501.2

NORTHWEST ALASKAN PIPELINE COMPANY

1120 20th Street, N.W.
Suite S-700
Washington, D.C. 20036
(202) 872-0280

GOA-82-1120

September 29, 1982

"BUSINESS" Information for Federal Government Purposes in Accordance with 10 CFR 1504 (F.R. Vol. 46, No. 240, December 15, 1981, pages 61222 thru 61234)

RECEIVED

OCT 04 1982

State of Alaska
Office of
Pipeline Coordinator

Mr. William Black
Director of Engineering
Office of the Federal Inspector
2302 Martin Drive
Irvine, California 92715

Re: "Ditch Plug Methodology," Forwarding Of

Dear Mr. Black:

Enclosed for your information are four (4) copies of an NWA report entitled "Ditch Plug Methodology." This document completes action on Activity #34 in NWA's Key Activity Checklist, Revision #1 of September 23, 1982, and provides support for the pipeline segment of Design Criteria Manual, Vol. 1, Section 13 (Ditch Configuration).

The information in the enclosure is considered confidential/ proprietary by Northwest Alaskan Pipeline Company and remains the property of Alaskan Northwest Natural Gas Transportation Company, a partnership. The petition attached to this letter requests OFI to consider this document "Business" information pursuant to 10 CFR Part 1504. All rights are reserved with respect to the enclosed work, and unauthorized reproduction is prohibited; this material is protected as an unpublished work under the Copyright Law of the United States, 17 USC §101 *et seq*.

Yours truly,

NORTHWEST ALASKAN PIPELINE COMPANY

Edwin (Al) Kuhn

Edwin (Al) Kuhn
Director
Governmental Affairs

EAK/rlc
Enclosures (4 copies)
cc: J. Sizemore, OFI, Anchorage (w/4 copies)
N. Hengerer, OFI, Washington, D.C. (w/1 copy)
A. Ott, SPO, Fairbanks, (w/2 copies)
J. McPhail, Alyeska (w/2 copies)

19820929-2

Enclosure to Northwest Alaskan Pipeline Company letter GOA-82-1120, September 29, 1982 to Mr. William Black

PETITION FOR "BUSINESS" DESIGNATION
SUBMITTED TO OFI PURSUANT TO 10 CFR PART 1504

I. The information enclosed with the above referenced Northwest Alaska Pipeline Company (NWA) letter, qualifies for a "BUSINESS" designation on the basis that it is confidential/ proprietary, commercial information, the release of which may substantially impair the competitive position of the sponsors of the Alaska gas pipeline segment of the Alaska Natural Gas Transportation System (ANGTS). NWA has incurred substantial costs to develop the information, involving over four years' work and major expenditures, including both direct and indirect costs. Moreover, the sponsors do not have a final, unconditional Certificate of Public Convenience and Necessity from the Federal Energy Regulatory Commission (FERC), and the information clearly would be of substantial value to anyone contemplating construction in Alaska or in similar climates and geologic regimes. Even after a final FERC certificate has been obtained, the information contained in the document submitted is of such a nature that it might be used in third-party litigation against the sponsors. NWA has given serious consideration to a request for a "SENSITIVE" designation and to the recent order from the International Trade Commission, Department of Commerce (e.g., 15 CFR Parts 379, 385 and 399, published F.R. Vol. 47, No. 2, January 15, 1982, p. 141) restricting export of technical data related to gas transmission. Although the less restrictive "BUSINESS" designation has been requested, the technology represented by this information clearly should not be disclosed except as authorized by NWA.

II. The OFI may contact the following named persons concerning this petition:

Mr. Edwin (Al) Kuhn, Director-Governmental Affairs
Northwest Alaskan Pipeline Company
1120 20th Street, NW
Washington, D.C. 20036
Phone: 202/872-0280

Mr. William J. Moses, General Counsel
Northwest Alaskan Pipeline Company
3333 Michelson Drive
Irvine, California 92730
Phone: 714/975-4003

Mr. George P. Wuerch, Manager-Regulatory and Governmental Affairs
Northwest Alaskan Pipeline Company
3333 Michelson Drive
Irvine, California 92730
Phone: 714/975-6560

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145A

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Edwin A Kuhn

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Director
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Irvine, California 92730
Phone: 714/975-6560

CONFIDENTIAL/PROPRIETARY

DITCH PLUG METHODOLOGY

145-A

RECEIVED
OCT 04 1982
State of Alaska
Office of
Pipeline Coordinator

"BUSINESS" information for Federal Government purposes in accordance with 10 CFR 1504 (F.R. Vol. 46, No. 240, December 15, 1981, pages 61222 through 61234).

REV. NO.	REMARKS	APPROVED: ORIGINATOR	APPROVED: ENGINEERING	APPROVED: ENVIRONMENTAL AFFAIRS	APPROVED: CONSTRUCTION
	H02				
0	ISSUED FOR REVIEW				

NORTHWEST ALASKAN PIPELINE COMPANY	DOC. NO.	
	DATE	REV.
	28 SEPTEMBER 1982	0

TABLE OF CONTENTS

1.0 INTRODUCTION

The gas pipeline will be constructed through many areas where groundwater occurs in sloping terrain at or near the ground surface. The pipeline ditch will intercept this water and may change the existing flow pattern. If the ditch backfill is more permeable than the in-situ material, the ditch will provide a channel which will tend to collect water and provide a path for increased flow downslope along the pipeline. The alteration of the groundwater flow pattern is potentially detrimental to the surrounding environment, adjacent structures and the stability of the pipeline ditch.

In order to minimize the effects of water flow within the ditch, ditch plugs will be designed and installed at appropriate locations to fulfill one or more of the following three functions:

- Restrict the flow of water at either a point of entry into the ditch or at a point of exit from the ditch, see Section 3.0.
- Restrict seepage erosion of the ditch backfill, see Section 4.0.
- Restrict the ditch water flow in order to limit thermal degradation of the permafrost surrounding the pipe, see Section 5.0.

Ditch plugs are not designed to control the flow of groundwater in the soil outside the ditch, nor are they designed to control surface erosion. For surface drainage and erosion control, see Section 11.0, Drainage and Erosion Control, of the Pipeline Design Criteria Manual (Reference 1) and Stipulation 1.6.1, Plan No. 8, Erosion and Sedimentation Control (Reference 2).

This report presents the philosophy, criteria and methodology for the design, location and construction of permanent ditch plugs. It does not cover temporary structures for the control of ditch water flow during construction.

2.0 DITCH PLUG PERFORMANCE CRITERIA

For satisfactory performance, the constructed ditch plug system should fulfill each of the following requirements:

- o Provide a low permeability barrier across the ditch cross-section to reduce or restrict water flow within the ditch.
- o Provide an outlet for the controlled exit of ditch water to the ground surface to prevent seepage erosion upslope of the ditch plug.
- o Provide for surface grading (including berms as required) to divert the water outflow away from the ditch.

Typical cross sections of alternative ditch plug designs are presented in Figures 1, 2 and 3.

2.1 LOW PERMEABILITY BARRIER

The purpose of the barrier is to interrupt the flow of water along the pipeline ditch in order to restrict the quantity of flow and/or reduce the velocity of flow. The barrier must effectively prevent a continuation of flow within the limits of the ditch excavation. For maximum effectiveness, it must be constructed to restrict water flow along the interface of the pipe and the barrier, as well as at the interface of the ditch wall and the barrier. Any loose and/or disturbed materials on the ditch walls and bottom will be removed prior to construction of the barrier to ensure a tight contact of the barrier with the ditch walls and ditch bottom. Additionally, keying into the ditch walls and bottom may be used to ensure a better seal. Specifications will be developed during final design.

The following materials are under consideration for use in constructing low permeability barriers:

- o Sprayed-in-place polyurethane.
- o Fine gravel or concrete sand uniformly mixed with 15 to 20% of bentonite by weight.
- o System of jute bags filled with either a sand-bentonite mixture or a soil-cement mixture.
- o Lean concrete, preferably using an expansive cement.
- o Well compacted select backfill or jute bag system sealed with a low permeability barrier such as gunite, asphaltic layer or polyurethane foam.

2.2 DITCH WATER OUTLET

Water flow in the ditch is restricted by the low permeability barrier and water will collect upslope of the barrier until the water level reaches the ground surface. Any additional water entering the ditch upslope of the ditch plug will increase the hydrostatic head and cause a flow through the backfill, out of the ditch and onto the ground surface. The purpose of the water outlet is to provide a controlled exit for the water outflow which will prevent the occurrence of seepage erosion. The outlet will be constructed so that it will provide a permeable path for the water flow to the surface, and will also restrain (or filter) the backfill against the erosive force of the flowing water.

The water outlet is placed immediately upslope of the low permeability barrier. It is constructed of a select free draining material overlain by a filter blanket. The free draining material provides a controlled path for water flow through the filter to the ground surface. Specific requirements for the free draining material and the filter depend upon the ditch backfill material to be used and the native soil conditions to be encountered. These requirements are discussed in greater detail in Section 4.0 and will be determined during detailed design.

2.3 SURFACE DRAINAGE

Provisions for surface drainage of the water outflow must be provided to ensure that it is diverted away from the ditch and does not pond on the surface at the ditch plug or flow downslope as surface water and re-enter the pipeline ditch. A diversion berm may be used where water outflow occurs and the potential for surface erosion exists. All surface grading, including location and dimensions of the berm, will be compatible with drainage and erosion control criteria outlined in Section 11.0, Drainage and Erosion Control, of the Pipeline Design Criteria Manual (Reference 1) and Stipulation 1.6.1, Plan No. 8, Erosion and Sedimentation Control (Reference 2).

3.0 DITCH PLUGS TO RESTRICT LOCAL FLOW

3.1 DESIGN PHILOSOPHY

Ditch plugs will be installed in the pipeline ditch immediately upslope of locations where there is a potential for the diversion of the ditch water flow from the ditch to an intersecting channel (or other region) where detrimental effects may occur to the surrounding environment, adjacent structures or the stability of the pipeline ditch.

At locations where there is a potential for concentrated local flow into the ditch, ditch plugs will be installed in the pipeline ditch immediately downslope of the source. The plugs will restrict the continuation of this flow along the pipeline ditch. At certain locations, it may be necessary to provide a special ditch plug design without the water outlet (or a ditch plug alternative) to effectively shut off the flow. These plugs not only restrict high volume flow in the ditch which causes ditch integrity problems, but they also prevent dewatering of adjoining lakes or other bodies of surface water. In some cases, they may be used on slopes in order to cause ditch water outflow upslope of a location where discharge could create aufeis which may have adverse effects on adjacent facilities or the environment.

3.2 CRITERIA FOR LOCATION

Ditch plugs to restrict water flow in the pipeline ditch will be installed at potential groundwater problem areas identified by groundwater assessment programs, which include the following locations:

- At locations where the pipeline passes near existing lakes or other surface bodies of water and there is a potential for draining the surface water by groundwater flow. A ditch plug will be placed where diversion is anticipated.

- At stream crossings where there is a possibility of diverting stream flow down the ditch and away from the normal channel flow. Ditch plugs will be placed on the downslope side of the stream to hold it in its natural course.

- At TAPS oil and fuel gas pipeline crossings which exhibit groundwater flow potential. Ditch plugs will be installed both upslope and downslope of the crossing. This will restrict flow within the gas pipeline ditch from being diverted into the foreign pipeline ditch, as well as restrict diversion of water flow from the foreign pipeline ditch into the gas pipeline ditch.

- o At locations where it is desirable to block ditch flow in order to minimize icings and aufeis at a downslope location. A ditch plug will be placed a sufficient distance upslope to limit potential interference by icing accumulations.

- o At locations where concentrated groundwater flow entering the pipeline ditch is encountered during construction. A ditch plug will be placed downslope from the observed location.

- o At locations where flow from cross drainages, such as low water crossings, might be diverted down the ditch. A ditch plug will be placed on the downslope of the crossing.

3.3 DITCH PLUG ALTERNATIVES

Ditch plugs to block local flow may be replaced with one of the following alternatives:

- o In non-permafrost areas, placement of low permeability backfill such as soil cement.

- o In permafrost areas, maintaining the ditch in a frozen state.

4.0 DITCH PLUGS TO RESTRICT SEEPAGE EROSION

4.1 DESIGN PHILOSOPHY

The potential for seepage erosion exists at locations where the uppermost groundwater flow line or phreatic surface intersects the ground surface. The following three general conditions must be present before seepage erosion can develop and become problematic:

- The native soil around the pipeline ditch or the ditch bedding and padding or backfill material must be susceptible to seepage erosion.

- There must be a continuation of water flow of a sufficient duration to allow the progression of erosion to create subsurface erosion voids detrimental to the integrity of the pipeline.

- The hydraulic pressure must be of sufficient magnitude to overcome the shear strength of the soil and provide a buoyant force sufficient to move the soil particles. Thus, fine-grained soil at the surface may be washed away by the flowing water, leaving voids. The pressure, or hydraulic gradient, necessary for this to occur is defined as the critical hydraulic gradient.

Seepage erosion problems cannot develop unless all three conditions occur. The absence of any one of these conditions precludes the need for ditch plugs to prevent seepage erosion.

Free draining granular soil sufficiently pervious to allow seepage to pass through without developing excess hydrostatic pore pressure is not considered susceptible to seepage erosion. Additionally, the case in which the native soils surrounding the ditch are more pervious than the ditch bedding and padding material is not considered to be susceptible to seepage erosion. The groundwater flow conditions in this case should be looked at with a three-dimensional view. According to the principle of water flowing toward the points of least resistance, the majority of groundwater will flow beside or below the pipeline and down the slope. The water flow within the bedding and padding will be minimal. The potential for bedding and padding material being eroded is very low. A typical situation for this case is where cement stabilized backfill is used above the pipeline centerline in the ditch.

The water flowing in the pipeline ditch could be intercepted groundwater (subsurface water), surface water infiltration (precipitation, water generated from melting snow, etc.) or the combination of both. The flow may be either perennial or seasonal.

For the purpose of ditch plug design it is assumed that there is a potential for groundwater flow into the pipeline ditch on all unfrozen slopes. It is further assumed that groundwater flow may occur on frozen slopes within the active layer and to a depth that may result from thaw either during the dormant period or during the operational life of the pipeline.

Given that water is flowing within a ditch that is susceptible to seepage erosion, one needs only to determine locations where a critical hydraulic gradient is likely to occur along the pipeline alignment. Placement of properly designed ditch plugs at these locations would restrict seepage erosion. Ditch plugs will interrupt the flow and divert the water upward through the ditch plug outlet (filter blanket). This relieves the excess hydrostatic pressure and prevents movement of the susceptible soil through the filter. Unfortunately, these locations are difficult and impracticable to predict. The critical hydraulic gradient varies considerably with soil type and soil density.

Since critical hydraulic gradient locations cannot be accurately and reasonably predicted, the design approach is based upon the conservative assumption that a seepage erosion problem exists at locations where the phreatic surface is likely to intersect the ground surface. These locations can be related solely on longitudinal ground slope along the pipeline if the following assumption are made:

- o Ditch water flow is steady state.
- o Ditch water flow in the ditch is gravity flow.
- o Ditch bedding and padding material is more permeable than the native material surrounding the ditch.

This is the approach that was taken by ALYESKA Pipeline Service Company in the determination of ditch plug locations for TAPS (Reference 3). The ALYESKA approach was probabilistic in nature. The study considered permeability ratios of ditch bedding and padding to native material of 1000, 100 and 10. The study concluded that it is highly unlikely that seepage erosion can be sustained on longitudinal slopes of 9% or less. For slope greater than 9%, a design maximum spacing between ditch plugs was determined.

Ditch plugs to restrict seepage erosion will be constructed in the gas pipeline ditch in accordance with the design spacings shown in Reference 3. Ditch plugs will be spaced along slopes at spacings not exceeding those shown in Table 1.

4.2 CRITERIA FOR SUSCEPTIBILITY TO SEEPAGE EROSION

The pipeline route is considered susceptible to seepage erosion except where:

- o Ditch plug material which will freeze during the dormant period and remain frozen during the operating life of the pipeline.

- o The native soil or weathered bedrock surrounding the pipeline ditch below the top of the pipe padding consists of clean, free draining gravels, sandy gravels, or gravelly sands containing 0-6 percent passing the No. 200 sieve material (i.e., the in-situ material is more permeable than the backfill).

- o The backfill above the ditch padding conforms to the requirements for ditch plug filter blanket material.

4.3 CRITERIA FOR LOCATION

Ditch plugs will be installed at the following locations if these locations are considered to be susceptible to seepage erosion:

- o Along unfrozen slopes exceeding 9 percent longitudinal slope.

- o Along frozen slopes exceeding 9 percent longitudinal slope only if the thaw bulb progresses to the bottom of the pipeline during the anticipated dormant period or below the centerline of the pipeline during operation.

4.4 DITCH PLUG ALTERNATIVES

Ditch plugs to restrict seepage erosion may be replaced with one of the following alternatives:

- o Placement of low permeability backfill such as soil cement.

- o Placement of native or common backfill above the ditch padding that meets the gradation limit for ditch plug filters.

5.0 DITCH PLUGS TO LIMIT THERMAL DEGRADATION

5.1 DESIGN PHILOSOPHY

Substantial lengths of ice-rich permafrost ground will be crossed by the gas pipeline. Construction activities will cause disturbance to the thermal balance of the ground and result in thawing of the permafrost. Several summers may elapse between initial construction activities and pipeline start-up, and additional thawing of the permafrost may occur due to the convective heat transfer from water flowing in the ditch. The area of influence of the chilled pipeline after start-up may not be sufficient to restabilize the total area thawed during the dormant period.

The reasons to prevent or limit such thaw include:

- Maintain pipeline lateral support.
- Prevent excess pipeline settlement.
- Provide support at bends.
- Prevent pipeline flotation.
- Prevent pipeline exposure due to settlement of ditch materials.
- Maintain existing thermal balance beneath and around existing facilities (TAPS oil and fuel gas pipelines, Dalton Highway, etc.).

Geothermal analyses are performed in conjunction with geotechnical evaluations in order to design ditch modes that prevent or limit thaw to acceptable levels. The geothermal analyses consist of two-dimensional simulations to predict thaw during the dormant period and during the 25 years of operations. The computer program models transient, two-dimensional heat conduction with a change of state for a variety of boundary conditions. One limitation to the basic simulation is that convective heat transfer into the ground (such as from flowing groundwater) cannot be modelled.

Water will be generated from melting snow and the thawing active layer. Some of this water may flow into the pipeline ditch from the surrounding area. Additionally, precipitation may infiltrate through the backfill into the ditch. The water collected in a sloping ditch will flow in the permeable backfill due to the hydraulic gradient. Because of the convective heat transfer associated with the flowing water, thawing may occur in addition to that predicted by the basic geothermal simulation.

To restrict any additional thaw resulting from water flowing within the ditch cross section, ditch plugs could be installed at a spacing close enough to effectively reduce ditch water flow to that rate occurring in the in-situ soils. The spacing required would be that which causes the water to pond behind each plug to a level equal to the bottom of the next plug immediately upslope. Such a close spacing is considered overly conservative. Rather than blocking flow and eliminating convective heat flow, the design approach consists of determining the critical water velocity which will induce maximum additional thawing acceptable for design. The critical velocity established for a given thaw rate is then used to select the ditch plug spacing.

The maximum extent of acceptable additional thaw depends upon the ditch mode and soil characteristics, including thaw strain potential. No restrictions on thaw are required for thaw stable areas.

In the thaw unstable areas, thaw which does not progress below the centerline of the pipeline is not considered detrimental.

The determination of allowable additional thaw is contingent upon the results of the basic geothermal simulation and the ditch modes. For example, a type IIB permafrost ditch mode with four inches of boardstock insulation placed over the pipeline ditch might allow thaw due to conduction to a depth of one foot above the bottom of the pipe during the dormant period. If this ditch is located in a soil with a thaw strain potential less than 30 percent, an additional 4 feet of thaw might be acceptable without detrimental effects to the pipeline or the environment. For this case an additional 4 feet of thaw due to convective heat transfer from ditch water flow would be acceptable. The velocity of ditch water flow must then be limited to that which would cause this maximum thaw during the dormant period.

An analysis of the thawing of frozen ground due to the convective heat transfer from ditch water flow will be performed. A relationship between velocity of flow and rate of thaw will be developed. From this relationship, a maximum acceptable flow velocity for each ditch mode and soil type will be determined. All input data and analysis parameters will be consistent with the project geotechnical/geothermal data and assumptions for the ditch mode design.

The velocity of flow in the ditch will be calculated as the product of the soil permeability and the hydraulic gradient which can develop between adjacent ditch plugs. The permeability to be used will be the average permeability of material meeting the requirements of the specifications for ditch bedding and padding. The maximum hydraulic gradient will be taken as the difference in elevation between the base of one ditch plug and the top of the adjacent downslope ditch plug.

5.2 CRITERIA FOR LOCATION

Ditch plugs will be installed in the pipeline ditch to limit thermal degradation in locations where the following conditions exist simultaneously:

- o The pipeline is installed in thaw unstable frozen slopes.
- o The velocity of water flowing through the permeable backfill along the slope is greater than the velocity of flow required to cause the maximum extent of thaw to exceed the allowable thaw for the given soil conditions.

The allowable thaw will be determined in detailed design in accordance with the geotechnical criteria outlined in Section 21.0, Geotechnical/Geothermal Analysis, of the Pipeline Design Criteria Manual.

5.3 DITCH PLUG ALTERNATIVES

Ditch plugs to limit thermal degradation may be replaced with one of the following alternatives:

- o Placement of a low permeability backfill such as soil cement.
- o Placement of an additional thickness of boardstock insulation over the pipeline ditch sufficient to prevent thaw from exceeding allowable limits.
- o Maintaining the ditch in a frozen state.

6.0 DESIGN PROCEDURE

Areas where ditch plugs are required will be identified on the construction drawings during detailed design. Figure 4 shows the logic flow diagram for determination of ditch plug requirements. Groundwater assessment programs will identify locations where ditch plugs may be required to block local water flow. Ditch plugs required to prevent detrimental dewatering of sensitive streams or channels will be identified during detailed design based on geometry of the crossing and sensitivity of the stream.

Table 1 will be used to determine spacing for ditch plugs required to restrict seepage erosion. Spacing for ditch plugs to limit thermal degradation will be developed based on ditch mode, longitudinal slope and thaw strain potential. These spacings will be shown as indicated in Table 2. At locations where plugs are required for both seepage erosion and limitation of thermal degradation, plugs spaced at the closer of the two required spacings will serve both purposes.

Field verification will be made during construction to ensure the applicability of the design locations and to determine if additional ditch plugs are required. Exact location will also be determined during construction based on the design spacing charts and actual field conditions. Location will consider requirements for surface drainage of water outflow and the effect of the outflow on adjacent areas and facilities. Where the potential for icing problems exist, locations for placement of ditch plugs will be selected to restrict adverse impacts.

7.0 MAINTENANCE

Ditch plug locations will be periodically monitored after installation. Potential maintenance problems relate primarily to the effects of the water outflow through the filter blanket. Surface erosion which might occur will be remedied by regularly planned maintenance. The occurrence of seepage erosion at the surface adjacent to the ditch plug filter would be evidence of its ineffectiveness.

Monitoring of the Right-of-Way between ditch plugs, as well as on other slopes where no ditch plugs have been installed may detect other locations where seepage erosion is occurring.

Seepage erosion at any location may be corrected by placing additional free draining granular material and/or filter fabric covered with granular material over the actual seepage location and providing appropriate surface drainage.

8.0 TABLES

MAXIMUM DITCH PLUG SPACING
TO RESTRICT SEEPAGE EROSION

LONGITUDINAL GROUND SLOPE (PERCENT)	MAXIMUM SPACING MEASURED ALONG THE SLOPE (FEET)
0 - 9	NO DITCH PLUG REQUIRED
9 - 12	400
12 - 15	250
15 - 20	200
20 - 25	150
25 - 30	125
> 30	100

NOTE : THE VALUES SHOWN IN THIS TABLE ARE EXTRACTED FROM ALYESKA REPORT HD - 017, "DITCH PLUG DESIGN AND LOCATION FIELD MANUAL," JUNE 18, 1975. (WITH MODIFICATIONS)

TABLE 1

MAXIMUM DITCH PLUG SPACING TO LIMIT THERMAL DEGRADATION

		LONGITUDINAL GROUND SLOPE (PERCENT)	DESIGN THAW STRAIN (PERCENT)			
			0 - 10	10 - 20	20 - 30	> 30
DITCH CONFIGURATION	II B	0 - 6				
		6 - 12				
		12 - 20				
		20 - 30				
		> 30				
	II A	0 - 6				
		6 - 12				
		12 - 20				
		20 - 30				
		> 30				

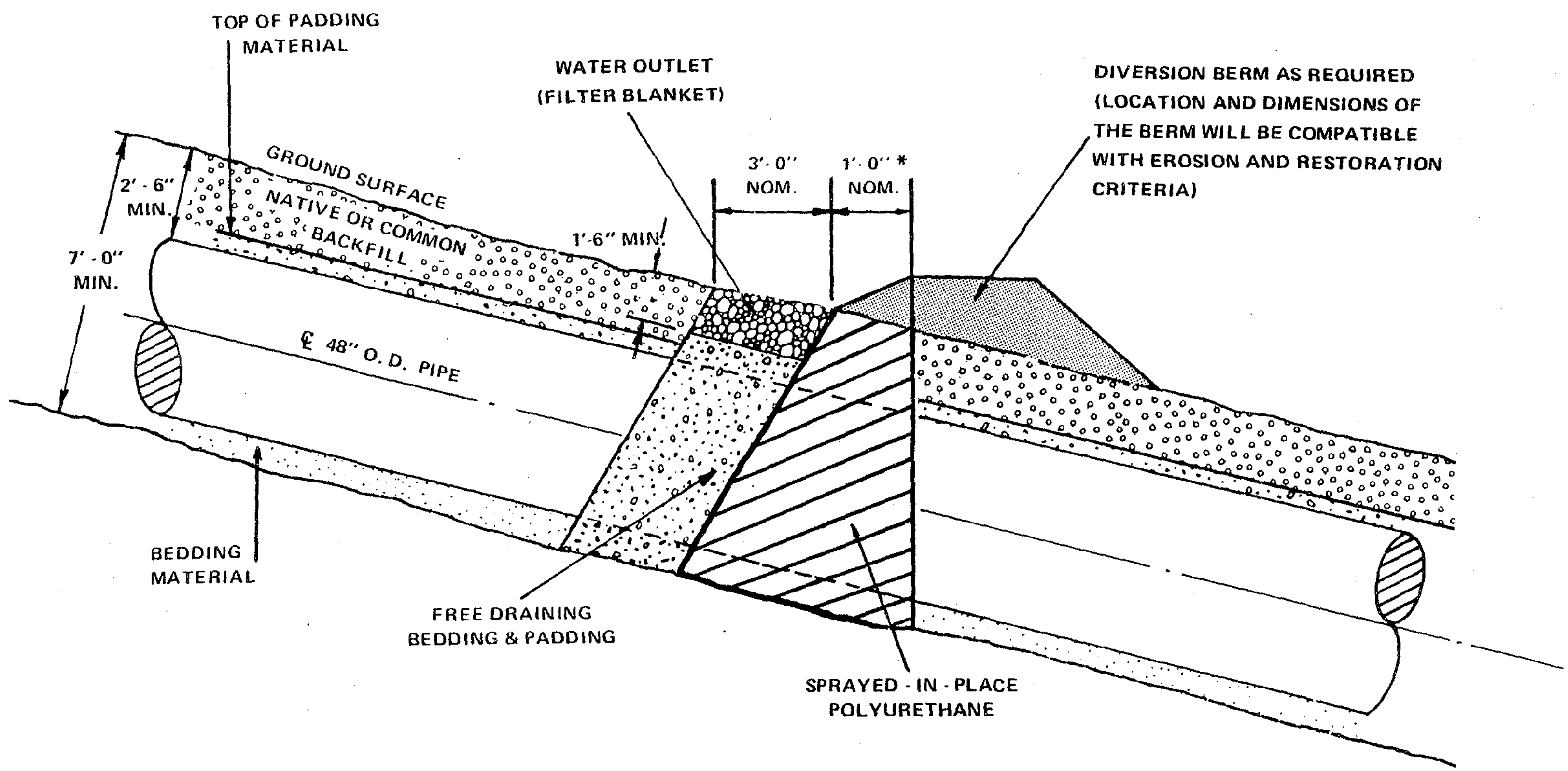
NUMBERS IN BOXES INDICATE MAXIMUM DITCH PLUG SPACING MEASURED ALONG THE SLOPE

TABLE 2

9.0 FIGURES

FIGURE 1

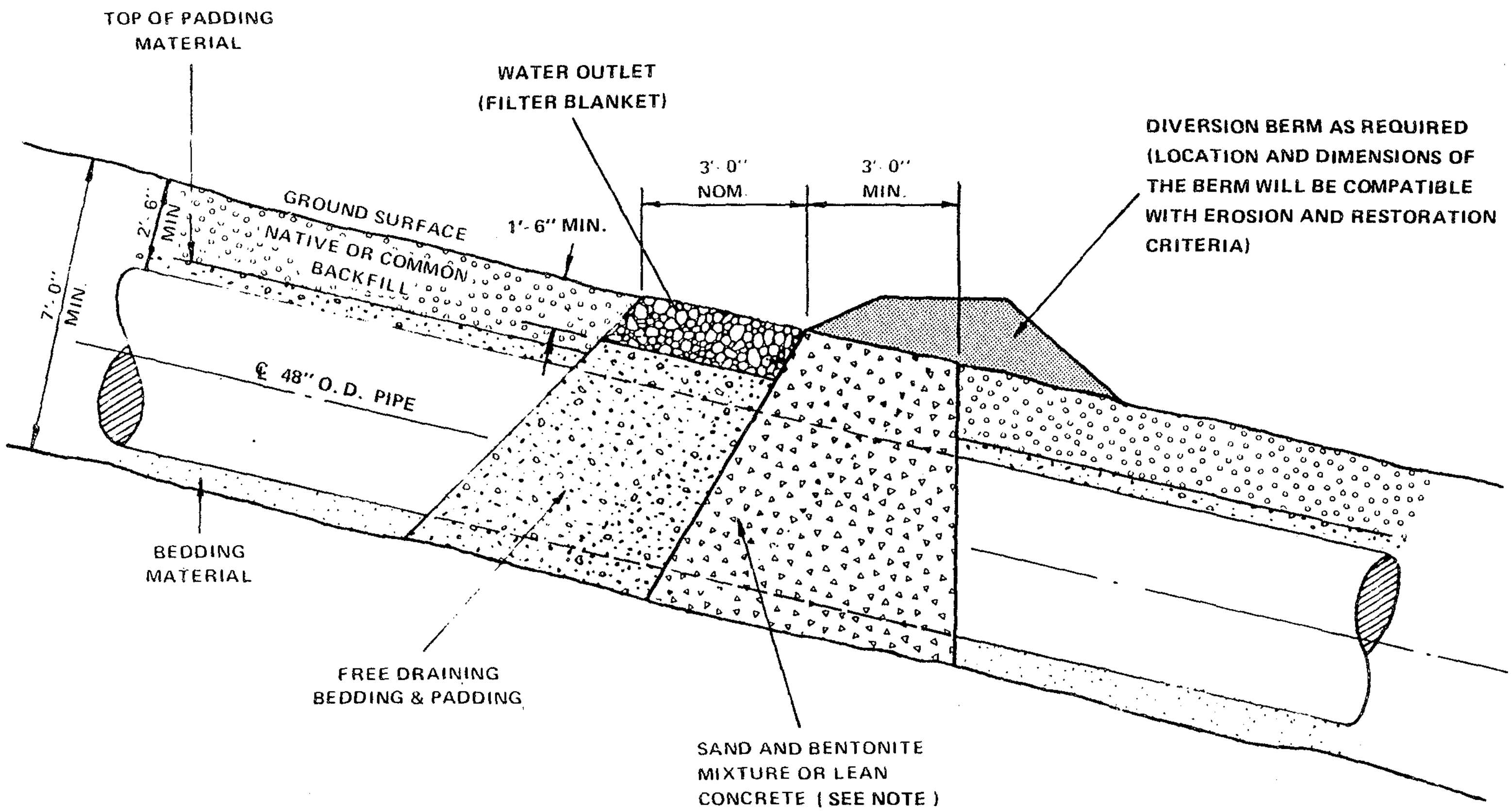
TYPICAL DITCH PLUG - TYPE 1



NOTE : * FINAL THICKNESS WILL BE BASED ON MANUFACTURER RECOMMENDATION

FIGURE 2

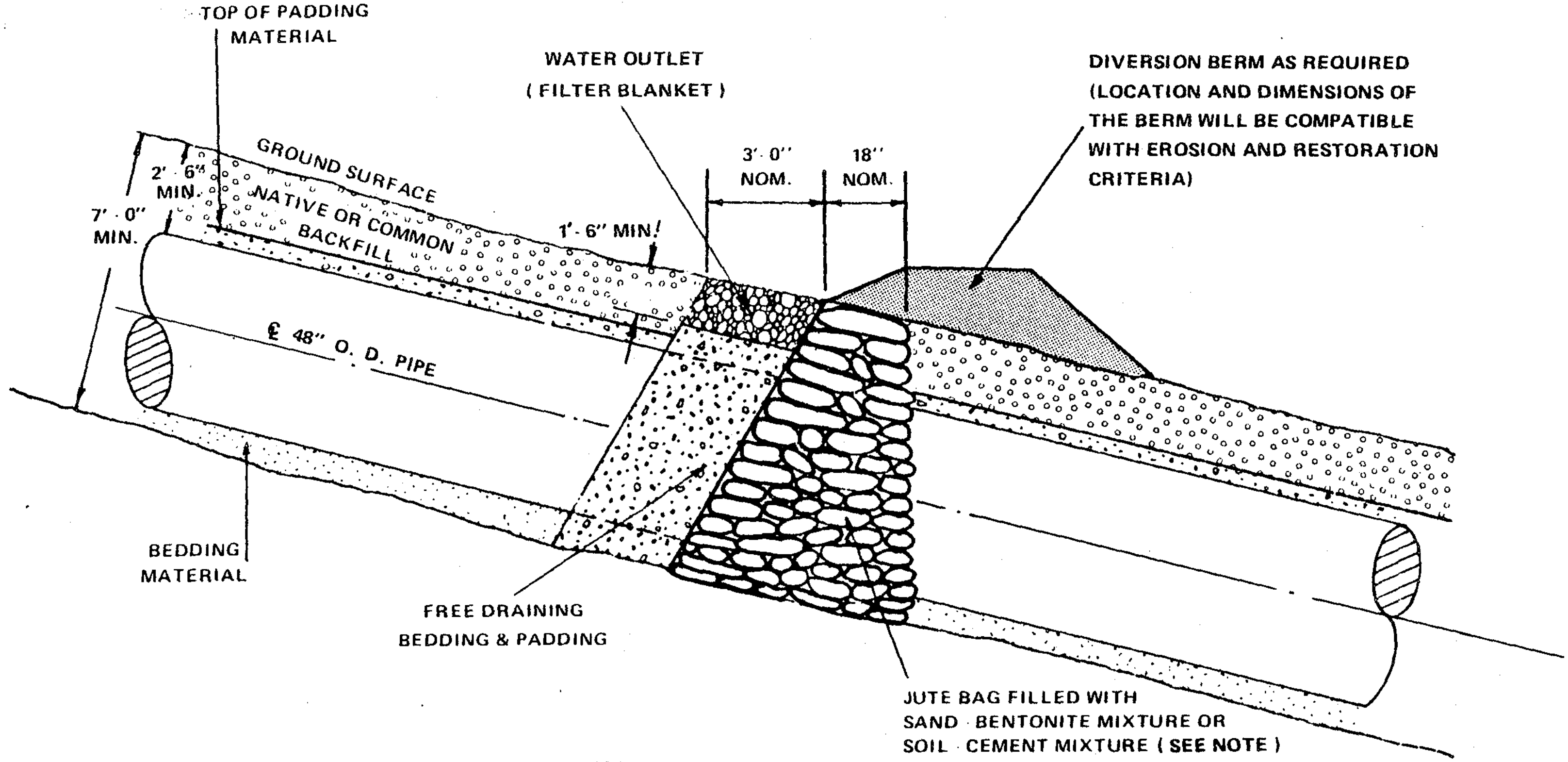
TYPICAL DITCH PLUG - TYPE 2



NOTE: SAND AND BENTONITE MIXTURE MAY BE REPLACED WITH A WELL COMPACTED SELECT BACKFILL SEALED ON THE UPSLOPE FACE WITH A LOW PERMEABILITY BARRIER SUCH AS GUNITE, POLYURETHANE FOAM OR AN ASPHALTIC LAYER.

FIGURE 3

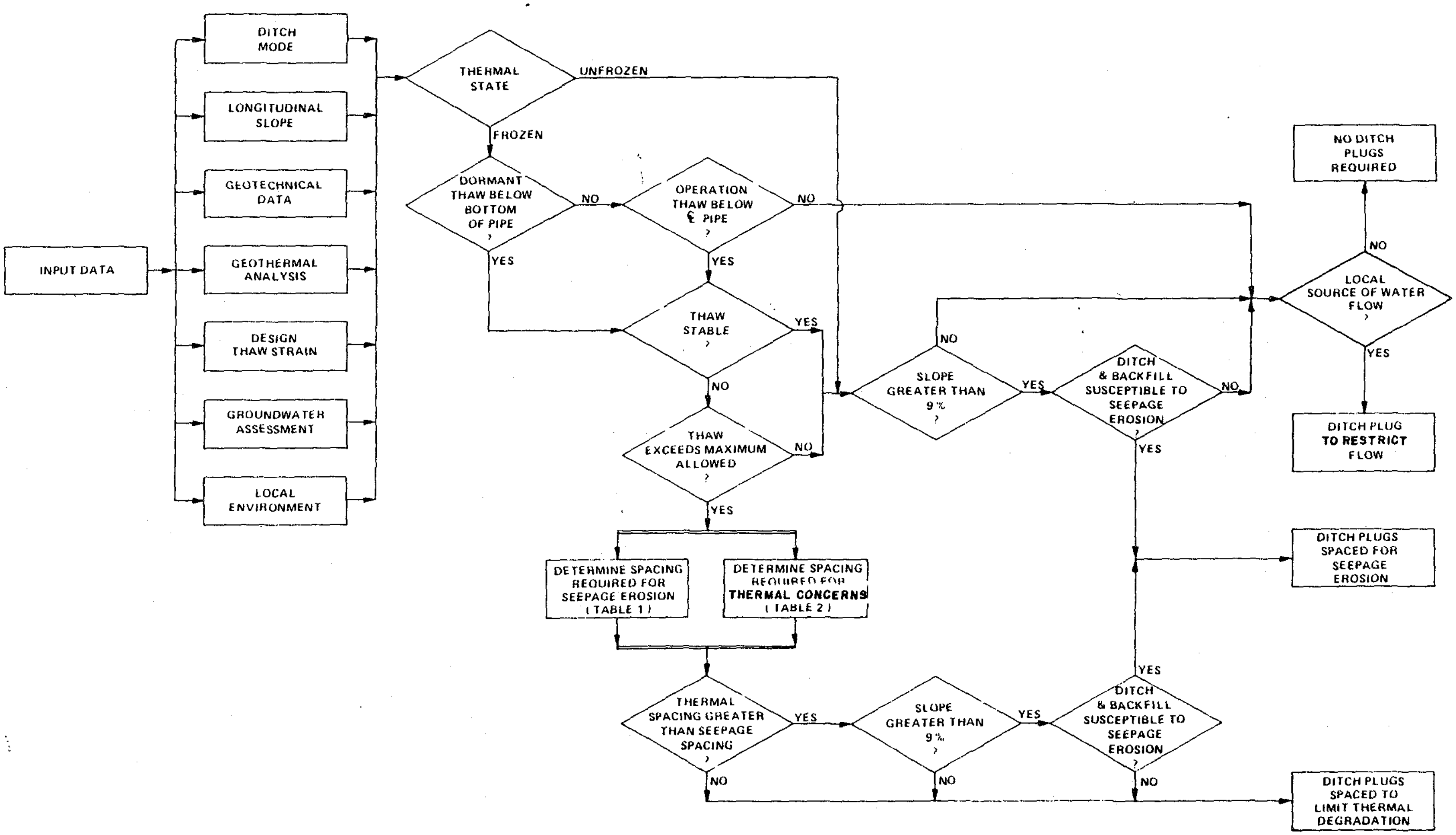
TYPICAL DITCH PLUG - TYPE 3



NOTE: JUTE BAGS MAY BE FILLED WITH OTHER SELECT MATERIAL AND SEALED ON THE UPSLOPE FACE WITH A LOW PERMEABILITY BARRIER SUCH AS GUNITE, POLYURETHANE FOAM OR AN ASPHALTIC LAYER.

FIGURE 4

LOGIC DIAGRAM FOR DITCH PLUG REQUIREMENTS



10.0 REFERENCES

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2. ANNGTC Project Report, "Stipulation 1.6.1, Plan Numer 8, Erosion and Sedimentation Control," October, 1982.

3. ALYESKA Report HD-017, Ditch Plug Design and Location Field Manual, Revision 1, Prepared by R & M Consultants, Inc., June 18, 1975.