effective insulation design.

Table 4-3 -- Seismic Liquefaction Design Process

The outline on this table takes a good approach, but the text on liquefaction is a poor expansion of the outline. The most serious omission from the text is mass movement due to liquefaction on sloping ground.

5.0 HYDRAULOGICAL CONSIDERATIONS

5.1.1, Page 5-1 -- Design Floods

Where NWA could affect TAPS crossing and/or river training structures, the computed PDF must be equal to or greater than that of TAPS for the purpose of assessing the impact on TAPS.

If a structure designed for a Frequency Design Flood (FDF) or for temporary use could affect TAPS, a design flood as outlined in comments on Section 2.1.7.3 should be used for temporary works and the PDF must be equal to or greater than that of TAPS PDF to determine impact on TAPS.

5.1.2, Page 5-3 -- Flood Levels and Velocities

On steep braided streams the HEC-2 and/or HEC-6 analysis may not result in accurate site-specific answers. Local conditions such as islands and bars can affect design water levels. Where NWA construction and operation could affect TAPS and/or require additional protection for TAPS, a detailed assessment verified and/or modified according to field conditions will be necessary. River crossing limits shown by NWA on the "P" series of drawings generally indicate shorter river design areas than TAPS. For example, Dietrich River crossing at M.P. 185.7-NWA does not consider TAPS spur field area upstream within the river crossing limits. TAPS is concerned that by underestimating the areas subject to flooding, NWA is also underestimating segments of TAPS that could be affected by their proposed works.

5.1.3, Page 5-3 -- Scour

Where NWA's construction and operation could affect TAPS crossings and/or river training structures, NWA should assess the impact using methods comparable to those used by TAPS and where necessary should undertake remedial measures to protect TAPS. The remedial measures should be designed in a manner comparable to the approach used by TAPS.

TAPS is concerned about the impact of nominal 2-1/2 feet. cover depths at unclassified crossings. (See comments in Section 1.6.)

5.1.4, Page 5-5 -- Lateral Migration

NWA needs to develop design criteria and approaches for:

- Possible channel switching into material sites where this could affect TAPS. Material sites of concern are noted in the mile-by-mile review.
- Possible channel switching along the additional NWA cleared right-of-way next to TAPS. Probability of this will determine need for and design of river training structures.
- Channel switching on alluvial fans and their design approach for fans. TAPS design on some fans assumes that if and when major switches occur, the channels will be restored to their original location. NWA's design must insure that TAPS maintenance type approach in these instances is not precluded.

5.1.5, Page 5-6 -- Channel Control Structures

Additional control structures will be required if NWA's construction or operation might have an impact on TAPS that cannot be avoided in another manner. Structures should be designed using criteria equal to or more conservative than that used by TAPS.

Freeboard for structures subject to aufeis must be 3 feet above PDF level or 4 feet above aufeis level, whichever is greater. NWA indicates only 3 feet above aufeis level which does not allow for initial breakup flow over the aufeis.

Where additional structures are required to protect TAPS, their maximum height, riprap requirements, and spacing should be equal to or better than criteria developed for TAPS.

Existing Corps of Engineers criteria for riprap, which NWA proposes to use, is not applicable to spurs. The criteria should be used only for structures essentially parallel to the flow such as revetments and guidebanks. Riprap criteria developed for spurs by TAPS should be used for the design of upgrading measures or additional structures.

Riprap quality specificatons should be equal to or better than TAPS criteria (TAPS Specification 2.21) where modifications, upgrading, or new structures are required to ensure the integrity of TAPS. Where TAPS structures are breached by NWA, the reconstruction of the structures should be in accordance with TAPS specifications and to their satisfaction. Riprap damaged during handling must be replaced.

Where additional structures or modifications are needed to protect TAPS, NWA should develop criteria, schedule, and plans for the completion of the work. For example, the time between clearing -- a possible prime impact on TAPS -- and completion of the pipeline could be 2 years. During this interval, the TAPS line will not be fully protected. NWA will either have to:

- Construct the necessary permanent works immediately following clearing and breach and restore them during and following pipe laying operation respectively or,
- Construct temporary works which adequately protect TAPS during design flood conditions. The design flood used for these temporary works should be in accordance with the criteria outlined in Section 2.1.7.3.

5.2.1, Page 5-10 -- Groundwater Program

Tensiometer - NWA proposes to use a freeze depressant. The type is not specified. Use of it could affect the accuracy of the data.

5.2.2, Page 5-13 -- Aufeis

The results of an analysis of the effect of groundwater on freeze bulb size is given, but there is no description of how the analysis was performed. Until the analytical procedure is known, the results are questionable.

Assuming that the freeze bulb size is conservatively calculated, it is not clear how the amount of aufeis will be estimated.

SECTION VI

Comments Relative To Civil Construction Typical Drawings,
Drawing Series: 4680-10-00-0-C-XXX

DWGS C-001 - C-022 (General)

No activities shall be allowed within the agreed to 15-foot safety zone adjacent to TAPS and all related facilities. This includes activities related to delineation and construction of the protective barrier required to protect TAPS from gas pipeline construction. Therefore, a "clear" 15-foot zone shall be maintained between TAPS "related facilities" and the nearest point of the NWA safety barrier.

Stripping under any new NWA workpad extensions must be carefully controlled (degree of stripping and time of year) to prevent excessive damage to the tundra mat. The current typical sections merely indicate "strip as required."

C-002

Grading codes in Chart C should accommodate cut slope standards in Table 6.

Workpad typical designation should include provision for designating workpad insulation.

Allowance should be made for loss of pipe backfill into ice rich soils during the dormant period prior to development of the NWA freeze bulb.

C-003 - C-005

The locations on Typical Sections Series 30-XX-XX are listed in Table 7 of the Description as not being adjacent to TAPS; however, an examination of the mile-by-mile design indicates that in many cases these are proposed to be used in close proximity to TAPS. The effect of these sections on TAPS should be addressed. Considerations on these sections should include drainage routing, erosion control, and slope stability.

C-003 - C-011

Where these typicals indicate the use of dual level workpads, the traffic course must be of the required thickness on the 2:1 transition slope to protect the insulation and to provide adequate trafficability in areas with poor subgrade conditions.

In many areas TAPS cut slopes have been stabilized with a combination of techniques which may include drainage control, surficial treatments, and revegetation. Restoration of these facilities will be required. Aufeis or groundwater problems may result from cut slopes. Hence, a complete analysis will be required in each case.

C-006 - C-011

Typical cross-sections should show a protective barrier.

C-007

The two cross sections which show NWA workpad fill upslope of TAPS are violations of a fundamental NWA routing criteria and could cause workpad or thaw plug failures which could jeopardize TAPS.

C-009 - C-013

These typical drawings should indicate the 15-foot clear safety zone adjacent to TAPS belowground pipeline as well as include a safety barrier outside of the 15-foot clear safety zone.

C-009

Typical cross sections 10L-OLR and 10R-0LR assume that the TAPS workpad will not have to be extended. The designs, however, do not provide for a safety area or a protective barrier. Incorporation of these items into the design will typically require a 15-20 foot workpad extension.

Typical cross sections 10L-5R and 10R-5L also assume that the TAPS workpad will not have to be extended. The designs, however, do not provide for safety area or a protective barrier. Incorporation of these items into the design will typically require a 20-25 foot extension over thaw stable material on steep cross slopes.

C-010

Typical cross sections 11R-5R and 11L-5L will have construction equipment working at the top of slopes as steep as 1/4: 1 in bedrock or 1-1/2:1 in frozen soils. In the case where cut slopes are steeper than 1:1, a reroute of NWA must be required to place NWA far enough upslope that a protective barrier can be erected on top of the slope to preclude the possibility of NWA construction equipment falling on TAPS. In the case of cut slopes shallower than 1:1, a specifically designed protection berm must be required to preclude the possibility of equipment rolling down the steep excavation face and impacting the backfill over TAPS. These conditions are especially critical in the cases where NWA plans to do only minimal excavation and construct workpad at the top of the escarpment.

C-011

Typical cross sections 10R-5R and 10L-5L assume that the TAPS workpad will not have to be extended. The designs, however, do not provide for a safety area or a protection barrier. Incorporation of these items will typically require a 15 feet - 20 feet workpad extension and a significantly larger cut volume.

C-014 - C-015

The "General Typical Cross Section Minimum Alyeska and NWA Pipe Offsets" is the only typical which shows insulated workpad. This section, however, does not show the effect of safety and protective barrier on the workpad extension required.

The "General Typical Cross Section Granular Material Overlay of Alyeska B/G Workpad" indicates that no consideration has been given to workpad extension required to provide the protective barrier and safety zone.

The "General Typical Cross Section Barrier Protection for Alyeska A/G Pipeline" is not considered appropriate for the following reasons:

- protective barrier infringes upon the 15 foot safety zone and provides insufficient space for TAPS emergency and maintenance traffic;

- the barrier cross section should provide for a 15-foot clear distance between the outside of any TAPS facility and the toe of barrier. This 15 foot clear distance must be maintained to insure access to TAPS facilities for operations and oil spill contingency efforts;
- the typical barriers shown are insufficient to protect TAPS (Page II-1, Section II);
- the assumptions, which show that a 12 percent longitudinal grade is the breakpoint for barrier design, cannot be justified and do not meet criteria proposed by the State of Alaska;

Using NWA 80-foot distance from TAPS facility does not provide NWA with a 50-foot nominal workpad. Minimum TAPS aboveground beam support is approximately 6-1/2 feet from design centerline. With a 15-foot clear safety zone, this only allows a 38-foot workpad geometry remaining for use by NWA. Using worst case or largest TAPS beam size will provide a NWA workpad of about 27 feet using similar geometry. The safety barrier must be constructed on that portion of the workpad remaining for use by NWA.

Sheets C-014 - C-015

To insure thermal integrity of the TAPS fuel gas pipeline, the surrounding soils must be maintained in a frozen condition. The maintenance of the frozen state of these soils will require insulation from the toe of slope on the Prudhoe Bay haul road to well beyond the centerline of the fuel gas pipeline.

The TAPS structural workpad design included a component to compensate for thaw settlement under the workpad. Much of this settlement has occured to date. If the workpad extension is constructed as shown on this cross section, a mound could result in the center of the workpad as the workpad extension settles.

<u>C-016 - C-020</u>

All four of the typical drainage structure and erosion control drawings are shown on each alignment sheet. Definitive information on the location and size of these structures should be provided.

<u>C-016</u>

This example of permanent drainage structures should provide for culverts or culvert extensions with subgrade insulation.

<u>C-016 - C-018</u>

a) Temporary bridges, culverts and ramps must be designed in a manner to ensure they have no impact on TAPS. This requirement could affect:

   length of bridge;

   height of bridge;

   extent, height and slope of access ramps;

   extent of riprap downstream of culverts;

   and riprap design at abutments. (If banks at TAPS crossing are not riprapped, NWA riprap could increase local scour.)

   The design flood for temporary structures should be such that the probability of the design flood during the life of the structure is equal to the probability of the PDF during the life of the TAPS pipeline.

C-017

It appears that NWA will use TAPS low water crossings (LCW) whenever possible. In many instances, temporary culverts were used during TAPS construction. These culverts were reconstructed as LWC's suitable for light vehicular use following construction. In some cases the TAPS workpad was breached to allow drainage. Upgrading of these LWC's will be required prior to use by heavy construction vehicles.

C-021

a) NWA Workpad - TAPS belowground crossing

- Minimum workpad thickness over the pipe is shown as four feet.

  TAPS assumes this workpad thickness to be permanent to protect TAPS from NWA wheel loading; as permanent fill this will have to be armored where located in floodplains (e.g., Atigun M.P. 165.75 and Chandalar River (south face of Atigun Pass) at M.P. 172.5). Armoring can cause local scour and altered flow patterns.
- Design for specific crossings must demonstrate no adverse traffic related stresses induced in TAPS.
- TAPS concern is about the size of the berm in streams and the impact on TAPS.

[NOTE: This typical shows the NWA pipe above natural grade and with only 2-1/2 feet cover depth and does not match with 4680-10-00-9-P-602.]

P-201

The limits of pipe insulation should be defined in the profile of this drawing.

P-301

(Set on Weights)

A specific gravity of 1.0 and a negative buoyancy of 5 percent seems low because silt laden water can have a greater specific gravity.

TAPS concern is if NWA pipe floats, it may result in: additional fill placed by NWA over the pipe; or increased blockage of subsurface flow and resulting aufeis development.

These could impact TAPS freeboard at VSM and the magnitude of overbank flow.

P-305

Cross country pipeline methods generally preclude field bending for smaller unclassified streams. This results in lack of cover over the gas pipeline and potential aufeis and spring breakup erosion.

P-601 and P-607

NWA indicates in drawing P-101 a ditch bottom width of six feet with 1/4:1 ditch walls; the ditch top will be +10 feet wide. If P-104 or P-105 are used and ditch depth is 12 feet, the neat width will be 12 feet, however, the actual value will be greater due to sloughing. Therefore, assume a ditch width of 12 feet and assume a typical minimum TAPS bent spacing of 56 feet (actually varies from 40 to 70 feet) and a nominal VSM to centerline distance of 10 feet. Based on these assumptions one calculates a minimum crossing angle of 70 degrees. In many cases soil conditions will dictate maximum possible separation which amounts to a 90 degree crossing.

General Note 3 says "For Workpad Construction Details at Crossings see Drawing No. 4680-10-00-C-021 Misc. on RW Construction" no such detail exists on the referenced drawing. Also, no detail is provided for field bend layout to avoid infringing on safety zone clearance of 15 feet.

P-602, 604, 605, 606, 607

Layout of 120 feet radius bends is unrealistic and does not reflect common construction practice. Compaction efforts for berm construction must not damage TAPS. This condition may occur due to increased stresses caused by compaction equipment operating over TAPS. Site specific schedule, plans and specifications should be provided for each crossing by NWA of TAPS.

P-804

Designs for ditch breaker spacings should be specified for various ground slopes.

SECTION VII

Mile-By-Mile Analysis

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
2-3	5.78-17.11	Prudhoe Bay area	Insulated Work Pad	Confirmation of frozen condition below insulation required prior to use. If not frozen, upgrading of TAPS workpad required for summer or fall use. Insulated low water crossings must be used to extend TAPS drainage structures. Design must meet TAPS specifications.
2	6.58-6.78	Animal Crossing	Unstable Pad	Deterioration of pad and thaw-bulb creates potential for thermal/hydraulic erosion and trench instability. Move gas line a minimum of 200-feet to West.
2	9.88-10.31	Little Put River (Grayling Gulch)	Workpad Fuel gas line	Fuel gas line crossing by 36-inch uninsulated pad may cause thawing of frozen soils around FGL. Drainage structures must be compatible with TAPS structures.
			River crossing	TAPS workpad and VSM riprapped at crossing. Creek experiences extremely high, short duration spring run off. NWA to determine impact of construction, workpad, temporary bridge or culvert on spring breakup flows. Move Gas line an additional 150-feet upstream to minimize impact on TAPS.
3-5	17.11-23.70	TAPS B/G North of Haul Road	Workpad Deterioration	The TAPS workpad has undergone extensive thaw settlement and is impassable for much of the summer. Any delays in the construction schedule will result in pipeline construction on saturated and soft pad. Every effort to maintain construction schedule is recommended for this area. Thaw bulb and groundwater flow will cause pad and ditch instability. Insulation and protective cover required over fuel gas line. Trench instability a potential concern. Drainage structures must be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
4	17.50	TAPS B/G North of Haul Road	Access road crossing	Protective barrier and workpad upgrade required at access road 4-APL-1.
4	21.45	North of Haul Road	Access road crossing	Protective barrier and workpad upgrade required at access road 4-APL/AMS/ASY-3.
5	23.5-27.5	Sag River Floodplain	River Training Structures	TAPS river training structures in this area were damaged in 1977 due to material sites. Additional mining could have similar consequences. NWA to determine impact on TAPS of: 1. Material sites 5-1, 5-2, 5-3B, 5-3A. Temporary stockpiles and diversion dikes must be considered. 2. Storage yard 5-1. 3. Access roads across TAPS spurs, 5-APL/AMS-3 and 5-APL/AMS-4.
5-8	23.70-43.82	Haul Road North of Franklin Buff	Fuel Gas Line	Insulation required over fuel gas line. Drainage structure design to be thermally compatible with fuel gas line.
5	25.82	Haul Road north of Franklin Buff	Access road crossing	Protective barrier and workpad upgrade required at access road 5-APL/ASY-2.
5	26.89	Haul Road north of Franklin Buff	Access road crossing	Protective barrier and workpad upgrade required at access road 5-APL-AMS-3.
5	26.89	Haul Road north of Franklin Buff	Access road crossing	Protective barrier and workpad upgrade required at access road 5-APL/AMS-4.
6	32.21	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 6-APL-2.
6-7	33.0-36.0	Sag River Floodplain	Floodplain segment	Similar to the general concerns expressed for M.P. 23.5-27.5

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				Specifically in this reach, NWA to determine impact of: 1. Material site 6-2 and 7-1 2. Access road 7-APL-2 3. Storage yard 7-1 on TAPS floodplain segment and river training structures.
7	34.82	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 7-APL/AMS/ASY-1.
8	41.03	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 8-APL/AMS-1.
8	43.00-43.50	Sag River Floodplain	Floodplain segment	NWA to determine impact of material site 8.2 on TAPS river training structure at 43.0. Consider mining, stockpiles and possible diversion.
8	43.59	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 8-APL-2.
8	46.52	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 8-APL-4.
8-14	45.24-79.70	Haul Road	Fuel Gas Line	Insulation required over fuel gas line. Drainage structures design must be thermally compatible with fuel gas line.
9	47.73	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 9-APL/AMS-1.
10-11	52.5-59.0	Sag River Floodplain	Floodplain segment	NWA to address impact on TAPS river training structures of: 1. Material sites 10-1A, 10-1B, 10-2, 10-3, and 11-2.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				2. Temporary storage yard 10-1 3. Access road 11-APL/AMS-1 Factors to consider are: - long term impact of mining, - temporary stockpiles, and - temporary diversion dikes.
10	55.47	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 10-APL/AMS/ASY-2.
14	75.70-80.00	Sag River Floodplain	Floodplain segment	NWA to determine impact of: 1. M.S. 10-1, 14-2 and 14-3 2. Upgrading of access roads 14-APL/AMS-2 and 14-AMS-3 3. Storage yard 14-1 on breakup flow on TAPS line in floodplain segment subject to extreme aufeis. Alteration or blockage of long-established subchannels in floodplain can lead to channelization of flow over TAPS thawed right-of-way.
14-17	80.39-96.00	Happy Valley Area	Fuel Gas Line	Insulation required over fuel gas line. Drainage structure design must be thermally compatible with fuel gas line.
11	58.70	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 11-APL/AMS-1.
12	63.31	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 12-APL/AMS-1.
14	75.60	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 14-APL/AMS-1.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
14	77.93	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 14-APL/ASY-2.
14	79.90	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 14-AMS-3.
15	82.58	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 15-APL-2.
16	91.68	Sag River Floodplain	Access road crossing	Protective barrier and workpad upgrade required at access road 16-APL/AMS-3.
17	96.02	Happy Valley Area	TAPS Crossing	Crossing is in ice rich silts with high liquefaction potential. Potential for thermal degradation and loss of support on adjacent VSM. Recommend crossing further to north and maintaining minimum 200-foot separation between lines with NWA to east.
18-19	98.74-108.59	North of Pump Station 3	Insulated Workpad	Confirmation of frozen conditions below insulation required prior to use. If not frozen, upgrading of TAPS workpad required for summer or fall use. Insulated low water crossings must be used to extend TAPS drainage structures. Design must meet TAPS specifications.
			Steep slopes gas pipeline upslope of TAPS 102.7-103.0	The NWA alignment in this area is upslope of TAPS on a steep, highly liquefiable slope. TAPS integrity jeopardized. Steep slope requires protective barrier. Requires detailed slope stability analysis and increased separation distance.
			Steep slopes 105.1-105.27 105.96-106.23 107.88-107.96 108.36-108.59	Protective barrier or increased separation distance required to protect TAPS from construction equipment.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			TAPS crossing 108.59	TAPS crossing is in area of high liquefaction potential and sloping ground. Trench stability is also a concern. TAPS concerned about loss of adjacent support to VSM in frozen silt. Crossing angle too shallow. Acceptable crossing angle is 90° in these soils. Recommend elimination of this crossing and at MP 115.1 by following haul road.
20	111.24-113.82	Pump Station 3 area	Access road crossings	Crossings of snow workpad areas by access roads 20-APL-1 and 20-APL-2 require special design and TAPS approval.
21	115.15	South of Pump Station 3	TAPS crossing	Crossing of TAPS is made in an area of high liquefaction potential. The workpad in this area has settled extensively. The crossing can be eliminated by following the haul road from MP 108.2 to 115.1.
21-22	116.38-124.39	Slope Mountain	Insulated Workpad	Confirmation of frozen conditions below insulation required prior to use. If not frozen, upgrading of TAPS workpad required for summer or fall use. Insulated low water crossings must be used to extend TAPS drainage structures. Design must meet TAPS specifications.
			Steep slopes Gas pipeline upslope of TAPS 117.57-119.30	The NWA alignment in this area is upslope of TAPS. Steep slope requires protective barrier. Requires detailed slope stability analysis and increased separation distance.
			Steep slopes Gas pipeline upslope of TAPS 120.0-120.60	The NWA alignment in this area is upslope of TAPS on a steep, highly liquefiable slope. TAPS integrity jeopardized. Steep slope requires protective barrier. Requires detailed slope stability analysis and increased separation distance.

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20	120.75	Slope Mountain	Access road crossing	Protective barrier and workpad upgrade required at access road 22-APL/AMS-1.
22	120.72-120.98 124.49-124.83	Slope Mountain	Steep Slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
22	122.92	Oksyukuyik Creek (Upper)	River crossing	If a temporary bridge or culverts are used by NWA, erosion downstream of the crossing could impact TAPS VSM. Impact must be determined and if required, mitigative measures taken by NWA.
22-24	124.40-132.92	Sag River - Kuparuk River	Fuel gas line	Insulation required over fuel gas line. Drainage structure design to be compatible.
24	132.29-132.38	Kuparuk River	River crossing	NWA to determine impact of river crossing and pipeline crossing in floodplain. Concerned about aufeis and overbank scour adjacent to the VSM.
			TAPS crossing	Potential for loss of adjacent support to VSM in frozen silt. VSM are buttressed because of potential floodplain scour. Move crossing uphill to the south. The 45° and 75° bends proposed by NWA will require ells or more space for field bends. NWA must cross TAPS at 90°.
24-25	132.38-140.70	South of Kuparuk River	Insulated work workpad stability. Fuel gas line	Confirmation of frozen condition below insulation required prior to use. If not frozen, upgrading of TAPS workpad required for summer or fall use. Insulated low water crossings must be used to extend TAPS drainage structures. Design must be thermally compatible with fuel gas line.
			Steep Slopes Gas pipeline upslope of TAPS 132.38-136.26	The NWA alignment in this area is upslope of TAPS on a steep, highly liquefiable slope. TAPS integrity jeopardized. Steep slope requires protective barrier. Requires

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				detailed slope stability analysis and increased separation distance.
25-27	141.97-148.01	Galbraith Lake	Insulated workpad. Fuel gas line	Confirmation of frozen condition below insulation required prior to use. If not frozen, upgrading of TAPS workpad required for summer or fall use. Insulated low water crossings must be used to extend TAPS' drainage structures. Design must be thermally compatible with fuel gas line.
			Steep Slopes 136.47-136.93 138.26-138.43 139.10-139.70 140.00-140.44 143.47-144.50 144.82-145.09	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
26	142.79	Galbraith Lake	Access road crossing	Protective barrier and workpad upgrade required at access road 26-APL-1.
27	148.01	North of lower Atigun River crossing	TAPS crossing	NWA crosses TAPS on sloping ground with a high liquefaction potential. The soils in this area are fine grained with a high ice content. Problem with the loss of adjacent support to VSM in frozen fine-grained soils. Crossing angle is too shallow and the bend will require an ell or greater space for field bends.
27	148.60-148.70	Lower Atigun River	Gas pipeline upslope of TAPS	Unstable slope uphill from TAPS requires detailed slope stability analysis and/or alternative alignment.
27	151.81	Unnamed Creek south of lower Atigun River crossing	River crossing	NWA to determine impact of proposed material sites 27-2 and Storage Yard 27-1 upstream of TAPS VSM-type crossing of alluvial fan. TAPS concerned that additional mining will result in channel switching and scour at the TAPS crossing.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
28	154.15	Unnamed Creek south of lower Atigun River crossing	River crossing	NWA to determine impact of material site 28-1 on TAPS bridge-type crossing of alluvial fan. Mining on south side of fan could result in channel switching, and scour next to VSM.
28-29	155.54-162.95	Atigun River	Gas pipeline upslope of TAPS	Increased separation distance required between lines or realign to uphill side of Haul Road.
			Insulated workpad 156.05-162.92	Confirmation of frozen condition below insulation required prior to use. If not frozen, upgrading of TAPS workpad required for summer or fall use. Insulated low water crossings must be used to extend TAPS drainage structures. Design must meet TAPS specifications.
29	163.90	Atigun River	Access road crossing	Protective barrier and workpad upgrade required at access road 29-APL/AMS-3.
30-31	165.81-171.63	Upper Atigun River Floodplain	TAPS crossings Floodplain	Crossing at MP 165.81 will be difficult because of 80° bend angle required following TAPS crossing. A realignment should be considered. Impact of berm over NWA at crossing on local scour and flow channelization must be assessed.
				Impact of mining, stockpiles and diversion dikes at M.S. 30-2 on TAPS floodplain design to be determined by NWA.
				Impact of construction, particularly if temporary diversion dikes are necessary in the narrow gorge area upstream from MP 170, to be determined. Diversion dike could channelize high intensity flows over TAPS.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				TAPS crossing at MP 171.63 is extremely tight considering location of Haul Road and spacing required to install field bends. To avoid conflict with TAPS this crossing could be moved south. Elimination of the crossing should also be considered for the reasons as noted below, for 171.68-174.8.
30	166.05	Upper Atigun River	Access road crossing	Protective barrier and workpad upgrade required at access road 30-AMS-1.
30	168.45	Upper Atigun River	Access road crossing	Protective barrier and workpad upgrade required at access road 30-APL/AMS-2.
31	171.68-174.80	Atigun Pass	Pipeline integrity. TAPS crossings. Floodplain design. Gas pipeline upslope of TAPS on steep slopes. Protective barrier.	At the proposed crossing of TAPS at MP 172.18 surface and subsurface flow could be affected by NWA. Crossing located in area of high liquefaction. The crossing on the south face of the pass at 174.50 is located in the active stream channel in a very restricted area. If a berm is used over NWA line it could result in local scour and flow channelization over TAPS buried line. To avoid these crossings and the crossing at 171.63, NWA should consider a realignment about 200 feet west of TAPS starting at 171.63. The crossing at 174.50 can also be eliminated by staying west of TAPS in the upper North Fork of the Chandalar River. Burial depths are comparable to or less than that required for present alignment on the floodplain fringe. Since there is insufficient room for a second pipeline, the TAPS owners are concerned about NWA's construction impact on TAPS floodplain design. Specifically: 1. TAPS cover depths over insulated box segment, a very critical design factor, could be affected by construction and operation of NWA.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				2. Impact on armored sidebend buttress on south side of pass must be determined. 3. TAPS has a deep buried armored section in the narrow gorge area near bottom of south face of pass. If disturbed, areas to be restored in accordance with TAPS specifications. From 172.67-174.96 the proposed NWA alignment is upslope from TAPS on a steep highly liquefiable slope. TAPS integrity jeopardized. Requires detailed slope stability analysis and increased separation distance. Protective barrier will be required particularly down south face. Impact of dike on TAPS floodplain design to be determined.
31-32	173.80-179.80	Atigun-Chandalar	Workpad	Drainage structures must be compatible.
31-32	174.80-179.80	North Fork Chandalar River	Liquefaction. Gas pipeline upslope TAPS on steep slopes. Floodplain design.	The proposed alignment upslope of TAPS from 176.57 to 177.25 will require protective barrier and detailed slope stability analysis. Alignment is on a steep highly liquefiable slope where parallel construction could affect TAPS integrity. Increased separation distance necessary to insure integrity of TAPS. The NWA alignment could impact TAPS in the floodplain segments. Specifically: 1. Construction and operation of NWA could cause flow channelization over TAPS from 174.8-175.3 and from 177.0-179.7. 2. Additional aufeis generated by NWA could affect TAPS remote gate valve at 176.6.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				3. If culverts or a bridge are used in access road 32-APL-3, aufeis levels in the floodplain could be affected.
32	177.79	Chandalar River	Access road crossing	Protective barrier and workpad upgrade required at access road 32-APL/AMS/ASY-1.
32	179.80-181.86	Chandalar Shelf	Slope stability and liquefaction. Trench stability. Workpad. TAPS crossing	The TAPS workpad requires upgrading in the area. The steep slope on south side of shelf has long longitudinal tension cracks and has undergone minor movements. The soils throughout are highly liquefiable. Trench stability and the short and long term effects of proximate construction and operation of NWA will have to be evaluated. Protective barrier will be required or increased separation distance from 180.31-181.0 Crossing of TAPS at 181.86 is at bottom of slope in liquefiable soils. Burial depth conflicts with TAPS. Crossing can be eliminated if NWA realigned west of TAPS starting at 174.5. Drainage structures must be compatible.
33	184.10-185.26	Dietrich River downstream of White Spruce Forest	Impact on TAPS floodplain segments	TAPS is deep buried from 184.1-185.0. Probably little impact on integrity of TAPS line, however, increased clearing could induce Dietrich River to follow the cleared area and make operations access for TAPS more difficult. From 185.3-185.6 TAPS is elevated and protected by river training structures. Parallel and adjacent construction by NWA will result in:

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				1. Increased flow down right-of-way which will cause local scour around VSM and additional attack on spurs. 2. Temporary breaching of spurs during construction which will result in TAPS line being unprotected for design flood conditions during the breached period. Material site 33-2 and possible culverts or bridge on access road 33-AMS-2 will result in altered channel flow patterns. Concerns are aufeis generated at culverts or bridge which could affect clearances on VSM, and temporary diversion dikes or stockpiles and flow through the access road which could direct main channel attack on the VSM. NWA will probably have to be deep buried in this area. This being the case, recommend consideration of an alignment further west of TAPS.
33	185.70	Dietrich River	Access road crossing	Protective barrier and workpad upgrade required at access road 33-APL-3.
33-34	184.22-190.81	Dietrich River	Workpad	Where TAPS has workpad and drainage structures, NWA design must be compatible.
33-34	185.27-190.80	Dietrich River	Impact on TAPS River and Flooplain design	Specific concerns are: 1. Impact on river training structures at 186.8. Structure will have to be extended upstream. Breaching of structures during construction is a concern because of attack on this bank during high flows and allowable construction period governed by fish window from June-August. 2. Possible flow channelization as a result of increased aufeis development.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				3. Increased aufeis development as a result of bridge or culverts that might be installed in 34-APL-1 at 188.95.
				4. Impact of additional clearing and construction disturbance on stability of nose of alluvial fan at 188. Concern is increased erosion of fan nose which could eventually impact on TAPS' integrity.
			Steep slopes 185.27-185.35 186.78-187.30 188.30-188.67	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Gas pipeline upslope of TAPS 186.78-187.30 188.30-188.67 189.33-189.45 189.70-190.08 190.45-190.67	The NWA alignment in this area is upslope of TAPS. Requires detailed slope stability analysis and increased separation distance.
33	187.17	Dietrich River	Access road crossing	Protective barrier and workpad upgrade required at access road 33-APL-4.
34-35	190.81-197.85	Dietrich River	Workpad	Required workpad rehabilitation may be greater than that anticipated by NWA.
			Impact on TAPS river and floodplain 190.80-193.50	Specific concerns are: 1. Additional flow down cleared right-of-way south of Nutirwik Creek. Structure at 190.8 will have to be extended, possibly riprapped and new structures added downstream.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				2. Impact on TAPS revetment constructed from excess concrete set-on weights. Structure designed for overbank flow. Increased clearing will increase magnitude and possibly frequency of flow down right-of-way. Toe erosion a concern. Dike or plugs across right-of-way may be required.
				3. Material site 34-3 and access road 34-APL/AMS-2. Main concern is impact of stockpiles and diversion dikes on TAPS line particularly at the remote gate valve at 197.1.
			Steep slopes 193.08-193.30 194.29-194.72	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			TAPS crossing 197.83	No allowance appears to have been made for field bends.
			Access road crossing 195.64	Protective barrier and workpad upgrade required at access road 35-APL/AMS/ASY-1.
36	200.10	Dietrich River	Access road and material site Floodplain	NWA to determine impact of access road 36-APL/AMS-1 and material site 36-1 on: 1. river attack on TAPS' river training structures, 2. remote gate valve at 200.38, 3. crossing of TAPS in shallow buried mode.
36	200.23-200.43	Dietrich River	Gas pipeline upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
36	205.00-205.10	Snowden Creek	Material site	NWA to address and determine impact of: 1. Crossing of access road 36-APL/AMS/ASY-3 under TAPS' elevated line at 205. 2. Additional mining will increase the possibility of needing remedial measures at the crossing. Concern is headward cutting across TAPS if flow diversion through material site occurred.
37	205.74	Dietrich River	TAPS crossing	Crossing of TAPS elevated line. Potential for loss of adjacent support in frozen, fine-grained soils classified as highly liquefiable. Special study required. Crossing angle is too shallow. Minimum crossing angle should be 90°.
37	207.78-207.89	Dietrich Camp	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
37-38	207.67-217.28	Lower Dietrich River	Workpad	Required workpad rehabilitation may be greater than that anticipated by NWA. Drainage structures to be compatible.
			Steep slopes 211.20-211.28	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Floodplain and crossing 211.50-212.00	NWA to determine impact of:: 1. Increased flow down TAPS right-of-way and possibly increased attack on dikes upstream of Dietrich River crossing as a result of clearing by NWA. 2. Impact on guidebanks at TAPS bridge crossing. Structures may have to be extended and reoriented. Upstream tie-in point on south bank of particular concern.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				Concerned about diversion dikes which might be used if major flood occurs while they are still in place. Possible redirection of flow to sagbend structures is of particular concern.
			TAPS crossing 215.42	Problem with loss of adjacent support to VSM in frozen fine-grained soils. Crossing angle should be 90°.
			River training structure 217.15	NWA to determine impact of additional clearing on TAPS elevated segment in floodplain. Breaching and reconstruction of river training structure at 217.15 a particular concern.
37	209.79	Lower Dietrich River	Access road crossing	Protective barrier and workpad upgrade required at access road 37-APL/AMS-2.
38	211.91	Lower Dietrich River	Access road crossing	Protective barrier and workpad upgrade required at access road 38-APL-1.
38	214.47	Middle Fork Koyukuk River	Access road crossing	Protective barrier and workpad upgrade required at access road 38-APL-2.
38	215.17	Middle Fork Koyukuk River	Access road crossing	Protective barrier and workpad upgrade required at access road 38-APL-3.
39	217.33-217.48	Middle Fork Koyukuk River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
39	219.95-220.26	Middle Fork Koyukuk River	Gas pipeline upslope of TAPS	NWA is uphill of TAPS in an area with a high potential for liquefaction. Requires detailed slope stability analysis and increased separation distance.
39	222.05-222.66	Middle Fork Koyukuk River	Workpad	Required workpad rehabilitation may be greater than that anticipated by NWA. Drainage structures must be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			Gas pipeline upslope of TAPS liquefaction 222.30-222.55	NWA is uphill of and adjacent to the TAPS buried line. The soils area are classified as highly liquefiable. A special study or a reroute to the haul road will be required in this area. The ground surface adjacent to TAPS has settled extensively.
			River crossing 222.45	Adequate restoration of steep banks a necessity. Restorative measures shall be compatible with TAPS works and shall not induce additional scour.
40	223.00-223.70		Liquefaction and uphill construction	NWA is uphill of an elevated TAPS and adjacent to the haul road in an area of high liquefaction potential on sloping ground. A special study will be required in this area.
40	226.60-226.80		Liquefaction and uphill construction	NWA is uphill of an elevated TAPS line and adjacent to the haul road in an area of high liquefaction potential on sloping ground. A special study will be required in this area.
40-41	227.66-229.40	Middle Fork Koyukuk-Hammond River	River crossings TAPS crossings	TAPS concerns are: 1. Crossing of A/G line at 227.65 is less than 30° -- much too shallow. Minimum angle is 70°. Protective barrier required. 2. Access road 40-APL-3 crossing under A/G line at approximately 228. Workpad upgrade and protective barrier required. 3. Impact of clearing required for access road 40-APL-3 on overbank flow along spurs. 4. Impact of clearing for the NWA crossing on approach flow conditions to TAPS' Middle Fork Koyukuk bridge crossing.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				5. Increased possibility of flow switching from Hammond into Middle Fork Koyukuk as a result of clearing for access road 40-APL-4 and north side of NWA's Hammond River crossing. Workpad upgrade and protective barrier required. 6. Clearing for Hammond crossing could direct flow towards upstream end of TAPS' guidebank at south side of Hammond crossing. 7. Impact of access road 41-APL/AMS-1 on the same guidebank structure. Crossing of access road under TAPS A/G at 229.4. Workpad upgrade and protective barrier required. As suggested on previous occasions, recommend NWA consider an alternative alignment to cross to east side of haul road at 227.6 and follow an alignment downstream of the Hammond and Middle Fork Koyukuk River haul road crossings. The advantages of this routing are: 1. Eliminates 3 access road crossings of TAPS elevated line; 2. Eliminates potential impacts of roads, clearings etc. as noted above; and 3. Results in a shorter pipeline route. The disadvantages are: two additional crossings of the Haul Road; and potential impact of gas pipeline on aufeis and TAPS bridge freeboard. Since NWA is insulated, impact of line on aufeis levels should be minimal.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
41	229.61-231.42	Middle Fork Koyukuk River	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
41	231.60	Middle Fork Koyukuk River	Access Road crossing	Access road 41-APL-2 appears to cross over guidebank on north side of TAPS crossing. If this is the case, structure to be well restored. Protective barrier required at crossing.
41	232.10-234.99	Middle Fork Koyukuk River - Minnie Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
			Minnie Creek River crossing 232.85	NWA to determine impact of clearing and operation on: 1. Potential development of subchannel across north floodplain. 2. Freeboard at crossing. 3. Bank migration at TAPS crossing which has special-design VSM.
			Liquefaction and trench stability 232.90-235.02	NWA is adjacent to elevated TAPS in area characterized by sloping ground and a high liquefaction potential. Trench stability will have to be evaluated.
			Steep slopes 232.21-232.27	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Floodplain 234.00-234.50	NWA to determine impact of additional clearing on overbank flows and TAPS integrity.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			TAPS Crossing 235.02	No allowance for field bend spacing for sharp angle to cross pipeline at about 75° Trench stability a particular concern at the crossing. Crossing angle of 90° required.
41	232.53	Minnie Creek	Access road crossing	Protective barrier and workpad upgrade required at access road 41-APL-3.
41	233.19	Minnie Creek	Access road crossing	Protective barrier and workpad upgrade required at access road 41-APL-4.
43	245.10	Coldfoot camp	Access road crossing	Protective barrier and workpad upgrade required at access road 43-APL/AMS/ASY-2.
45	253.22-253.56	Cathedral Mountain	Access road Workpad reuse	Access road 45-APL/AMS-1 and use of TAPS workpad will require protective barrier.
			TAPS crossing 254.02	Crossing angle appears to be too shallow (about 45°). Boring A202-19 shows this soil to be frozen fine-grained soil. Minimum angle should be 90°. Ample clearance must be provided for field bends to cross TAPS in a tangent. Crossing appears to conflict with TAPS transition. Recommend moving the crossing south by about 1000 feet.
45-46	254.02-263.80	South of Cathedral Mountain to South Fork Koyukuk River	Liquefaction and trench stability	NWA is on downhill side of elevated TAPS line in an area characterized by highly liquefiable permafrost soils on sloping ground. Potential for thaw plug and trench instabilities. Site specific studies will be required throughout this area.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			Steep slopes 254.16-254.27 255.94-256.06 257.37-257.53 257.83-257.91 258.13-258.20 258.27-258.40 259.37-259.46 259.74-260.92 262.06-262.43 263.52-263.67	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Workpad 254.00-260.95 261.42-263.70	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
			Access Road crossing 255.10	Access road 45-APL/ASY-2 crosses under TAPS elevated line.
46	259.92	South Fork Koyukuk River	Access road crossing	Protective barrier and workpad upgrade required at access road 46-APL/ASY-1.
46	262.63	South Fork Koyukuk River	Access road crossing	Protective barrier and workpad upgrade required at access road 46-APL/AMS-2.
46	264.05	South Fork Koyukuk River crossing	River crossing Access road crossings	NWA to determine impact on TAPS' freeboard and structures. Area subject to heavy icings. Banks to be well restored. TAPS guidebanks proposed for access roads 46-APL-3 and 46-APL-4 to be properly restored following use. Protective barrier required.
47	264.25	South Fork Koyukuk	TAPS crossing	Tight bends to provide appropriate crossing angle do not allow for space needed to install field bends. Crossing should be moved further south away from flood plain and alignment modified slightly to allow space for field bends to cross TAPS at 90° in a tangent.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
47-48	264.26-273.41	South Fork Koyukuk	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be required.
			Steep Slopes 264.51-264.74	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Liquefaction Uphill construction. Thaw plug stability 264.70-266.30	NWA is upslope of an elevated section of the TAPS line. NWA typical sections show a fill added upslope to extend the pad with a 2:1 step. No cutting is planned. The soils in this area are frozen and fine grained with zones of massive ice. The area is classified as highly liquefiable. Recent observations in this area indicated significant differential settlements, impassable pad, unstable cut slopes, and ponding on the uphill side of the pad. NWA planned workpad extension could cause thaw plug instability and, in the event of dynamic loading, could force a failure towards the elevated TAPS line. Planned workpad configurations adversely affect the stability upslope of the TAPS line and are therefore unacceptable.
			Steep slopes Gas pipeline upslope of TAPS 264.90-266.13	The NWA alignment in this area is upslope of TAPS. Steep slope requires protective barrier. Requires detailed slope stability analysis and increased separation distance.
			Liquefaction Trench stability, and thaw plug stability 266.40-273.50	NWA is adjacent and downslope of an elevated section of the TAPS line. The permafrost soils in this area are classified as highly liquefiable.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			Steep slopes 266.10-266.23 268.57-268.67 268.77-268.87 269.07-269.35 272.09-272.21	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
48	275.10	North of Jim River	Access road crossing	Protective barrier and workpad upgrade required at 48-APL/AMS-3.
49	278.42	Douglas Creek	Access road crossing, river crossing	VSM protected by riprap in heavy aufeis area. Riprap to be restored. NWA to determine impact of access road 49-APL-1 on aufeis levels at TAPS. Protective barrier and workpad require upgrade.
49	279.88	Douglas Creek	Access road crossing	Protective barrier and workpad upgrade required at access road 49-APL/AMS-2.
50-51	285.70-294.04	Prospect Creek-Bonanza Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
			Access road crossing 283.39	Protective barrier and workpad upgrade required at access road 50-APL-3
			River crossing Prospect Creek 285.50	NWA to determine impact of clearing on potential cutoff across south floodplain towards TAPS above-ground.
			Access road crossing 286.39	Protective barrier and workpad upgrade by NWA required at access road 50-APL-4
			Access road crossing 287.89	Protective barrier and workpad upgrade by NWA required at access road 50-APL/AMS-5

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			Liquefaction trench stability and thaw plug stability 285.70-286.30 292.15-292.35	NWA is adjacent to an elevated section of the TAPS line on a longitudinal slopes. The soils in these area are frozen and classified as highly liquefiable. These concerns must be evaluated by NWA.
			Steep slopes 285.86-287.57 287.84-289.89 290.32-292.27	Requires detailed slope stability analysis and increased separation distance.
			Gas pipeline upslope of TAPS 287.50-287.69 291.60-291.81	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Access road crossings 288.91 291.44 292.36 293.69	Protective barrier and workpad upgrade by NWA required at access road crossings 51-APL/ASY-2, 51-APL/AMS-3, 51-APL-4 and 51-APL/AMS-5
			Gas pipeline upslope of TAPS 289.85-290.30	NWA is located upslope of an elevated section of the TAPS line. The pad has settled and is deeply rutted in this section. The soils are classified as frozen and highly liquefiable in this section. The slopes are gradual (about 3%) but the concerns should be evaluated in this section or separation distance increased.
			River crossing at North Fork Bonanza 292.45	Banks to be well restored. NWA to determine impact of additional clearing on flow down right-of-way south of crossing. TAPS training structure to be extended and/or upgraded and additional structures possibly required.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
52	294.05	South Fork Bonanza Creek	River crossing	Banks to be well restored particularly the north bank.
52	296.28	South Fork Bonanza Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 52-APL-2
52-54	297.88-306.72	Bonanza Creek - Fish Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
			Liquefaction and trench stability 297.75-298.15	NWA is located upslope of a buried section of the TAPS line. TAPS is buried deep below liquefiable slop-on-top. Liquefaction and trench stability will have to be evaluated. The surface adjacent to TAPS in this area has undergone differential settlement.
			Steep slopes 297.88-298.84 300.14-301.86 302.02-302.77 302.94-304.27	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
			Access road crossing	Protective barrier and workpad upgrade required at access road 53-AMS-3.
			Steep slopes Gas pipeline upslope of TAPS 299.06-299.20 299.80-300.18 304.48-306.76	Requires detailed slope stability analysis and increased separation distance. Steep slopes require protective barrier to protect TAPS from construction equipment.
			Liquefaction & trench stability at Fish Creek 301.35-301.80	NWA is adjacent and slightly upslope of a buried section of the TAPS Line. The soils are frozen and classified as highly liquefiable. TAPS is buried deep below the slop-on-top. Site specific stability analysis required to evaluate impact on TAPS and gas pipeline.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
			Access road crossing 301.92	Protective barrier and workpad upgrade by NWA required at access road 53-APL/AMS/ASY-1
			Liquefaction trench stability 302.80-303.60	NWA plans to build a parallel pad east of the elevated TAPS line (with pad west) in this section. Longitudinal slopes are 15 to 25% and the soils are frozen, fine-grained, and highly liquefiable. The NWA pad must be designed to fail away from the TAPS line during a dynamic event. Liquefaction and trench stability should be considered in a site specific analysis.
			Access road crossing 303.62	Protective barrier and workpad upgrade by NWA required at access road 53-AMS-3.
			Liquefaction and trench stability 304.30-304.60	NWA plans to build a parallel pad east of the elevated TAPS line (with pad east) in this section. Longitudinal slopes are up to 25% and the soils are frozen, fine-grained, and highly liquefiable. Liquefaction and trench stability should be considered in a site specific analysis.
			Access road crossing 304.77	Protective barrier and workpad upgrade by NWA required at access road 53-APL/AMS-4
			Liquefaction and trench stability at Fish Creek. 305.30-305.60	NWA plans to build parallel pad. Longitudinal slopes are up to 25% and the soils are frozen, fine-grained, and highly liquefiable. Liquefaction and trench stability should be considered in a site specific analysis.
			Trench stability and liquefaction 306.40-306.70	NWA is adjacent to a buried section of the TAPS line on a longitudinal slope. TAPS is deep buried because of a slop-on-top condition. Trench stability and liquefaction should be evaluated on a site specific basis.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
54-61	308.30-346.80	Old Man-Yukon	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
54	308.49-308.76 308.87-310.28	Kanuti River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
54	309.55	Kanuti River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 54-APL/AMS/ASY-1
54	309.90-311.60	Kanuti River	Liquefaction trench stability, workpad traf-ficability	NWA is adjacent to the workpad in a buried section on a longitudinal slope. The soils are frozen and classified as highly liquefiable. The TAPS workpad in this area is fine grained and impassable much of the summer season. Liquefaction and trench stability should be considered on a site specific basis in this section.
55	311.72	Kanuti River area	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 55-APL/AMS-1.
55	313.30-315.30 315.70-316.70	Kanuti River area	Liquefaction trench stability	NWA is adjacent to the workpad in an elevated section on sloping ground. The soils are frozen and classified as highly liquefiable. Liquefaction and trench stability should be evaluated on a site specific basis.
55	315.70-316.70	Kanuti River area	Liquefaction trench stability	NWA is adjacent to the workpad in a buried section on sloping ground. The soils are frozen and classified as highly liquefiable. Liquefaction and trench stability should be evaluated on a site specific basis.
55-56	316.71-319.30	Finger Mountain	Liquefaction	NWA will construct a pad parallel and adjacent to (east) the TAPS buried line. The NWA pipe will be buried to the east of their pad. The soils in this area are frozen and classified as

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
				highly liquefiable. The TAPS line is buried deep (slop-on-top case). The surface surrounding the TAPS line has undergone extensive settlement and is difficult to traffic. NWA predominantly downslope of TAPS. Trench stability and liquefaction will have to be evaluated on a site specific basis.
55-56	312.48-312.74 312.90-313.01 313.15-313.42 314.76-315.53 315.63-316.00 316.23-318.43 318.76-320.20 321.46-321.82 322.12-322.97	Finger Mountain	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
56	319.30-320.21	Finger Mountain	Liquefaction and trench stability	NWA is off the opposite side of the TAPS workpad in a buried section on longitudinal slopes. The soils are frozen and classified as highly liquefiable. TAPS is buried deep in bedrock (slop-on-top case). Trench stability and liquefaction must be evaluated on a site specific basis in this section.
56	319.71	Finger Mountain	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 56-APL/AMS-1.
56	320.21-321.20	Finger Mountain	Liquefaction and trench stability	Uncertainty about location of NWA as drawings and typical cross section number conflict. TAPS is buried deep below frozen, highly liquefiable soils in this area (slop-on-top case). If NWA is adjacent to TAPS as shown on the drawings, trench stability and liquefaction will have to be evaluated on a site specific basis.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
56-57	321.20-326.00	Finger Mountain	Liquefaction and trench stability	NWA is located off the opposite side of the TAPS pad in an elevated section on sloping ground. The soils in this section are frozen, fine grained and classified as highly liquefiable. TAPS tried to bury their pipe in two short segments of this section and could not keep their trench open long enough to set their pipe in. Trench stability and liquefaction will have to be evaluated on a site specific basis.
57	323.09	West Fork Dall River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 57-AMS-1
57	325.65 and 326.16	West Fork Dall River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road crossings of 57-APL-2 and 57-APL-3.
57	323.43-323.58 324.72-325.44 325.76-326.59 326.72-327.02 327.76-329.77 329.84-329.93 332.13-332.24	West Fork Dall River North Fork Ray River	Steep Slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
57-58	327.25-328.10		Liquefaction and uphill construction	NWA plans to build a new pad immediately adjacent and <u>upslope</u> of the TAPS elevated line in this section. The soils in this secton are fine grained, frozen, and classified as highly liquefiable. A workpad upslope of TAPS elevated line is not acceptable due to stability considerations. The TAPS integrity will be endangered by potential NWA workpad failures.
58	328.32	North Fork Ray River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 58-APL/AMS/ASY-1.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
58-59	329.30-357.30	North Fork Ray River	Liquefaction and trench stability	NWA is located off the opposite side of the TAPS elevated line in this section on sloping ground. NWA is downslope of TAPS. The soils in this area are fine grained, frozen, and classified as highly liquefiable. Trench stability and liquefaction will have to be evaluated on a site specific basis.
58	330.29	North Fork Ray River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 58-APL-2.
59-60	332.80-333.10 338.55-338.90	North Fork Ray River	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
59-60	332.32-333.44 337.57-337.73	North Fork Ray River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
59	336.49	North Fork Ray River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 59-APL-1.
60	338.90	North Fork Ray River	TAPS crossing	Crossing angle too shallow and does not account for geometry required for fieldbends. Alignment should be modified to permit crossing in a tangent at 90° in this extremely fine-grained frozen residual soil to avoid problems with loss of adjacent support to VSM.
60	339.56	North Fork Ray River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 60-APL/ASY-2.
60-61	340.96-341.07 341.42-342.06 343.09-344.00 344.41-344.86 344.94-346.14 346.61-346.76	North Fork Ray River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
60	341.25-341.35	North Fork Ray River	Slope stability	NWA is off the opposite side of the TAPS pad in an elevated section on a steep south facing slope. The slope has thawed silty sand over bedrock on it. The dynamic factor of safety is less than unity for this slope. A site specific analysis will be required.
60	341.45-342.20	North Fork Ray River	Liquefaction and trench stability	NWA is off the opposite side of the TAPS pad in an elevated section on a steep longitudinal slope. The soils in this area are frozen, fine-grained and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
61	343.50-344.75 345.35-346.00	North Fork Ray River	Liquefaction and trench stability	NWA is off the opposite side of the TAPS pad in an elevated section on steep longitudinal slopes. The soils are predominantly fine grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
61	346.85	North Fork Ray River	Access road crossing	Protective barrier and workpad upgrade required at access road D61-APL/AMS-2.
61-64	347.98-348.30 348.78-361.14	Ray River-Yukon River	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be ensured.
62-64	348.80-349.40 350.00-350.50 351.10-361.15	Ray River-Yukon River	Liquefaction and trench stability	NWA is off the opposite side of the TAPS pad in elevated sections on sloping ground. The soils are predominantly fine grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
62-64	348.90-349.47 349.57-350.44 350.06-350.40 351.13-351.26 354.02-354.17 358.92-359.17 359.54-359.78 359.86-360.00 360.13-360.19 360.41-360.65	Five Mile-Yukon River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
62	351.33	Five Mile	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 62-APL-2.
63	355.10 and 357.61	Five Mile	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road crossings of 63-APL/ASY-1 and 63-APL/AMS-2.
64	361.30-361.70	Yukon River	River crossing	NWA to ensure that banks are left undisturbed or well restored.
64	362.75	Pump Station 6	TAPS crossing	NWA must modify alignment to permit crossing at 90° in frozen fine-grained soils and to avoid problems with loss of adjacent support to VSM. Allowance must be made for geometry of fieldbends. This crossing is adjacent to an aboveground culverted crossing of the haul road by TAPS and non-standard VSM spacing. Recommend a re-evaluation of proposed crossing design and location.
			Liquefaction and trench stability	NWA crosses an elevated TAPS line on sloping ground. The soils in this area are frozen, fine-grained and classified as highly liquefiable. A special study will be required.
64	362.83-362.92	Pump Station 6	Steep slopes	Requires barrier or increased separation distance to protect TAPS from construction equipment.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
64-66	363.82-371.50	Pump Station 6	Workpad	Drainage structures to be compatible.
64	363.85-364.37	Pump Station 6	NWA Upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
64-65	363.80-364.30 364.95-365.15 365.55-365.70 366.60-366.95 367.20-367.55 368.00-369.50	Pump Station 6	Uphill construction liquefaction, trench stability and workpad stability	NWA plans to build a new pad adjacent and upslope of the TAPS elevated line. The soils in these areas are frozen, fine-grained and highly liquefiable. TAPS integrity would be endangered by NWA workpad failures. NWA planned construction in these areas is not acceptable. Suggest reroute to the nearby haul road.
64-65	364.68-364.88 364.96-365.06 365.13-365.48 365.66-365.74 365.79-365.88 366.07-366.24 366.99-367.23 367.43-368.00 368.56-368.89 369.31-369.55 369.68-370.88	Pit Ten Isom Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
65	364.95-365.14 365.58-365.73 366.60-368.95 367.20-367.55 368.00-369.55	Pit Ten Isom Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
66	371.50-374.53	Isom Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
66	371.15-372.00	Isom Creek	Liquefaction and trench stability and steep slopes	NWA is adjacent to the TAPS workpad opposite a buried section of the TAPS line on steep longitudinal slopes. The near surface soils in this area are predominantly fine grained, frozen and classified as highly liquefiable. TAPS is buried deep in this area (slop-on-top case). Trench stability and liquefaction must be evaluated on a site specific basis. Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
66	371.22-371.38 372.68-372.93	Isom Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
66	373.20-373.40	Isom Creek	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite a buried section of the TAPS line on sloping ground. The near surface soils in this area are fine-grained, frozen and classified as highly liquefiable. TAPS is buried deep in this area (slop-on-top). Trench stability and liquefaction must be evaluated on a site specific basis.
66	372.18-373.05 373.22-373.45 373.66-375.09	Isom Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
66	374.65-374.80	Isom Creek	Liquefaction, trench and workpad stability, and uphill construction	NWA plans to build a new pad adjacent and upslope of the TAPS elevated line. The soils in these areas are frozen, fine-grained and highly liquefiable. TAPS integrity would be endangered by NWA work pad failures. NWA planned construction in these areas is not acceptable. Increased separation distance required.
66-67	374.75-380.52	Isom Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
66	375.09	Hess Creek	TAPS crossing	Appears acceptable. Protective barriers required.
66-68	375.15-375.60 376.15-376.35 376.90-377.05 377.70-378.15 380.25-380.35 381.20-384.30	Hess Creek	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated TAPS line. The soils in this area are fine-grained, frozen and classified as higly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
67-68	381.29-386.45	Hess Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
67-69	375.94-376.11 376.29-377.14 379.28-380.30 380.77-381.33 381.47-382.01 382.43-382.57 384.51-385.96 387.37-389.12	Hess Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
67-68	378.30-378.40 379.15-379.25 384.50-385.80	Hess Creek	Uphill construction, liquefaction, trench stability and workpad stability	NWA plans to build a new pad adjacent and upslope of the TAPS elevated line. The soils in this area are frozen, fine-grained and classified as highly liquefiable. TAPS integrity would be endangered by NWA work pad failure. Increased separation distance required.
68	386.75	Hess Creek	River crossing	NWA to assess potential impact of: 1. MS 68-4B on overbank flows and possible headcutting through fine grained floodplain material upstream to TAPS bridge and VSM.
68	387.01-387.32	Hess Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
68-71	387.78-404.00	Hess Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
69-70	388.04-388.37 388.80-389.53 389.75-389.86 395.07-395.32 395.82-396.00	Erickson Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
69-70	389.41-390.73 392.72-393.92 394.03-394.74 394.92-395.03 395.18-395.29 395.48-395.78	Erickson Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
69	389.60-389.80 390.45-390.70	Erickson Creek	Uphill construction, liquefaction, trench stability and workpad stability	NWA plans to build a new pad adjacent and upslope of the TAPS elevated line. The soils in this area are frozen, fine-grained and classified as highly liquefiable. TAPS integrity would be endangered by NWA workpad failure. Increased separation distance required.
69-70	391.75-392.30 394.00-398.80	Erickson Creek	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated TAPS line. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
70-71	395.96-400.21 400.48-401.07 401.27-402.15 402.23-404.30	Lost Creek	Uphill	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
71	399.90-400.00 401.03-401.18 402.03-402.28	Lost Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
71	400.00-400.20 402.00-402.30	Lost Creek	Uphill construction, liquefaction, trench stability and workpad stability	NWA plans to build a new pad adjacent and upslope of the TAPS elevated line. The soils in this area are frozen, fine-grained and classified as highly liquefiable. TAPS integrity would be endangered by NWA work pad failure. Increased separation distanced required.
71	401.60	Lost Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 71-AMS-2.
71	404.00-406.65	Lost Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
71	403.10-404.25	Tolovana River	Liquefaction and trench stability	NWA is adjacent to the TAPS workpad opposite the elevated TAPS line. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
71	404.25	Tolovana River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 71-APL/AMS-3.
71-72	404.72-405.58 409.23-410.18 410.26-411.04 411.10-411.27	Tolovana River Wilber Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
72	407.60-409.30	Tolovana River	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated TAPS line on sloping ground. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction will have to be evaluated on a site specific basis.
72-73	408.61-412.16	Tolovana River Wilber Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
73	411.41	Wilber Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 73-AMS-1.
73	411.43-411.53 411.72-412.35 412.51-416.07 413.00-413.70 413.79-417.23	Wilber Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
73	412.16-413.72	Wilber Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
73	412.30-413.70	Wilber Creek	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated TAPS line on sloping ground. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
73	414.20	Wilber Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 73-APL/AMS/ASY-2.
73	415.00-415.17	Wilber Creek	NWA uphill of TAPS	Requires detailed slope stability analysis and increased separation distance.
73	414.50-414.75	Wilber Creek	Uphill construction, liquefaction, trench stability and workpad stability	NWA plans to build a new pad upslope of the TAPS elevated line. The soils in this area are frozen, fine-grained and classified as highly liquefiable. TAPS integrity would be endangered by NWA work pad failure. Increased separation distance is required.
73	416.07-424.36	Slate Creek - Tatalina River	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
73-74	416.10-416.70 417.75-420.00 421.00-421.45	Slate Creek - Tatalina River	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite an elevated section of the TAPS line on sloping ground. The near surface soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
74	417.30-419.20 420.00-421.18 421.56-422.14	Slate Creek - Tatalina River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from equipment.
74	420.52	Tatalina River	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 74-APL-2.
74	420.60	Tatalina River	River Crossing	NWA to determine: 1. impact of crossing on aufeis and flood levels, 2. impact of additional clearing on floodplain flows velocities and magnitudes, 3. impact of construction and restoration on back migration of TAPS' bridge. A greater separation distance is recommended.
74-75	422.51-423.03	Tatalina River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
75-76	424.36-424.96 425.56-427.33 427.33-428.62	Globe Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
75	424.37-425.36	Globe Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
75	424.40-425.20 428.25-428.80	Globe Creek	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated TAPS line on sloping ground. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
75	425.20	Globe Creek	TAPS crossing	Provide realignment to cross Alyeska at 90° in a tangent section to minimize loss of adjacent support to VSM in frozen fine grained soils. Allow for geometry to place field bends.
75	425.40-439.95	Globe Creek	River crossing	NWA to determine impact of construction and operation of buried line (relatively shallow) on: 1. aufeis and flood levels at TAPS crossing, 2. bank migration, 3. overbank flows
75	426.39-428.82	Globe Creek	Workpad	Required Workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
75	427.40-427.65	Globe Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
76	430.00-433.81	Aggie Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
76-77	430.32-438.88	Aggie Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
76	430.83	Aggie Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
76	430.85	Aggie Creek	Access road crossing	Protective barrier and workpad upgrade required at access road 73-APL/ASY-3.
76	433.91	Aggie Creek	Access road crossing	Protective barrier and workpad upgrade required at access road 76-AMS-5.
77	433.94-434.16 434.23-434.43	Aggie Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
77	434.75	Aggie Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 77-APL/ASY-1.
77	434.83-436.39 437.08-439.30 439.98-441.44	Washington Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
77-78	438.88-440.00	Washington Creek	Workpad	Drainage structures to be compatible.
78	439.90	Washington Creek	River crossing	Impact of NWA on TAPS to be determined.
78	440.00-445.99	Washington Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
78	440.20-440.56	Washington Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
78	441.62-444.78 447.34-448.53	Washington Creek - Chatanika River	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
78	443.00-443.90	Washington Creek - Chatanika River	Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated TAPS line on sloping ground. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis in this area.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
79-80	447.35-450.48	Chatanika River	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
79	448.06-448.32	Chatanika River	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
79	448.33-450.40	Treasure Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
79	449.60-450.25	Treasure Creek	Uphill construction, liquefaction, trench stability and workpad stability	NWA plans to build a new pad upslope of the TAPS elevated line. The soils in this area are frozen, fine-grained and classified as highly liquefiable. TAPS integrity would be endangered by NWA work pad failure. Increased separation is required.
80	450.48-451.65 452.30-452.63 452.83-453.37	Treasure Creek - Murphy Dome	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
80	450.49-455.90	Treasure Creek - Murphy Dome	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
80	453.03-453.33 453.36-453.55 453.66-453.85	Treasure Creek - Murphy Dome Road	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
80	454.15-454.58 454.83-455.56 455.74-455.83	Murphy Dome	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
81	459.40-459.70	Engineer Creek	Liquefaction and trench stability	NWA is adjacent to the TAPS workpad, opposite the elevated section of the TAPS line on sloping ground. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
81	459.64-465.42 460.59-461.04	Engineer Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
81	459.93-465.98	Engineer Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
81-82	459.41-463.55	Engineer Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
81-82	461.19-462.95	Gilmore Road - Chena Hot Springs Road	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
81-82	461.47-462.30 462.80-463.00	Gilmore Road - Chena Hot Springs Road	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
82	463.28-463.70	Chena Hot Springs Road	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
82-85 86	465.99-467.49 467.67-477.62 479.57-490.11	Chena River - Moose Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
85	479.85-481.10	Moose Creek Crossing	River crossing	NWA to insure that: 1. Banks at crossings at 479.85 and 481.1 are well restored, 2. Chilled buried line has no impact on freeboard at elevated crossings and on aufeis levels.
85	482.05	French Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 85-APL-2.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMENTS
85-86	483.95 484.25 484.75 485.70	French Creek	River crossing	NWA to insure: 1. Banks at crossings at 483.95, 484.25, 484.75 and 485.7 are properly restored. 2. Chilled buried line has no impact on aufeis levels and freeboard on elevated crossings at 485.7.
86	486.27	French Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 86-AMS-1.
86	487.00	French Creek	TAPS crossing	Appears acceptable.
86	488.26-488.34	French Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
86	488.55-489.10 489.40-489.50	French Creek	NWA upslope of TAPS	Requires detailed slope stability analysis and increased separation distance.
87-88	494.57-496.34	Pump Station 8	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
			Liquefaction and trench stability	NWA is adjacent to the TAPS work pad opposite the elevated section of the TAPS line on sloping ground. The soils in this area are fine-grained, frozen and classified as highly liquefiable. Trench stability and liquefaction must be evaluated on a site specific basis.
88	495.58-495.72 496.00-496.38	Pump Station 8	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
88-93	496.34-522.29	GVEA Alignment	Workpad traffic along pipeline	Protective barrier and workpad upgrade by NWA required where TAPS workpad is to be used for access. Access roads such as 92-APL-1 indicate TAPS pad to be used for access.

NWA A.S.	NWA MILE POST	DESCRIPTIVE LOCATION	CONCERN	SPECIFIC COMMEN-
92	517.57	GVEA Alignment	Access road crossing	Protective barrier and workpad upgrade required at access road 92-APL-1.
93	522.29-527.07	Rosa Creek	Workpad	Required workpad rehabilitation may be greater than anticipated by NWA. Drainage structures to be compatible.
93	522.30-522.58 522.65-523.23 523.54-523.63 524.72-524.77	Rosa Creek	Steep slopes	Requires protective barrier or increased separation distance to protect TAPS from construction equipment.
93	524.11	Rosa Creek	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 93-AMS-1.
93-97	527.07-547.82	Shaw Creek Flats	Workpad traffic along pipeline	Protective barrier and workpad upgrade by NWA required where TAPS workpad is to be used for access. Access roads such as 92-APL-1 indicate TAPS pad to be used for access.
94	528.20	Shaw Creek	TAPS crossing	Modify alignment to provide 90° crossing of TAPS in frozen very fine-grained soils to minimize loss of adjacent support to VSM.
95	536.16	Quartz Lake Road	Access road crossing	Protective barrier and workpad upgrade by NWA required at access road 95-APL-3.