POTENTIAL IMPACT

OF

PROPOSED GAS LINE

ON THE

TRANS-ALASKA PIPELINE SYSTEM

A Preliminary Discussion

of Gas Line Design, Construction,

Maintenance and Operation Aspects

Affecting the Trans-Alaska Pipeline System

Prepared April, 1979

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TABLE 1

POTENTIAL IMPACT OF PROPOSED GAS LINE ON TRANS-ALASKA PIPELINE SYSTEM

Category	Gas Line Criteria As They Relate To Integrity of Trans-Alaska Pipeline System	Potential Oil Line Damage Mechanism
I. Design 1. Geotechnical/ Foundation		
A. Slope Stability	The gas line must be designed and located on slopes such that slope stability in the vicinity of the oil pipeline is not reduced to an unsafe level. Consideration must be given to both short term and long term stability, including the effects of earthquakes and the potential influence that the cold gas line may have on ground water and surface water flow patterns as they affect stability.	Slope failure may intersect oil line, causing severe damage or rupture.
B. Liquefaction	The gas line design must not cause a "high liquefaction" potential to develop in areas near the oil pipeline which are not currently designed to withstand the effects of soil liquefaction.	Liquefaction may cause slope failure and lead to consequences described above.
C. VSM Soil Support	The gas line must be designed and located such that the capacity of the soil to support the above ground oil pipeline in a stable manner is not adversely affected. Consideration must be given to alteration of the thermal regime such that additional thaw settlement or frost jacking is not introduced to the VSM.	Removal of support by excavation may cause support failure. Increased thawing may reduce support to an unsafe level. Frost jacking may damage above ground oil line.
D. Below Ground Pipeline Support	The gas line must be designed and located such that the degree of restraint provided by soil surrounding the below ground oil pipeline is not reduced to an unsafe level either temporarily or permanently. Consideration must be given to the effects of excavation near the oil pipeline as well as to the alteration of drainage patterns affecting the capacity of the soil to restrain the buried oil pipeline.	Removal of soil restraint at bends may allow thermally induced strains.
E. Crossings	Buried pipeline crossings must be designed and located (generally above the oil pipeline) in order to minimize the potential for damage during construction. In addition, the crossings must be designed to eliminate any adverse effects such as changes in the thermal regime during operation.	Construction equipment may damage oil line.

TABLE 1

POTENTIAL IMPACT OF PROPOSED GAS LINE ON TRANS-ALASKA PIPELINE SYSTEM

Category	Gas Line Criteria As They Relate To Integrity of Trans-Alaska Pipeline System	Potential Oil Line Damage Mechanism
2. Civil		
A. Erosion Control/ Surface Drainage	The gas line must be designed such that drainage patterns are not altered in a manner adversely affecting the oil pipeline. The effects of aufeis produced by the cold gas line must be considered in particular. The effects of the gas line on culverts and other drainage facilities must also be studied.	Surface erosion may expose oil line or relieve restraint. Aufeis may induce erosion at undesirable areas during breakup. In addition, aufeis may completely capture the above ground oil line and restrain it in a manner contrary to design requirements.
B. Workpad Stability/ Geometry	The gas line must be designed and located such that the workpad (existing or new) does not become workpad located on liquefiable or otherwise unstable soil must be located downslope of the above ground oil pipeline unless acceptable stabilization measures are applied.	Workpad slope failure may affect the oil line as described in "Slope Stability and Liquefaction."
3. Thermal	The gas line must not alter the thermal regime in the vicinity of the oil pipeline such that detrimental thawing or frost jacking occur. The effects of construction disturbance on areas of massive ice as they relate to oil pipeline integrity must be considered.	Alteration in thermal regime may cause oil line displacements which stress the pipe beyond its design capacity.
4. River & Floodplain A. Hydraulic	The gas line and any associated structures at river crossings and floodplains must be designed and located so that the hydraulic regime is not affected adversely. Consideration must be given to potential adverse changes in channel migration patterns, adverse increases in backwater depth at the above ground pipe or river training structures and adverse increases in scour depth. The gas line must not cause aufeis to be produced which subsequently affects the oil line and its associated structures adversely. The gas line must not influence flow patterns by virtue of its "frozen plug" such that flow is directed over or near the oil line in a detrimental manner.	Alteration of the stream hydraulic regime may affect the oil line by causing increased scour, or may inundate the above ground line by increasing backwater depth. Either event may cause oil line failure.
B. Material Sites	Location and operation of material sites must be such that the hydraulic regime as described above is not altered in a manner adverse to the oil pipeline.	Material sites may cause alterations in the hydraulic regime as described above.
5. Proximity A. Blasting	The gas line must be located such that effects of blasting during construction do not adversely influence the oil pipeline.	Stresses induced by nearby blasting may damage or fail the oil line.

TABLE 1

POTENTIAL IMPACT OF PROPOSED GAS LINE ON TRANS-ALASKA PIPELINE SYSTEM

Category	Gas Line Criteria As They Relate To Integrity of Trans-Alaska Pipeline System	Potential Oil Line Damage Mechanism
B. Ditching	The gas line must be located such that limits of ditching do not intersect the oil pipeline ditch, the VSMs, transition buttresses, subsurface drainage structures, valves, fences, river training structures, slope buttresses or any other associated pipeline structure. With respect to below ground oil pipeline the gas line must be located such that ditch excavation does not remove soil which is required to restrain the oil pipeline at bends. At river crossings or floodplain crossings, the gas line must be located such that, during excavation of the gas line, flow does not occur in the excavated ditch which could enlarge the ditch by erosion and thus affect the oil pipeline as described previously.	Removal of material adjacent to the oil line may cause a loss of support which results in pipe overstress.
6. Cathodic Protection	The gas line must be designed so as not to adversely affect the oil pipeline cathodic protection system (i.e., at crossings).	Reduction of cathodic protection may result in long term oil line system failure.
2. Special Construction A. Buried Animal Crossings	The gas line must be designed such that the function of the oil pipeline at special buried animal crossings is not adversely affected. In addition, the utility as an animal crossings must not be impaired.	New thermal disturbance may cause additional thaw and potential oil line overstress.
B. Refrigerated Burial	The gas line must be designed to be compatible with any area of the oil pipeline which is thermally protected by a refrigeration system or by free standing heat pipes.	New thermal disturbance may reduce the effectiveness of oil line thermal protection.
C. Atigun Pass	The gas line must be designed to be compatible with and not to influence the integrity of the special buried oil pipeline construction of Atigun Pass.	Special thermal consideration required.
D. Other Areas	The gas line must be designed to be compatible with any other special construction areas of the oil pipeline so designed.	Special study required.
II. Construction 1. Blasting	Blasting must be controlled during construction such that oil pipeline design criteria are not exceeded and such that overbreak or flyrock do not damage the oil line. A control system must be established and utilized.	Blasting may damage the oil line.

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POTENTIAL IMPACT OF PROPOSED GAS LINE ON TRANS-ALASKA PIPELINE SYSTEM

Category	Gas Line Criteria As It Relates To Integrity of Trans-Alaska Pipeline System	Potential Oil Line Damage Mechanism
2. Damage by Construction Activity	A safeguard system must be devised and utilized which eliminates the chance of damage to the oil line by nearby construction activity.	Construction activity ma damage the oil line.
3. Pipeline Crossovers	Wherever construction equipment must cross the oil line, precautionary measures must be taken where necessary to eliminate the possibility of collision with the above ground pipe or damage to the below ground pipe by overloading.	Construction activity ma damage the oil line.
4. Workpad	The existing workpad may require upgrading to meet construction trafficability requirements. In addition, measures must be taken to prevent damage to insulation on the existing insulated workpad.	Current workpad is not thic enough for construction traf fic. Construction may damag workpad insulation.
5. Bridges	Existing access road and workpad bridges must be assessed for load-carrying capacity. Bridges must be upgraded or load limits must be enforced to prevent damage to Alyeska property.	Construction traffic ma damage bridges.
6. Erosion Control/ Revegetation	Erosion control features and all construction damage in general must be restored to "original condition." Disturbed areas must be revegetated in a manner similar to original conditions.	Erosion may lead to expensiv repair.
7. Fish Passage	Maintenance of a fish passage on the oil pipeline which has been impaired as a result of gas line construction activities shall be NAPCO's responsibility.	Fish passage may be impaire
8. Survey	Permanent survey control monumentation and reference points disturbed by gas line construction must be replaced. Cost of such replacement should be the responsibility of NAPCO.	
III. Maintenance	Maintenance of the gas line shall be consistent with standards set for design and construction and shall not jeopardize the integrity of the oil pipeline.	
IV. Operations	The gas line shall be operated in a manner which does not jeopardize the safety of the oil pipeline.	

POTENTIAL EFFECTS OF THE GAS LINE
ON SLOPE STABILITY AND LIQUEFACTION

neral Considerations:

its design and subsequent construction of the pipeline, Alyeska has accounted for safety aspects relating to bility of earth slopes. Alyeska's activities provided conditions for an environment which precludes stability-ated integrity problems. Many site-specific variables, including geometry, water conditions, temperature ime, physical properties, geography and outside stresss influences, were considered. This design has resulted a safe level of performance which could change if any variables are altered. It is then, these factors, which y be altered unfavorably which must be considered in analyzing the potential effects of the proposed gas e on slope stability.

e-Specific Considerations: (See Table 2)

omplete mile-by-mile analysis would require more time than is available. Areas, however, have been flagged consideration at a later date to selectively diagnose each zone to determine its non-criticalness.

r the most part, static, deep-seated slope instabilities are not a great hazard. This is not true for the shallow, d flow movements which may be initiated due to changes in thermal conditions. These changes can be nimized by proper design/construction techniques. Areas of potential susceptibility have been flagged in ble 2 for future site-specific analysis. At that time, parameters for each site-specific analysis must be esta-shed, based on final NAPCO intentions.

stability related problem is the "french drain" effect (i.e. any trench may intercept surficial water and ect a concentrated flow along the buried pipeline.) This problem has not been evaluated in this discussion, should be in any complete review.

TABLE 2

FLAGGED AREAS OF POTENTIAL CONCERN
REGARDING SLOPE STABILITY AND LIQUEFACTION

scription*		NAPCO Milepost**	Comments
47	Sta 9240	526	Long term workpad stability
50	Sta 9937 - 10090	515 - 512	Liquefaction, Short term workpad stability, Aufeis thaw sensitive
53A	Sta 35 - 53	493	Aufeis, Thaw plug, Workpad stability (Slop-on-top)
56	Sta 808±	478±	Ice rich area, Long term pad stability, Liquefaction, Thaw sensitive
62	Sta 660 - 700	441	Thaw plug, Liquefaction, Long term workpad stability, Ice rich area, Thaw sensitive
64	Sta 1200 - 1340	431	Thaw plug, Liquefaction, Long term workpad stability
66	Sta 1810	420	Long term workpad stability
67	Sta 2220	413	Liquefaction, Long term workpad stability
68	Sta 2535 - 2610	407 - 406	Thaw sensitive, Stability problems
69 - 74	Sta 2780 - 1110	403 - 375	Thaw plug stability, Slop-on-top, workpad stability etc.
75	Sta 1220 - 1290	373	Long term workpad stability, Thaw stability of surficial deposits
76	Sta 1600 - 2000	366 - 363	Long term workpad stability, Thaw stability of surficial deposits

TABLE 2

FLAGGED AREAS OF POTENTIAL CONCERN
REGARDING SLOPE STABILITY AND LIQUEFACTION

scription*		NAPCO Milepost**	Comments
78	Sta 172 - 175	354	Long term workpad stability, Liquefaction
80	Sta 789 - 897	342 - 341	Workpad stability
81	Sta 1100	337	Workpad stability
82	Sta 92 - 94	336	Thaw sensitive, Thaw stability, Workpad stability
87	Sta 560 - 650	333 - 298	Ice rich areas, Thaw sensitive, Thaw stability, Slop-on-Top, Workpad stability, etc.
88	Sta 700 - 740	297	Workpad stability
91	Sta 1590 - 1596	279	Thaw plug stability, Workpad stability, VSM sensitive to thermal disturbance
93	Sta 652	267	Liquefaction if thawed
95	Sta 1080 - 1090	261	Solifluction, Workpad stability, Thaw sensitive
95	Sta 40 - 515	259 - 250	Workpad stability
100	Sta 450	229.5	Workpad stability
103	Sta 1365	212.5	Workpad stability
105	Sta 1900	202	Workpad stability, Thaw plug stability
109	Sta 845 - 870	179	Workpad stability, Liquefaction if thawed
110	Sta 160 - 162	170	Thaw sensitive area, etc.
	Sta 224 - 236	172	
119	(?)	124 - 129	Thermal and Thaw sensitive (Snow workpad area)
121	Sta 990 - 1015	106	Massive ice ("Ice Cut")
122	Sta 1573 - 1580	96	Long term workpad stability

PSC Construction Station and Alignment Sheet given in Description column
Accuracy estimated ± 1 mile

POTENTIAL EFFECTS OF THE GAS LINE ON WORKPAD STABILITY

General Considerations:

The gas line must be designed and located such that the existing or new workpad does not become unstable and adversely affect the safety of the oil pipeline. Any workpad located on liquefiable or otherwise unstable soil must be located downslope of the above ground oil pipeline unless acceptable stabilization measures are applied.

Alyeska's specific concern is that a workpad slope failure may affect the oil pipeline as described in "Slope Stability and Liquefaction." During the design and construction of the oil pipeline, numerous measures were used to ensure workpad stability. These measures included locating the workpad downhill in relationship to the above ground pipeline, construction of special transition buttresses and special erosion control structures including insulation, special vegetative treatments, placement of heat pipes and relocation of the line. Similar measures will be required for the gas line even though the line temperatures are below 32 degrees Fahrenheit because the new workpad construction can cause the instability.

Site-Specific Considerations:

All locations where transition buttresses were constructed are areas of specific concern. These areas are shown in Table 3.

Locations of liquefiable soil will have to be identified on a site-specific basis. As a general rule, cross slopes in excess of 10 per cent can lead to an unstable workpad. Many of the areas of concern are included in the Section on "Slope Stability." Additional areas of concern are listed in Table 4. Only areas where the oil pipeline is elevated, ground slopes are moderate to steep, and workpad extension is opposite to the oil pipeline are included. These areas should be regarded suspect until detailed analysis shows otherwise. Additional areas not included in the table should also be evaluated, based on a study of the in-situ soils, water table, thermal effects and transient conditions as well as other pertinent factors.

TABLE 3

SUSPECT AREAS OF WORKPAD INSTABILITY

Description	NAPCO Milepost	Comments
Pump Station 4	148.1	Approximate Volume of Buttress: 2,000 Off Proposed Line
Pump Station No. 5	277.6	Approximate Volume of Buttress: 3,100 Off Proposed Line
Fish Creek	297.9	Approximate Volume of Buttress:1,300 Off Proposed Line
Fish Creek	301.7	Approximate Volume of Buttress: 1,400 Off Proposed Line
Hess Creek	380.7	Approximate Volume of Buttress: 2,700 Off Proposed Line
Upper Lost Creek (Tiney's Nightmare)	394.7	Approximate Volume of Buttress: 3,000 Off Proposed Line
Wilber Creek	405.9	Approximate Volume of Buttress: 7,000 Very Deep Burial Area
Little Globe	421.3	Approximate Volume of Buttress:2,200 Very Deep Burial Area

TABLE 3

SUSPECT AREAS OF WORKPAD INSTABILITY

Description	NAPCO Milepost	Comments
Aggie Creek	424.1	Approximate Volume of Buttress: 9,000 Very Deep Burial Area
Washington Creek	431.3	Approximate Volume of Buttress: 10,700 Very Deep Burial Area
Chatanika River	437.2	Approximate Volume of Buttress: 1,200 Very Deep Burial Area
Treasure Creek	441.0	Approximate Volume of Buttress: 1,300 Very Deep Burial Area
Tanana River	527.8	Approximate Volume of Buttress: 6,700 Off Proposed Line

TABLE 4

"SUSPECT" AREAS OF WORKPAD INSTABILITY
"CAUSED" BY PROPOSED LOCATION OF "NEW" WORKPAD

Approximate NAPCO Mileposts	Approximate NAPCO Mileposts
97.0 - 98.5	321.2 - 322.3
110.0 - 124.4	358.0 - 363.7
124.4 - 128.3	378.0 - 380.7
151.5 - 152.1	407.6 - 408.3
209.3 - 211.7	415.2 - 415.9
217.3 - 219.0	416.3 - 418.3
219.7 - 221.6	422.8 - 423.4
226.5 - 228.2	423.9 - 424.2
260.0 - 260.4	478.0 - 479.0
280.6 - 281.7	490.0 - 491.5
287.4 - 287.6	492.8 - 493.2
297.6 - 297.8	514.1 - 527.0
299.2 - 299.5	

POTENTIAL EFFECTS OF THE GAS LINE ON VERTICAL SUPPORT MEMBERS (VSMs)

General Considerations:

Approximately 50 to 60 per cent of the oil pipeline's alignment is constructed in the above ground Above ground support is utilized in areas where subsurface soil conditions consist of permafrost (i.e. nially frozen ground), and are sensitive to thermal degradation.

The above ground pipeline is supported on pile bents or vertical support members (VSMs), spaced at a imate 60-foot intervals. The majority of these VSMs are equipped with heat pipes. These devices support integrity by absorbing heat from the soil around the VSM, dissipating it to the atmosphere, t maintaining a frozen bulb around the pile.

The gas line must be designed and located such that the capacity of the soil to support the above gro pipeline in a stable manner is not adversely affected. Consideration must be given to alteration of the t regime such that additional thaw settlement or frost jacking is not introduced to the VSM.

Ditch excavation for gas line burial is a prime concern, especially in areas close to the VSMs. To that the load-carrying capacity (both vertical and lateral) of the VSM is not adversely affected, exca at crossings should be kept a minimum of 15 feet from the VSM. This distance should be determ include the effects of thermal degradation resulting from prolonged exposure to thawing during c tion.

Additionally, several VSMs have been installed as integral design factors, serving as special workpa ation. Any insulation or its protective gravel cover should be replaced as soon as possible when c by gas line construction. This aspect is especially critical during summer construction.

Another consideration of gas line construction is alteration of existing drainage patterns around c the oil pipeline. Introduction of flow, either surface or subsurface, around the VSMs will serious the thermal regime and could result in progressive thawing with a reduction in load-carrying Special measures should be implemented to prevent adverse changes in drainage patterns and to ponding around the VSMs where required.

The gas line crosses under the above ground oil pipeline at several locations along the proposed a Significant frost heaves of the gas line could produce detrimental effects at these crossings. Thes over" points also warrant special consideration.

Site-Specific Considerations:

Site-Specific considerations have not been addressed in this preliminary study.

POTENTIAL EFFECTS OF THE GAS LINE ON UNDERGROUND PIPELINE SUPPORT AND BURIED PIPELINE FEATURES

General Considerations:

The gas line must be located such that ditching limits do not intersect the oil pipeline ditch, transition buttresses, subsurface drainage structures, valves, river training structures, slope buttresses or any other associated oil pipeline structure. Removal of material adjacent to the oil pipeline may cause a loss of support, resulting in pipe overstress.

At river crossings or floodplain crossings, the gas line must be located such that flow does not occur in the excavated ditch during gas line excavation. Any flow in the excavated ditch may enlarge the ditch by erosion, resulting again in a loss of support.

The gas line must be designed and located such that the degree of restraint provided by soil surrounding the below ground oil pipeline is not reduced to an unsafe level. Excavation effects near the oil pipeline should be studied as should the alteration of drainage patterns affecting the soil's capacity to restrain the buried oil pipeline.

Site-Specific Considerations:

Table 5 is a partial list of significant buried features which must be addressed on a site-specific basis during gas line design.

TABLE 5

Description	NAPCO Milepost	Comments
Insulated box areas	171 & 394.3	Spoil from construction activities must not be placed over the insulated box. Heat loss through the top of the box is part of the design.
Deep burial areas	406 (but not exclusive of other areas)	The weight and grade of TAPS pipe had maximum depths of burial. These areas of deep burial should be flagged to limit the additional loading over TAPS pipe.
Buried revetments	192 - 198	In some floodplain areas, buried rip rap was used to protect TAPS pipe from scour. This rip rap was placed on the river side of the pad. These areas should be flagged for later evaluation.
Workpad traffic flow	Line Wide	Workpad traffic flow must be controlled to prohibit possible use of the ditch crown as an alternate route for vehicles. Vehicular traffic might overstress the below ground pipe.
Transitions of TAPS to above ground mode at the bottom of steep slopes	372.3 - 393.2 (but not exclusive of other areas)	Protection must be given to protect the transition pipe from equipment, rocks, etc. from rolling down steep slopes and striking the pipe.
Aerial below ground crossings of state haul road	95.1, 130.8, 148 and other areas)	Support of casing surrounding pipe must be assured. Planning must also be given to rerouted traffic when above ground pipe is on either side of the road.

TABLE 5

escription	NAPCO Milepost	Comments
otection of buried defill buttresses ed for sidebend straint	7, (but not exclusive of other areas)	For increased sidebend restraint, sidefill buttresses were constructed to restrain the outside of sidebends where the in-situ soil was not suitable. These areas of granular fill must be identified and protected from sloughing into gas line excavation.
debend areas where e bend projects toward e gas line excavation.	Line Wide	Sidebend areas with marginal sidebend restraint should be identified and possible surcharging performed before excavation.
otection of structural d sidefill overfills	Line Wide	Overfills must not be regraded nor mined for additional backfill of gas line activities.
otection of water ble during construction d operation of gas ne	Line Wide	Over bend areas were designed with water table below pipe or above pipe. With an increase in water table elevation, some bends may need additional restraint. The placement of spoil or the freezing of the soil during operation of the gas line may change the water table situation.
avations in areas extensive ice-rich aterial	179 - 179.5 (but not exclusive of other areas)	Excavation in slop-on-top areas must be planned such that the ditch won't remain open for a long period of time and experience thermal degradation. This degradation may affect TAPS pipe integrity, generate mudslides, and/or reduce workpad trafficability.

POTENTIAL EFFECTS OF THE GAS LINE ON TAPS FUEL-GAS LINE AND OIL LINE CROSSINGS

General Considerations:

Gas line crossings must be designed and located (generally above the buried oil pipeline) to minimize potential damage to the pipeline during construction. Crossings must be designed to eliminate any adverse effects during operation such as adverse changes to the thermal regime.

Alyeska's specific concern is that NAPCO construction equipment may damage the oil line by breaking cathodic protection test leads or the zinc ribbon, damaging pipe coating, denting or puncturing the pipe. To minimize the chances for these types of damages, the gas line should be placed above the buried oil pipeline where practical. This may require artificial berms. In some locations, such a berm may destroy local drainage, be subject to scour and erosion or create adverse visual impact. In such cases the gas line may have to either be relocated or buried under the oil pipeline. Relocating the line is preferred.

Crossing under the above ground oil pipeline is also a concern because of the possibility of construction equipment damaging the line. The clearance between the ground and the bottom of the above ground oil pipeline varies from two to 17 feet. Any crossing under the above ground oil pipeline should be at site-specific locations which gives maximum clearance and provides maximum distance between VSMs. At above ground oil pipeline crossings, some positive means of damage prevention such as "Headache Bars" must be provided.

Site-Specific Considerations:

All proposed crossings of the oil pipeline by the gas line, including but not limited to the following identified 63 crossings, create concern. In addition, Alyeska is concerned that the maintenance and operation of the oil pipeline will be adversely affected during periods when the haul road, access roads or the workpad are blocked by construction equipment or while the roads are being dug up to bury the gas line. Alternate means for access, such as run-a-rounds, will be required during construction.

TABLE 6

Locations Where NAPCO Proposes To Cross Below Ground Oil Pipeline

114.3	199.7	391.9	473.9
163.8	232.3	403.6	477.3
169.4	235.1	431.4	511.3
172.3	238.0	440.0	514.3
179.5	292.9	453.9	525.8
195.9	302.9	456.4	

Locations Where NAPCO Proposes To Cross Above Ground Oil Pipeline

90.7	281.7	372.1	408.8
108.5	289.5	373.7	410.0
130.8	301.7	381.0	416.7
148.0	333.3	383.3	430.2
212.4	341.1	395.9	435.5
224.6	343.1	397.0	437.2
240.0	357.0	399.4	441.0
242.4	364.2	400.1	472.2
260.0	365.3	406.0	
271.8	369.2	407.6	

Locations Where NAPCO Proposes To Cross TAPS Fuel- Gas Line

23.7	95.0	98.0	148.0

POTENTIAL EFFECTS OF THE GAS LINE ON EROSION CONTROL AND SURFACE DRAINAGE

General Considerations:

The gas line must be designed such that drainage patterns are not altered in a manner adversely affecting the oil pipeline. The effects of any aufeis produced by the cold gas line must be considered in particular. Effects of the gas line on culverts and other drainage facilities must also be considered.

Specifically, Alyeska is concerned that surface erosion may expose the oil pipeline or lead to VSM instability. Aufeis may induce erosion at undesirable locations during breakup. In addition, aufeis may completely capture the above ground oil pipeline and restrain it contrary to design requirements.

Local drainages may become blocked. Flooding may occur and specific drainage patterns altered, all leading to erosion and thermal degradation.

Special designs, including relocation of streams, construction of ditch checks, revegetative measures, rip rap, culvert installtion, low water crossings and pipe ditch plugs, were used along the oil pipeline to prevent erosion. These measures were selected after a foot-by-foot review. Gas line construction should not be detrimental to these measures nor nullify their effects.

Site-Specific Considerations:

Wherever the proposed gas line is near the oil pipeline corridor is an area of concern. Particularly, this is from NAPCO Milepost 4 to Milepost 540. General areas include, but are not limited to the following classifications:

1. Rivers, streams, ephemenol creeks and regions of concentrated surface flow (e.g. Milepost 365).
2. Aufeis areas (e.g. Mileposts 417 to 422).
3. Steep slopes, transverse levees and diversion levees (e.g. Mileposts 406 and 426).
4. Ice cuts (e.g. Mileposts 381 to 382).
5. Pipe ditch plugs (buried line on steep slope).
6. Transition buttresses (See Section on "Workpad Stability").
7. River training structures (See Table 7).

POTENTIAL EFFECTS OF THE GAS LINE ON RIVERS AND FLOODPLAINS

General Considerations:

Elevated river crossings were designed to account for potential scour around supporting structures and were based on pipeline design flood levels and navigation requirements. The design of buried river and floodplain crossings on TAPS required a thorough consideration of many factors including the primary criterion of pipe exposure to various streamflow forces.

Obviously, the above design basis did not include the thermal and hydrologic conditions that may be imposed by the gas line. Of particular concern is the aufeis or frozen plug that may be generated by the gas line which could indirectly expose the oil pipeline by riverbed scour, floodplain erosion, and lateral channel migration. Ice jams could endanger the elevated crossings. In other cases, unusual aufeis buildup could constitute a nuisance factor during routine oil pipeline access or emergency repairs.

Careful consideration must be given to the design and construction of the gas line where it passes through spur dikes. Unusual aufeis buildup could cause spur dike failure by over topping. Frost jacking of the gas line under the spur dikes could cause piping through the dike and catastrophic failure during breakup flooding. Obviously all construction breaches of river training structures must be carefully reconstructed.

Special care must be exercised in placing material site levees and access roads to avoid flood damage to the oil pipeline and its appurtenances.

Site-Specific Considerations:

Specific river and floodplain crossings where the proposed gas line may adversely affect the Trans-Alaska Pipeline are listed below by name and milepost. Other comments such as mode, relative location of the two lines and conditions are also provided.

TABLE 7

Description	NAPCO Milepost	Comments
Sagavanirktok River and Floodplain Crossing	25 - 28	Gas line passes through spur dike field protecting below ground oil pipe. River undergoes major change in flow regime at this point.
Sagavanirktok Floodplain Crossing	32.5 - 34	Gas line runs along an armored revetment. Below ground oil line.
Sagavanirktok Floodplain Crossing	51.9 - 53.5	Gas line passes through spur dike field. Below ground oil pipe.
Minor Stream Crossing	127.1 - 127.4	Gas line crosses small valley upstream from above ground oil line. Aufeis potential.
Minor Stream Crossing	130.9 - 131.3	Gas line crosses small stream downstream of above ground oil pipeline.
Atigun River Crossing	146.5	Below ground gas line crosses river 250 feet downstream from above ground oil line crossing. Potential for increased scour at crossing abutments.

TABLE 7

Description	NAPCO Milepost	Comments
Minor Stream Crossings	152, 156.9, 158.5	Below ground gas line crosses upstream from above ground oil pipeline on alluvial fan. Aufeis potential.
Atigun River Floodplain	163.8 - 167.5	Below ground gas line parallels below ground oil line in active floodplain. Potential for unusual aufeis buildup and channel scour.
Chandalar River Floodplain and Crossing	174.5 - 177.5	Below ground gas line follows below ground oil line and crosses river downstream from oil line. Aufeis and scour potential.
Dietrich River Floodplain	179.5 - 182	Below ground gas line and below ground oil line headwaters of river. Aufeis buildup.
Dietrich River Floodplain	183.0 - 183.3	Spur dikes crossed by gas line. Above ground and below ground oil line.
Dietrich River Crossing	183.3 - 183.5	Below ground gas line crosses upstream from below ground oil line. Aufeis and scour potential.
Dietrich River Floodplain and Crossing	183.5 - 188.0	Below ground gas line and below ground oil line in active floodplain and cross major channels several times.
Dietrich River Crossing	188.0 - 188.2	Below ground gas line crosses upstream from below ground oil line. Both lines cross in a constricted flow zone created by a highway bridge 100 to 200 feet upstream.
Dietrich River Floodplain	189.8 - 190.8	Below ground gas line and below ground oil line located in outside curve of floodplain.
Dietrich River Floodplain	192.2 - 193.7	Both below ground lines run along state highway. Oil line may be protected by river weight revetment.
Dietrich River Floodplain	193.7 - 194.4	Both below ground lines cross high gradient stream and alluvial fan. Gas line is downstream. High scour potential.
Dietrich River Floodplain	196.8 - 200.0	River training structures. No problem if present route out of floodplain is used.
Snowden Creek Crossing	202.3 - 207.8	Gas line crosses oil line downstream. Alluvial fan and high gradient stream. High scour potential.
Dietrich River Floodplain	203.8 - 204.5	Below ground gas line on stream side of below ground oil line in active floodplain.

TABLE 7

Description	NAPCO Milepost	Comments
Minor Stream Crossings	205.0 - 205.3 and 207.6 - 207.8	Below ground gas line crosses minor streams downstream from above ground oil line. Aufeis and minor scour potential to VSMs.
Dietrich River Crossing	209.0 - 209.3	Below ground gas line crosses river 500 feet upstream from above ground oil line and 700 feet from state highway bridge. Aufeis and flooding potential.
Middle Fork Koyukuk Crossing	211.7 - 212.7	Below ground gas line crosses river, 500 feet downstream from below ground oil line and 700 feet downstream of highway bridge. Aufeis and flooding potential.
Middle Fork Koyukuk Floodplain	221.7 - 222.3	Below ground gas line crosses spur dikes. Above ground oil line area.
Middle Fork Koyukuk Crossing	224.8 - 226.0	Below ground gas line crosses 1000 feet upstream from oil line. Aufeis and flooding potential.
Middle Fork Koyukuk Crossing	228.0 - 228.8	Below ground gas line crosses 300 feet downstream from below ground oil line. Aufeis, flooding and scour potential.
Middle Fork Koyukuk Floodplain	234.8 - 236.4	Below ground gas line passes through spur dikes.
Minor Stream Crossing	236.7 - 237.0	Below ground gas line crosses downstream from below ground oil line. Aufeis, flooding and scour potential.
Slate Creek Crossing	241.0 - 241.5	Below ground gas line crosses downstream from below ground oil line. Aufeis, flooding, and scour potential.
South Fork Koyukuk Crossing	259.8 - 260.1	Below ground gas line crosses upstream of above ground oil line. Lines cross in floodplain. Aufeis, flooding and scour potential.
Jim River Crossing	271.7 - 271.8	Below ground gas line crosses upstream from below ground oil line, Aufeis, flooding and scour potential.
Douglas Creek Crossing (at confluence of Jim River)	273.8 - 274.0	Below ground gas line crosses downstream from above ground oil line. Aufeis, flooding and scour potential.
Prospect Creek Crossing	280.3 - 281.1	Below ground gas line crosses downstream from above ground oil line. Aufeis, flooding and scour potential.

TABLE 7

Description	NAPCO Milepost	Comments
Bonanza Creek Crossing	287.4 - 289.5	Below ground gas line crosses upstream oil line. Crossover at Milepost 289.3. High aufeis potential with flooding.
Fish Creek	297.7 - 298.0	Below ground gas line crosses upstream from above ground oil line. Aufeis and VSM scour.
Kanuti River Crossing	305.5 - 305.7	Below ground gas line crosses upstream from below ground oil line. Aufeis and flooding scour.
Minor Stream Crossing	331.8 - 332.0	Below ground gas line crosses upstream from above ground oil line. High aufeis workpad blockage potential.
Hess Creek Crossing	379.8 - 380.4	Below ground gas line crosses downstream from above ground oil line. High aufeis, flooding and scour potential.
Erickson Creek Crossing	383.8 - 383.9	Below ground gas line crosses upstream from above ground oil line. Minor aufeis and flooding potential with access blockage.
Erickson Creek Crossings	387.7 - 387.9 388.7 - 388.9	Below ground gas line crosses downstream from above ground oil line. Minor aufeis and flooding potential with access blockage.
Lost Creek Crossing	393.0 - 393.3	Below ground gas line crosses downstream from above ground oil line. Minor aufeis and flooding potential w ith access blockage.
Tolovana River and Floodplain Crossing	388.2 - 400.2	Below ground gas line crosses downstream and upstream from above ground and below ground oil lines. High aufeis with flooding and scour potential.
Wilber Creek Crossing	406.0 - 406.1	Minor aufeis flooding and scour potential.
Slate Creek	408.9 - 409.0	Minor aufeis, and flooding potential.
Tatalina River Crossing	412.7 - 413.1	Below ground gas line crosses upstream of above ground oil line. High aufeis, flooding and scour potential.
Globe Creek Crossing	417.2 - 417.5	Below ground gas line crosses 150 feet downstream of above ground oil line. Moderate aufeis and flooding potential.
Washington Creek Crossing	431.2 - 431.4	Crossover point of below ground gas line and above ground oil line. Moderate aufeis and flooding potential.

TABLE 7

Description	NAPCO Milepost	Comments
Chatanika River Crossing	437.0 - 437.7	Crossover point of below ground gas line and below ground oil line. High aufeis, flooding and scour potential.
Treasure Creek Crossing	441.0 - 441.2	Crossover point of below ground gas line and above ground oil line. Minor aufeis and flooding potential.
Chena River Crossing	457.8 - 458.0	Below ground gas line crosses downstream from below ground oil line. High aufeis and flooding potential.
Moose Creek Crossing	471.1 - 471.2	Minor aufeis potential.
French Creek Crossings	475.8 - 475.9 481.4 - 481.5	Below ground gas line downstream from above ground oil line. Minor aufeis, flooding and scour potential.
Little Salcha	490.0 - 490.4	Below ground gas line crosses upstream from above ground oil line. High aufeis, flooding and scour potential.
Salcha River Crossing	492.9 - 493.7	Below ground gas line crosses upstream from below ground oil line. High aufeis, flooding and scour potential.
Redmond Creek Crossing	497.1 - 497.3	Below ground gas line crosses upstream from above ground oil line. Minor aufeis buildup and access blockage.
Shaw Creek Crossing	517.1 - 517.4	Below ground gas line crosses upstream from above ground oil line. High aufeis, flooding and VSM scour.

POTENTIAL EFFECTS OF THE GAS LINE ON MATERIAL SITES

ieral Considerations:

ration of material sites located in rivers and floodplains may adversely affect the pipeline or appurten- :s such as spur dikes or other river training structures. Upstream pit operations such as perimeter dike struction may encourage river channel migration toward the pipeline and cause increased scour or damage iver training structures.

-Specific Considerations:

TABLE 8

cription	NAPCO Milepost	Comments
:avanirktok River odplain	24 - 62	Spur field damage in the vicinity of Milepost 27 and longitudinal dike construction in the vicinity of Milepost 33 related to mining operations upstream.
avanirktok River odplain	82 - 91	Spur field damage related to mining operations upstream.
ich River odplain	182 - 209	May affect river training structures and below ground pipe.
yukuk River odplain	211 - 250	May affect river training structures.

POTENTIAL EFFECTS OF THE GAS LINE ON BURIED ANIMAL CROSSINGS

:neral Considerations:

.e gas line must be designed such that the function of the Alyeska pipeline is not adversely affected at special ried animal crossings. In addition, their utility as animal crossings must not be impaired. Any additional ermal disturbance may cause additional thaw and potential overstress for the oil pipeline.

.e-Specific Considerations:

iried animal crossings are located at the following NAPCO Mileposts:

TABLE 9

Crossing No.	NAPCO Milepost
1	7
2	119
3	120
4	126
5	130
6	131
7	135
8	137
9	252
10	257

POTENTIAL EFFECTS OF THE GAS LINE ON PIPELINE CROSSOVERS

General Considerations:

Wherever construction equipment must cross the oil pipeline, precautionary measures must be taken to eliminate any possibility of collision with the above ground pipe or damage to the below ground pipe by overloading.

At designated road and trail crossings, the oil pipeline was designed to be crossed by 21,400-pound superimposed wheel load under all operating conditions. In some locations the criteria required the use of special casings or heavy wall pipe. In addition the backfill was specially compacted to meet special gradation requirements at all road crossings.

Site-Specific Considerations:

At some locations, particularly at temporary access road crossings, road crossing criteria were met during construction, but not during operation. All areas where NAPCO proposes to cross the oil line create areas of concern, not only because of the repeated nature of construction traffic, the chance of overload and possible removal of cover, but the risk that the area was not initially designed as a road crossing.

These areas include, but are not limited to, the following NAPCO Mileposts:

TABLE 10

Locations Where NAPCO Proposes To Cross The Oil Pipeline With Construction Equipment

Access Roads (Below Ground Pipeline)

23.7	35.9	47.1	77.1	167.4	195.9	291.3	370.7	422.2	456.8
25.9	38.8	50.3	78.8	176.0	197.6	306.4	391.5	423.6	472.2
30.0	40.5	51.9	80.2	176.1	235.2	314.2	406.5	426.1	530.0
31.8	43.2	54.6	115.5	181.5	238.6	335.2	416.1	435.3	530.1
32.7	43.8	74.7	166.0	188.7	241.4	367.4	419.5	437.6	531.8
35.4	44.9	75.2							

Workpad Switches

70.6	221.6	287.6	313.9	355.0	370.8	391.7	409.9	430.2	477.4
130.7	228.1	289.5	321.1	363.6	371.0	395.9	414.0	431.4	486.4
152.1	238.0	292.9	322.2	364.2	371.2	396.8	416.2	435.7	490.2
160.9	238.8	297.7	333.2	365.2	371.7	398.2	417.2	437.2	491.3
172.3	246.0	297.9	335.2	368.2	372.0	399.3	421.0	440.0	493.2
180.0	248.0	299.2	335.7	368.4	374.2	400.1	421.3	441.0	505.0
209.0	260.4	299.5	341.0	369.0	378.0	403.6	422.8	453.8	
215.0	271.8	301.7	343.2	369.4	383.8	405.9	423.4	456.4	
219.1	280.7	303.0	343.8	370.0	385.9	407.6	423.9	472.1	
219.7	287.5	311.7	344.2	370.4	386.7	408.9	424.1	473.8	

POTENTIAL EFFECTS OF THE GAS LINE ON THE WORKPAD

General Considerations:

The existing workpad will require upgrading to meet construction trafficability needs at site-specific locations. In addition, measures must be taken to prevent damage to insulation on the existing insulated workpad or where VSMs or buried pipe have been insulated.

The workpad was designed for three-year construction life. During construction, the area was constantly motor patrolled and additional fill (maintenance course) was implemented. Much of the workpad has settled. Additional traffic, particularly heavy construction traffic, could make the workpad impassable by Alyeska operation and maintenance personnel.

Damage to the workpad insulation can cause thermal erosion with subsequent ponding. Insulation was placed around many VSMs to limit thaw of the workpad, ensuring stability of the specific VSM.

Areas where the oil pipeline was built off a snow pad cause additional concern. If a pad is placed, thermal erosion may occur.

Alyeska would expect the workpad to be restored by NAPCO to its original condition after gas line construction.

Site-Specific Considerations:

Insulated workpad was provided from Pump Station 1 (NAPCO Milepost 5±) to the Atigun River (NAPCO Milepost 161) with the exception of sections of the pipeline located in major floodplain areas or located directly adjacent to the TAPS haul road.

Workpad insulation was placed around specific VSMs at various locations. This insulation extends out from the VSM from 15 to 25 feet. These VSMs are identified in the field by a yellow or red band of paint, placed on the VSM during construction.

Portions of the buried oil pipeline were insulated at transitions between the above ground and below ground pipeline. The pipeline was placed in a special insulated box at designated locations. These areas are identified in Table 5.

Snow pad areas also require special study. This problem has not been evaluated in this discussion but should be in any complete review.

POTENTIAL EFFECTS OF THE GAS LINE ON ACCESS AND WORKPAD BRIDGES

General Considerations:

Existing access road and workpad bridges must be assessed for load-carrying capacity. Bridges must be upgraded or load limits must be enforced to prevent damage to Alyeska property.

Site-Specific Considerations:

The following summary indicates existing workpad and access road bridge locations between Prudhoe Bay and Delta Junction. The bridge types are predominately Acrow panel, steel stringer, and Glulam structures. These bridges must be evaluated to determine their abilities to withstand expected loading by heavy construction equipment. Some bridges may require upgrading to support these loads or have load limits imposed to prevent structural damage.

TABLE 11

Bridge Location	NAPCO Milepost
Shaw Creek	517.5
Redmond Creek	497.5
Little Salcha	488.5
French Creek No. 1	476.0
French Creek No. 2	475.0
French Creek No. 3	474.5
French Creek No. 4	474.0
French Creek No. 5	472.5
Moose Creek No. 1	471.0
Moose Creek No. 2	470.0
Treasure Creek	441.0
Washington Creek	431.0
Tolovana River	399.5
Lost Creek (AS 71)	393.0
Erickson Creek No. 1	385.5
Erickson Creek No. 2	384.0
Fish Creek (AS 73)	380.0
87-APL-3A	300.0
87-APL-4	298.5
Fish Creek (AS 88)	298.0
Chandalar Airport	176.0
Sagavanirktok River (AS 123)	89.0
Sagavanirktok River (AS 123)	81.5

POTENTIAL EFFECTS OF THE GAS LINE ON SURVEY MONUMENTATION

eral Considerations:

ıg all portions of the below ground oil pipeline, no monuments were set on the actual points of tangency. :e locations were referenced by three aluminum capped and stamped reference point monuments, placed ınd right and at various distances from the oil pipeline centerline.

;e monuments represent the legal locations from which the point of tangency can be established and ROW boundaries located. Inevitably a large number of monuments will be disturbed, destroyed or buried ıg gas line construction and will have to be replaced by Alyeska.

replacement will require a survey crew and will not be cheap. It will also require a revision to the R.P. puter printout tables. NAPCO should pay both the cost of replacement and revision.