GEOTECHNICAL EVALUATION

POINTED MOUNTAIN GAS GATHERING SYSTEM

PRELIMINARY GRADING, STABILIZATION AND RESTORATION PLANS

FOR

PIPELINE ROUTE FROM WELL B-1 TO JUNCTION WITH PIPELINES A-1 AND A-2

SUBMITTED TO

AMOCO CANADA PETROLEUM COMPANY LIMITED

BY

ELMER W BROOKER & ASSOCIATES LTD.

THE ASSOCIATION OF
PROFESSIONAL ENGINEERS
OF ALBERTA
PERMIT NUMBER
P245
ELMER W. BROOKER
& ASSOCIATES LTD.

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AUGUST, 1972

E.W. Brooker & Associates Ltd.

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1. INTRODUCTION

As part of the development, by Amoco Canada Petroleum Company Ltd., of gas processing and gathering facilities at Pointed Mountain, Northwest Territories, plans are presently being formulated for the extension of the gas gathering system. Extension of the gas gathering system to Well B-1, which has been completed, and possibly to Well B-2, which will be drilled in the immediate future, is now proposed. Construction to date on the overall gas gathering system has been confined to lines from Wells A-1 and A-2 to the plant site.

Because concern has been expressed over the potential detrimental environmental effects construction of the gas gathering system may have on the local ecology, considerable engineering effort has been expended to date in design and construction of the gas pipelines in the area. Of particular concern has been the assessment of the stability of slopes on which the pipelines are to be constructed, and the method in which soil stabilization on slopes will be carried out during and subsequent to construction. In this regard, geotechnical engineering studies, relating to the stability of slopes along Line A-1, have been carried out to date (Slaney 1972, Brooker 1972), and a preliminary grading, stabilization and restoration plan has been prepared as a guideline for pipeline construction (Brooker 1972). This plan has been prepared for the slope section of the pipeline right of way, extending down the mountainside from Well A-1 to the lake bottom area.

As the gas gathering pipeline from Well B-1 traverses steep mountain slopes in its descent from Well B-1 to the plant site, engineering inspections and studies have also been carried out along the right of way of Line B-1. Although a formal report has not been prepared on the stability conditions along Line B-1, correspondence concerning this matter has been exchanged between personnel of E.W. Brooker and Associates Ltd., and Amoco Canada Petroleum Company Ltd. This report, outlining preliminary grading stabilization and restoration plans for Line B-1, has been based on the inspections of the B-1 right of way, the preliminary stability reports prepared previously for slopes in the area (Slaney 1972, Brooker 1972), and knowledge gained through implementation of the preliminary grading plans prepared for Line A-1.

II. PROPOSED PIPELINE ROUTE LOCATION & TOPOGRAPHY

The proposed section of pipeline, discussed in this report, extends from Well B-1 (Chainage 0 + 00), at an approximate elevation of 3,865 feet, to its junction with the existing lines from Wells A-1 and A-2 (Chainage 173 + 92.7), located at an approximate elevation of 1,215 feet.

Alignment of the pipeline right of way is as shown on Drawing No. A-1, Appendix A. This drawing also shows the near surface soil conditions (determined by L.G. Grimble & Associates Ltd.), and comments pertinent to existing slopes and slope stability conditions along the pipeline route.

The pipeline route, at the time of the last inspection (June 28, 1972), was cleared to an approximate width of 20 to 30 feet, along the alignment shown on Drawing

No. A-1. Future clearing of the right of way will extend to a maximum width of 120 feet in order to allow for preliminary grading of the right of way. The topography and vegetation along the pipeline route is characteristically alpine to sub-alpine meadow environment, with the vegetation consisting primarily of grasses and small shrubs. Below Chainage 33 + 00, the vegetation cover becomes heavier, as the slopes are descended, and consists predominantly of poplar and alder tree growth with smaller shrubs. Some heavy spruce and poplar growth occurs from about Chainage 80 + 00 to the end of the line. The average slope gradient of the route is 20 percent, with general gradients along the route ranging from about 10 to 35 percent. Some very localized gradients approach 100 percent. From approximate Chainage 10 + 00 to approximate Chainage 20 + 00, the line traverses an upgrade section in ascending the local summit, adjacent to which the well is drilled. The upgradient ranges from 10 to 45 percent and the summit elevation is about 4,080 feet. Cross-slopes on the line are relatively infrequent and where they occur are generally of about 5 to 10 percent gradient. Some localized areas possess cross-slopes in excess of 10 percent gradient. A few intermittent drainage courses intersect the right of way, approximately in the locations shown on Drawing No. A-1.

III. CONSTRUCTION AND OPERATIONAL ASPECTS OF THE PIPELINE

It is our understanding that construction of the B-1 gas line will be similar in detail to that of the A-1 line, presently under construction. A ~~10~~ 8 inch line and a 2 inch fuel gas line will be fabricated and buried in a trench under a minimum depth of cover of about 4 feet. Expansion loops and anchors will be provided as on the A-1 line. However, details of construction of loops, and location of loops and anchors are presently unavailable, as they are pending completion of design calculations to determine these factors. As in the case of Line A-1, loops will be housed in 60 inch diameter culvert half sections and will be completely buried. Anchor blocks will be of the conventional concrete anchor block design, and will be keyed into undisturbed soil and backfilled with suitable fill material, which will be tamped to provide the necessary passive resistance.

The gas gathering line, expansion loops and anchor blocks will be placed in excavations in undisturbed soil, except where local conditions dictate otherwise, wherein quality controlled fills will be provided. With the exception of two major sag areas and several minor gullies,all grading of the pipeline is contemplated to be downgrade and small local sag areas will be graded out of the line. Consequently, deep trenching and/or excavating along the route will be carried out to meet this requirement. The majority of construction activity and movement of construction equipment will be confined to one side of the right of way, as in the case of Line A-1, and ditch spoil, grading material, and expansion loops will be located on the opposite side.

Location of the pipeline within the right of way will be approximately on centreline, but may be offset to either side of centreline to take advantage of local terrain conditions.

It is understood that gas temperatures at Wellhead B-1 are somewhat lower than at Wellhead A-1, and are in the order of 170 degrees Fahrenheit. This lower temperature would necessitate fewer expansion loops than in the case of Line A-1. However, as it is planned to tie in Well B-2, less cooling of the gas will take place, due to higher flow rates, and more expansion loops may be required. The number and spacing of expansion loops is presently being determined. Insulation and armoring or rock shielding of the pipeline will be carried out where required.

Detailed and specific information concerning earthwork and construction plans are presented in the following sections.

IV. EARTHWORK AND CONSTRUCTION PLANS

A considerable quantity of earthwork will be required in the form of right of way preparation, trenching and backfilling of pipeline excavations, and regrading of right of way during the course of construction of the gas gathering line. The amount and extent of each of these items that will be required, will depend on the slope conditions in any particular section of right of way. Drawings No. A-2A and A-2B, Appendix A, show the existing centreline ground surface profile and the approximate proposed pipeline profile along the entire right of way section. Existing cross-slope gradients along the route and areas in which special or extra grading provisions will be required are also shown on the drawings. Details are also shown on the drawings for those areas requiring additional grading provisions, such as permanent cut and fill sections. Typical grading plans for other sections have been developed and are discussed in the following sections.

4.1. Typical Downslope Sections With Cross-Slopes of Less Than 10 Percent

The majority of the pipeline route consists of areas in which cross-slopes of less than 10 percent are prevalent and much of the route consists of sections with no cross-slope. Consequently, grading plans have been prepared that illustrate the typical cross-slope gradient. Grade preparation, pipeline installation, and regarding plans are shown on Figures 1 and 2, Drawing No. A-3, Appendix A.

Figure (1), Drawing No. A-3, shows a three step approach to preparation of the grade and installation of the pipeline on a typical slope with a cross-gradient of less than 10 percent. The first step consists of grading the right of way, as shown on the drawing, to provide a working and travelling surface for construction equipment. This working surface is approximately level in cross-section, 40 feet in width from centreline of the pipeline, and is to remain essentially as the final graded section of the pipeline right of way. In areas approaching 10 percent cross-gradient some grade restoration may be carried out, depending on local conditions. The quality of the fill section and the preparation of backslope surfaces will be subject to some quality control in those areas in which the initial grading will be retained as the final cross-section.

Downslope grading will likely be carried out over short sections of line to permit easier and safer operation of construction equipment and to remove minor undulations along the route.

The second step of the operation, illustrated in Figure 1, Drawing No. A-3, consists of trenching for the pipeline, stockpiling of trench material, and fabrication of the pipeline and fuel gas line. Trench dimensions will be approximately as shown in Figure 1. Contemporaneous with this operation is the installation of expansion loops and the construction of anchor blocks and trench plugs or cut-offs, as they are required.

Final step in the process is the backfilling of the pipeline trench, covering of the backfilled trench with a protective rip-rap cover, and regrading of the right of way, if and as required. The final step of the process is also shown in Figure 1, Drawing No. A-3. Subsequent to backfilling of the trench and regrading, provision of drainage measures and biological stabilization measures on the right of way will be carried out. These measures, as discussed in detail in subsequent sections of this report, will be carried out immediately after backfilling and regrading, such that construction and restoration are carried to completion as activities proceed downslope.

4.2. Typical Downslope Sections With Cross-Slopes Greater Than 10 Percent

Figure (2), Drawing No. A-3, shows the grading plans for those cross-slope sections at greater than 10 percent gradient. A 20 percent gradient has been illustrated and grading plans consist of three steps. The initial step consists of preparation of a temporary working surface through cutting and filling of the cross-slope section as shown. Quality control on filling will not be maintained nor will slope stability on temporary sections be considered critical. However, maximum backslopes of both temporary cut and fill sections will be limited to a maximum of one foot vertical to one foot horizontal to ensure reasonable temporary stability during the short construction period. Although cutting and filling, as illustrated in Figure 2, Drawing No. A-3, has been shown from the centreline of the right of way, location of cut and fill sections will be determined on the basis of existing field conditions and need not necessarily coincide with the centreline of the right of way or the pipeline.

Subsequent to preparation of the temporary working surface, trenching, pipe fabrication and backfilling will proceed as described previously and illustrated in Figures 1 and 2, Drawing No. A-3. The final step in the process is restoration of original grades, within practical limits. Quality control will be maintained on backfilling procedures. The highest quality fill consistent with field placement techniques and capabilities, as pertaining to the existing terrain conditions, will be achieved. After regrading has been completed, drainage provisions and biological restoration provisions will be carried out.

4.3. Typical Cut Fill Sections Along the Longitudinal Gradient of the Pipeline

Because of localized ridge and gulley features existing in several sections along the route, and the necessity of maintaining a downslope gradient where possible, some permanent cutting and filling will be required in localized sections along the pipeline. The major cut fill areas have been shown, on Drawings No. A-2A and A-2B, at their approximate locations along the profile. A typical detail of such a section is shown on Detail 'A', Drawing No. A-2B. As evident from the detail, an attempt will be made to maintain the pipeline in original undisturbed ground in order to minimize potential settlement problems. However, if excessive deep trenching is required in order to achieve this, burial of the pipeline in controlled fill will be an alternative scheme. Provisions will be instituted to deal with potential problems that may occur by settlement of fills. In areas where installation of the pipeline in fill is not practicable, deep trenching will be required. Decisions of this nature will be made by field engineering personnel.

4.4. Intermittent Drainage Courses

Some of the gulleys referred to in Subsection 4.3. may serve as intermittent drainage courses. The flow in these drainage courses, based on field inspection, appears to be quite sporadic and likely of very low volume and velocity, as channels are not well defined. Consequently, some or all of these intermittent drainage courses will be filled in to satisfy pipeline grading requirements. In the event that filling is carried out, a new drainage course profile will be established within the right of way. Any future drainage that may occur will be routed over the fill, which will be adequately rip-rapped and biologically stabilized to minimize channel erosion. A typical detail of the channel modification procedure is illustrated in Drawing No. A-2B, Appendix A. If deemed feasible, in the field, routing of drainage through culverts or other such conduits will be considered. However, this is presently deemed to be unnecessary as no major drainage courses are traversed by the pipeline right of way.

4.5. Areas Requiring Specialty Construction Consideration

4.5.1 Topographic Low - Approximate Chainages 5 + 00 to 10 + 00

Immediately adjacent to Wellhead B-1, a significant topographic low is encountered. Deep trenching can be reduced to a minimum by implementing major grading provisions between the wellhead and the 'low'. Development of the wellhead site itself, may require grading that will reduce the depth of anticipated cuts.

4.5.2 Topographic High - Approximate Chainage 19 + 50

As discussed above, a topographic high, about 200' above wellhead elevation, must be traversed, as the alternate bypass route displays slope instability. Detailed investigations have not been carried out on the ridge crest, thus trench difficulties are speculative. It is believed that broken or fractured bedrock will be encountered within the trenching depth, but it is unlikely blasting will be required to facilitate construction.

4.5.2 Topographic Low Near B-2 Tie In - Approximate Chainage 24 + 00

Several feet of fill and/or deep ditching will be required to achieve a continuous downslope gradient in this area. The pipeline alignment selected involves a minimum of cut-fill construction. It is expected that fractured or broken bedrock is present at a reasonably shallow depth from Chainage 24 + 50 to Chainage 29 + 00, thus every attempt to reduce the depth of deep ditching should be taken.

4.5.3 Topographic Low - Approximate Chainage 127 + 00 to 135 + 00

A major sag will be present near Chainage 128 + 00, unless a significant amount of fill and deep ditching is employed. Since this area does not appear to be a water course, only standard rip rap protection need be implemented. Deep ditching or major grading will be required downslope from the area of fill placement. If it is contemplated that the pipeline will be placed in fill material, attempts at a high degree of compaction should be undertaken.

V. DRAINAGE AND EROSION MINIMIZATION PROVISIONS

Based on observations of exposed surface soils and a review of available test pit information, near surface soils along the route appear to consist of silty and sandy clay till with numerous rock fragments. Soils in the upper reaches of the line consist of a very high sandstone rock fragment content, which decreases as the slope is descended. Available test pit information indicates that intact sandstone and shale bedrock appear to be relatively shallow in depth. Shales are more prevalent at the lower end of the line.

The insitu soils along the pipeline route vary in erosion susceptibility from low to moderate susceptibility, to high erosion susceptibility. The former soil types generally comprise the upper reaches of the route and extend to approximately Chainage 80 + 00. The latter, highly erosion susceptible soils, generally exist below Chainage 80 + 00 and extend to the lower limits of the line.

The severity of potential erosion depends not only on the soil characteristics, but on such factors as severity of rainfall, infiltration potential, degree and rate of runoff and degree of exposure of the soils to rainfall and runoff. To minimize potential erosion it is desirable to control some or all of these factors. However, of the foregoing factors only the latter two lend themsleves readily to any form of control.

With regard to control of erosion, drainage provisions, as discussed herein, will be incorporated on the regraded right of way to minimize degree and rate of runoff, and degree of exposure to runoff. Minimization of degree of exposure to rainfall and runoff will also be attempted through biological restoration, which will be discussed in greater detail in the following section.

Drawing No. A-4, Appendix A., illustrates the basic concepts for controlling or facilitating drainage on and/or along the regraded right of way. The drainage concept consists essentially of providing runoff flow checks along (laterally) and across (transversely) the right of way. In areas where transverse flow, across the right of way, is anticipated to be appreciable, lateral flow checks are proposed along the high side of the right of way. These lateral flow checks will serve to stop runoff, originating from off right of way areas, from crossing the right of way and contributing to erosion. The runoff water will be collected in the ditch area behind the berm and redirected downslope to a transverse flow check where it will be carried across the right of way. Lateral flow checks, where required, will be discontinuous so as to reduce runoff water velocities and quantities. Flow breakers will be provided, where required, in both lateral and transverse flow checks to minimize water velocities.

Lateral flow checks are anticipated to be required only in areas exhibiting steep cross-slope sections, where high erosion susceptible soils are present. As these areas are few in number, provision of lateral flow checks is expected to be minimal. Transverse flow checks, which will collect flow occuring in a longitudinal direction along the right of way, are contemplated for all anchor point and expansion loop locations. However, spacing,shape and orientation of transverse flow checks will be dependent on local gradients and the need for checking surface runoff. Intermediate transverse flow check locations will become apparent in the field.

In order to prevent erosion in the pipeline trench itself, rip-rapping over the backfilled trench will be carried out and impervious cut-off plugs or collars will be installed within the pipeline trench at or near expansion loop locations. These plugs, together with the anchor blocks, will check flow of water in the pipeline trench, if ingress of water inadvertantly occurs. However, the ingress of water to the pipeline trench is expected to be minimized by providing some quality control of trench backfill and backfilling procedures.

Typical construction details of lateral and transverse drainage checks, flow breakers, and rip-rap protection of flow surfaces are shown on Drawing No. A-4, Appendix A. As evident from the drawing, use of insitu construction materials is advocated. Ditch and berm construction for flow checks and breakers, using insitu soils, is shown on the drawing. Rip-rapping of flow surfaces will be carried out with local broken rock, or other suitable alternatives, such as sand or cement bags. Use of driven sheet piling is presently considered to be required only in very steep slope sections, or where earth retaining capabilities are required. Pipeline ditch plugs or cutoffs will be constructed of well compacted cohesive soil, bagged cement or bentonite. Typical location details of plugs or collars are shown on Drawing A-4, Appendix A. Based on previous experience on Line A-1, a cutoff spacing in the order of 100 to 150 feet is suitable for most slope sections.

VI. RESTORATION & BIOLOGICAL STABILIZATION OF SURFICIAL SOILS ON THE PIPELINE ROUTE

Immediately following implementation or construction of drainage provisions, biological stabilization will be carried out on those soils of moderate to high erosion susceptibility. These soils were noted to exist below approximate Chainage 80 + 00. However, depending on actual soil conditions encountered, some biological stabilization may be attempted upslope of approximate Chainage 80 + 00 in the areas that exhibit some soil content. In areas of very high rock content, biological stabilization measures are considered impractical.

The biological stabilization program presently envisaged will consist of seeding, fertilization and covering of freshly seeded and fertilized surfaces with brush or suitable trash cover (Wein, 1972). As shown on Drawing A-4, all surfaces, exclusive of rip-rapped surfaces or very granular soils, will be treated in this fashion.

Seed type to be used will be determined on the basis of field inspection and evaluation of existing soils by a qualified botanist, who will also determine type and rate of fertilization, and method and rate of seeding. Preliminary information indicates that a seed mix composed of domestic and native species, if possible, should be used. Domestic species, such as brome grass, creeping red fescue, red clover, and Russian wild rye grasses may be employed. Some success in revegetation, with annual cerals, has been achieved in subarctic environments and these may also be employed.

Although summer seeding has been found to meet with only limited success, reseeding immediately after construction in summer is advocated, in the belief that some 'take' will occur, which will assist in stabilization of surficial soils. After evaluation of the 'take', the right of way can again be reseeded in the late fall or spring, if required, using the more successful seed types. With respect to evaluation of successful seed types and biological restoration techniques, it is hoped that valuable experience will be gained from restoration of Line A-1. Re-fertilization may also be attempted, if deemed necessary. Spring or fall seeding can be carried out annually, as and if required, until native species have re-established themselves on the line, whereupon it can be terminated.

Initial seeding and fertilization may be carried out by hand 'broadcasting' or by aerial means, with subsequent seedings likely being carried out by aerial means. Brush supplies for protective covering of the seeding and soil surface will be obtained locally, where allowed. Placement of brush cover will be carried out by both manual and mechanical means.

VII. INSTRUMENTATION OF CRITICAL SLOPE AREAS

Based on previous inspections of the line, few potentially unstable slope conditions appear to be existent along the pipeline route. However, some areas where creep movement in slopes may be occuring were noted, and it is believed that further consideration should be given these areas during the course of construction of the line. Although some minor movement may be occuring, the stability of these areas has not been ascertained to be so critical that it is deemed necessary to recommend against construction of the pipeline. Consequently, it is believed that construction of the pipeline can take place without severe risk of failure. However, as a precautionary safeguard, instrumentation may be installed in critical slope areas, if they are detected in subsequent inspections of the line.

Instrumentation of the slopes would consist of slope movement measurement devices or installations. These installations may consist of precise survey markers installed in conjunction with slope indicators, if required. The need for field instrumentation, type and amount of instrumentation will be consistent with field requirements and the relative instability of the areas. Installation of the instrumentation will be contemporaneous with construction of the pipeline.

VIII. CLOSURE

The foregoing preliminary plans have been presented, based on the known requirements for relatively economic construction of a gas gathering system, in conjunction with the known requirements for minimal disturbance to the existing environment. As the physical act of constructing the pipeline will have an altering effect on the existing environment at Pointed Mountain, Northwest Territories, disturbance to the ecology cannot be completely prevented. However, it is believed that the construction plans outlined will keep to a minimum the detrimental environmental effects caused by the construction of a gas gathering pipeline from Well B-1 to the plant site area.

Respectfully Submitted,

ELMER W. BROOKER & ASSOCIATES LTD.

L.A. Balanko, P. Eng.

Garry R. Gilchrist, P. Eng.

LAB:GRG:blm

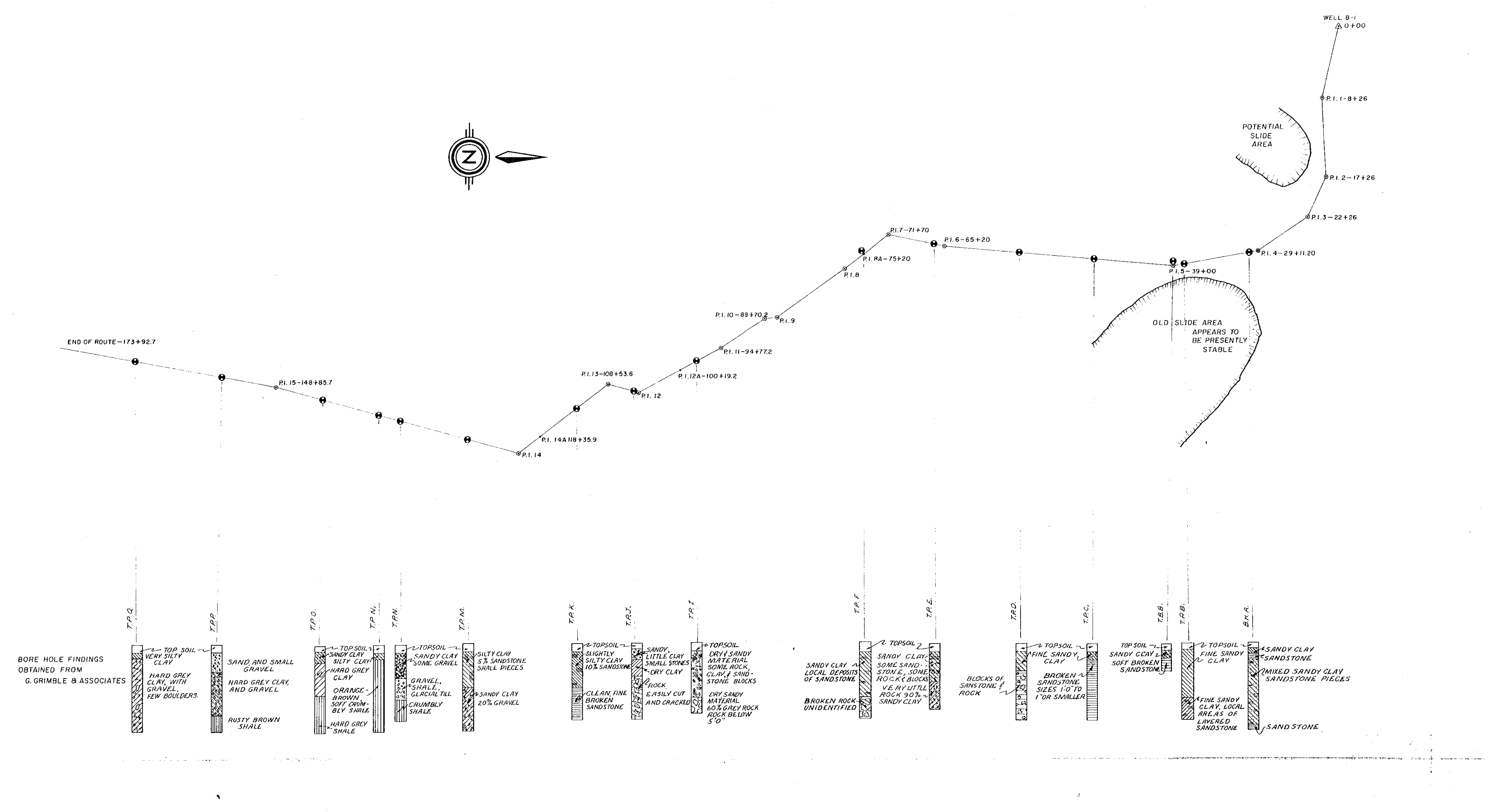
APPENDIX A

REFERENCES

Brooker, E.W. & Associates Ltd., 1972, Slope Stability Study, Pointed Mountain Gas Gathering System, Pointed Mountain, Northwest Territories, Unpublished Report to L.G. Grimble & Associates Ltd.

Slaney, F.F. and Company, 1972, Environmental Effects of Pointed Mountain Natural Gas Gathering Pipelines, Unpublished Report to Northern Economic Development Branch, Department of Indian Affairs and Northern Development.

Wein, Dr. R.S., Department of Botany, University of Alberta Personal Communication, 1972.



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					DATE DRAWN: 2/8/72	DESIGNED BY: G.P.	POINTED MOUNTAIN GAS GATHERING SYSTEM	SITE PLAN and BORE HOLE LOCATIONS
					CHECKED BY:	CHECKED BY:	PIPELINE B-1	DWG. A-1
					JOB No.: E-442-B	APPROVED BY:		SHEET No.

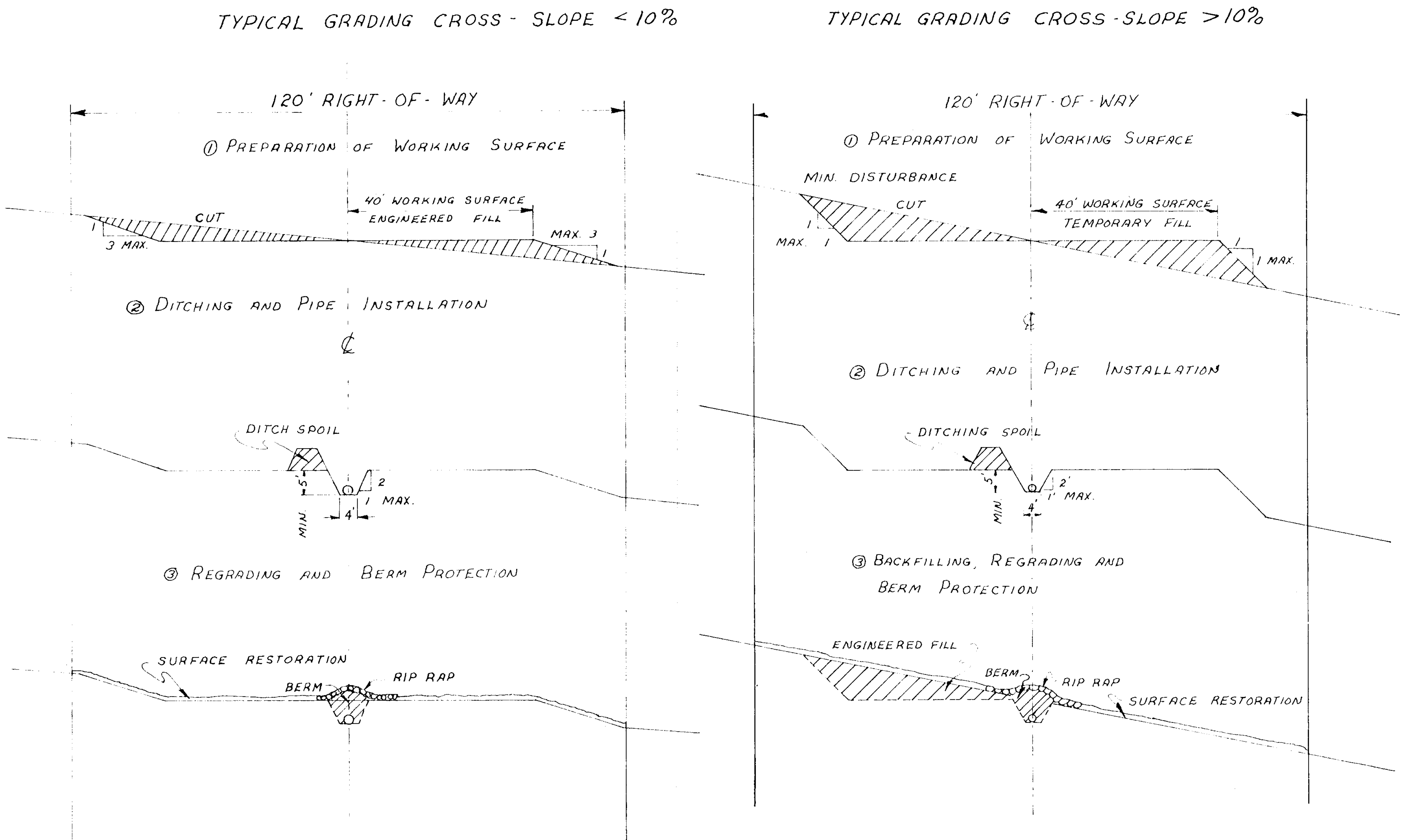
LEGEND

▮	AF	ANCHOR LOCATIONS
♦	EL	EXPANSION LOOP LOCATIONS
- - - - - - -		PIPE LINE PROFILE
———		℄ GROUND SURFACE PROFILE

AMOCO CANADA PETROLEUM COMPANY LTD.
POINTED MOUNTAIN GAS GATHERING SYSTEM
PIPELINE A-1

SURFACE PROFILE
(UPPER SECTION)

DWG. A-2-A E-442



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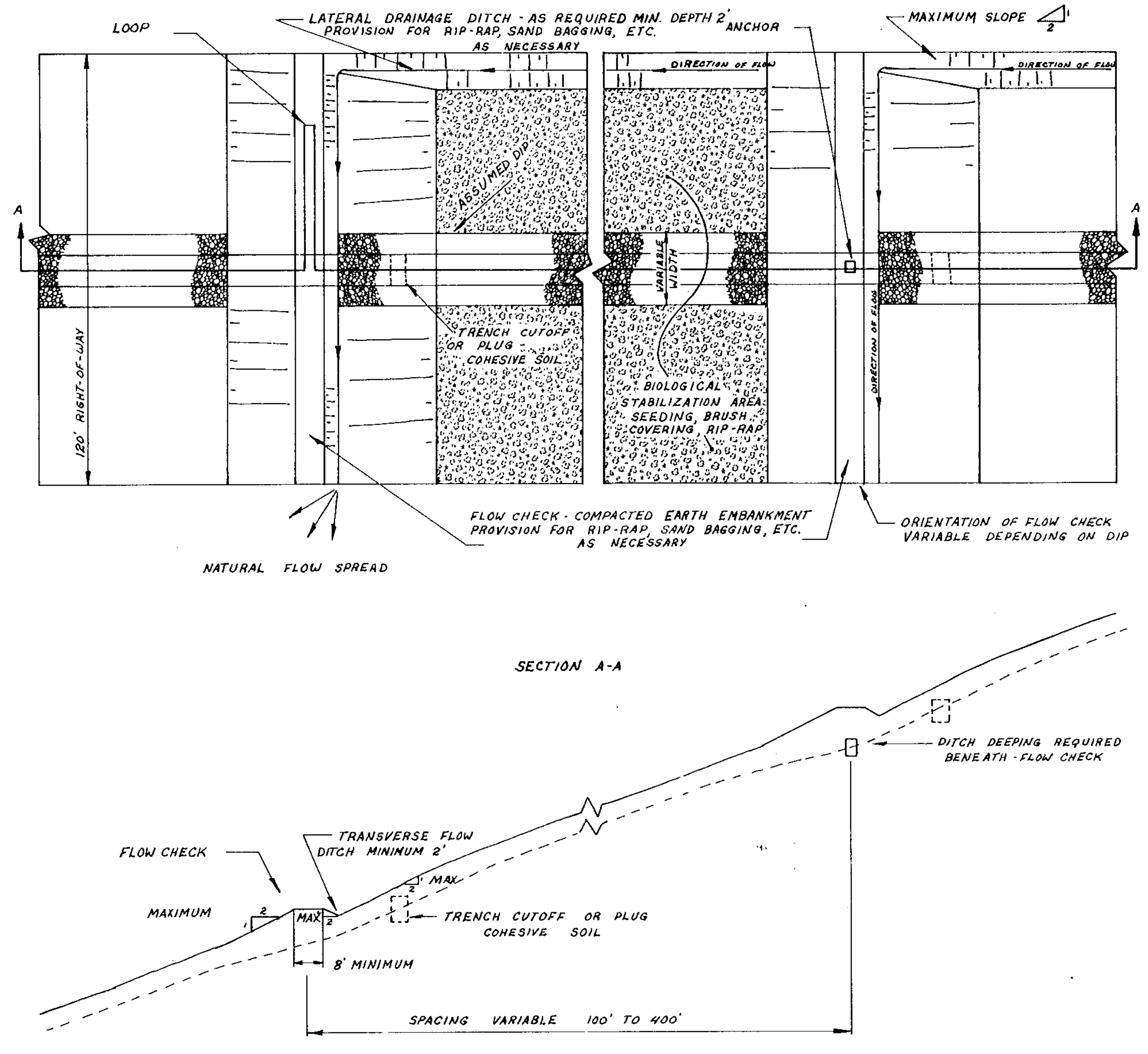
DATE DRAWN 1/8/72			
SCALE 1" = 20'			SHEET No
JOB No. E 4428			

DRAINAGE AND RESTORATION DETAILS

PLAN VIEW



REV. No.	DESCRIPTION	BY	APR.	DATE					
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					DATE DRAWN: 24/7/72	DESIGNED BY: G.R.G.	POINTED MOUNTAIN GAS GATHERING SYSTEM			
					CHECKED BY:	CHECKED BY:				SHEET No.
					JOB No.: E 442 8	APPROVED BY:	PIPELINE B-1			