CHUKCHI SEA TRANSPORTATION

FEASIBILITY AND COST COMPARISON

JOINT INDUSTRY STUDY

PHASE 2

PIPELINE COST ESTIMATING PROGRAMS

INTEC JOB No. H-046.3

NOVEMBER, 1986

INTEC ENGINEERING, INC.

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CHAPTER 1 INTRODUCTION AND SUMMARY

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1.1 INTRODUCTION

INTEC Engineering Report "Chukchi Sea Transportation Feasibility and Cost Comparison Joint Industry Study" (No. H-046.2) addresses crude oil pipeline and tanker transportation costs between the Lease Sale 109 area and a tanker loading terminal in southern Alaska. As part of this study, the computer program CHUKCHI2 was developed to aid in evaluating Chukchi Sea pipeline transportation costs.

The objective of this Phase 2 study work scope extension is to modify the program CHUKCHI2 to enable its application in the Alaskan Beaufort and Bering Seas for water depths of less than 300 feet. Specific areas of program enhancement include:

- improving pipeline sizing and wall thickness selection algorithms;
- including Beaufort Sea trench depth calculation procedures; and
- including construction season duration data for Bering and Beaufort Seas.

1.2 SUMMARY

This report is a supplement to the Chukchi Sea Transportation Joint Industry Study final report. Three different computer programs are developed for use in evaluating

Alaskan offshore crude oil pipeline costs:

CHUKPIPE - Chukchi Sea Pipeline Cost Evaluation;
BERPIPE - Bering Sea Pipeline Cost Evaluation; and
BEAUPIPE - Beaufort Sea Pipeline Cost Evaluation.

All three programs are similar in format and calculation procedures to the CHUKCHI2 computer program developed for the Lease Sale 109 area. The programs are described in Chapter 2. User's manuals for the three programs are presented in Chapters 3, 4 and 5.

CHAPTER 2
PROGRAM DESCRIPTION

2.0 GENERAL

The enhanced offshore Alaska Crude oil pipeline evaluation computer programs are developed as a family of three programs, one each for the Chukchi, Bering and Beaufort Seas. The programs are based primarily on Chapter 6 of the Transportation Study report and all have similar input and output formats to the previous computer program, CHUKCHI2.

The programs concentrate on offshore pipeline design, construction equipment evaluation and cost estimate preparation. Up to two offshore pipeline route legs can be analyzed. Also included in the pipeline transportation cost evaluation are:

- up to two overland pipeline route legs;
- pipeline operation and maintenance costs;
- offshore production structure costs; and
- TAPS tariff costs (if required).

Each program is organized into the following four major sections (Drawings No. 201 and 202):

- pipeline design;
- trenching analysis;
- installation analysis; and
- cost summary.

The programs are written in BASIC language for the IBM-XT, AT and IBM compatible computers. Pipeline data are input through a set of Data Statements and prompted user input during program execution. The programs are internally documented with remark statements to assist the user. Input data checking routines are included where practical for ease of program use.

2.1 PIPELINE DESIGN

The program pipeline design section determines the required pipeline diameter, materials costs and materials logistics costs. User input includes:

- pipeline length data;
- throughput rate;
- crude oil specific gravity and viscosity; and
- pipe yield strength.

In addition to defining the total offshore pipeline route lengths, the length input data are used to define trenching requirements, feasible trenching equipment, and construction season durations. Because of differences between the three geographical areas, offshore pipeline length data are specified differently for each of the computer programs. The pipeline length data breakdowns are as follows:

CHUKPIPE - pipeline length in 5 latitude ranges and 3 water depth ranges.

BERPIPE - pipeline length in 4 water depth ranges and specify pipeline location as north or south of 60°N latitude.

BEAUPIPE - pipeline length in 8 water depth ranges and specify distance offshore at pipeline end points.

The program user is given the option of selecting from several different pipeline diameter/operating pressure combinations. Pipeline designs for lengths of 50 miles or more should generally be based on maximum operating pressures of 1440 or 2160 psig (ANSI Pressure Class 600 or 900, respectively). Lower operating pressures will generally be more economical for shorter pipeline lengths. Pipeline wall thickness requirements are then calculated based on internal pressure requirements and an assumed maximum pipe diameter/wall thickness ratio of 48. If there are two offshore pipeline legs, the pipeline diameter and wall thickness design are based on the longer of the two.

The program user must input whether or not the offshore pipelines require insulation over their entire length. Otherwise, pipelines are assumed to be insulated only where installed in water depths less than 20 ft. Pipeline materials costs are then calculated and include:

- line pipe;
- corrosion coating;
- concrete weight coating;
- anodes;
- casing pipe (for pipe within a pipe insulation method);
- insulation; and
- bulkheads.

Pipeline materials logistics costs are computed based on $250/ton for transportation to the project site.

2.2 TRENCHING ANALYSIS

The pipeline trenching analysis consists of four steps:

- trench depth definition;
- trenching equipment selection;
- construction season definition; and
- trenching cost calculation.

Trench Depth Definition

The recommended Chukchi Sea trench depth calculation procedures are defined in Transportation Study report Chapter 6. Input variables used in CHUKPIPE include:

- pipeline length, water depth and latitude data;
- desired risk of ice keel contact;
- soil stratigraphy (soft over hard soil); and
- pipeline outside diameter (to obtain depth to bottom of trench).

For the Bering Sea, pipeline depths of cover (original seabed to top of pipe) are user input with data statements. Assumed values are 5 ft depth of cover for 0 to 165 ft water depths and 3 ft depth of cover for 165 to 300 ft water depths.

Beaufort Sea pipeline trench depths are calculated based on Alaskan Beaufort Sea ice gouge data (Weeks, et al., 1983). Calculations are done for 8 different water depth ranges. In water depths greater than 120 ft, Alaskan Beaufort Sea ice gouge data are not available and Canadian Beaufort Sea ice gouge parameters are assumed (Lewis, 1977). The program user must input the desired ice keel-pipeline contact return period.

The Beaufort Sea trench depth calculation procedure used in the program BEAUPIPE also allows a minimum pipeline depth of cover to be input for each water depth zone. If the calculated depth of cover is less than the specified minimum (due to a short pipeline length, shallow water depth, or low average contact return period) the minimum depth of cover is used.

Trenching Equipment Selection

The second step in the trenching analysis is to select trenching equipment compatible with the required trench depths, local soil conditions, pipeline water depth profile and geographical location. All three computer programs list feasible trenching equipment spreads and require the user to select a suitable method.

The programs then calculate the total number of weeks required for each trenching equipment spread. Trenching equipment production rate factors are based on Transportation Study report Chapter 6.

The more severe wave conditions in the Bering Sea south of the 60th parallel will result in increased weather downtime and hence will increase the required trenching times. This is modelled in BERPIPE by specifying the pipeline as located either north or south of 60°N latitude and utilizing a different set of trenching production rate factors in the Southern Bering Sea.

Construction Season Definition

The summer construction season duration is defined based on the pipeline location and equipment operating ice condition (A, B, or C). In the Chukchi Sea (program CHUKPIPE), the summer season is computed as the average season duration along the pipeline route leg in a median ice year. In the Bering Sea (program BERPIPE), a 17 week construction season (June through September) and Ice Condition A are used based on sea ice and wave height conditions (Brower, et al., 1977).

Beaufort Sea summer construction seasons are estimated based on the distance north of the Alaskan coastline to the offshore pipeline end points (Brower, et al., 1977 and LaBell, et al., 1983). The season duration is taken as the average for the two end points and a check is made to ensure that the median season duration does not equal zero at either end point. If the user has site specific construction season duration data, the season duration can be input during the computer run.

Winter construction seasons in the Chukchi and Beaufort Seas are considered to be 15 weeks long.

Trenching Cost Calculation

Trenching costs are calculated using the trenching cost equation and cost factors defined in Transportation Study report Chapter 6. The program user must input the number of years allocated to trenching operations and the program then calculates the total cost based on the previously defined equipment selection.

If the pipeline is located in the Beaufort Sea (Program BEAUPIPE), then the cost for one additional winter is added per trenching spread employed. This is to account for the equipment probably being unable to get past Point Barrow during the same year that it completes trenching operations.

2.3 INSTALLATION ANALYSIS

The pipeline installation analysis steps include:

- installation equipment selection;
- construction season definition; and
- installation cost calculation.

A single installation method is defined for each offshore pipeline route leg. If a portion of the line was installed during winter using the through-ice trenching method (Chukchi and Beaufort Seas only), then that length is subtracted to determine the pipeline length remaining to be installed.

The construction season definition and installation cost calculation procedures are similar to those used in the trenching analysis.

Required installation spread operating times are increased by 1.43 weeks to account for pipeline tie-ins. Laybarge spread operating times are increased by 25 percent if the pipeline is fully insulated.

2.4 COST SUMMARY

The cost summary format is the same for all three computer programs and includes the following calculations:

- offshore pipeline capital cost summary;
- onshore pipeline capital cost;
- offshore production structure cost;
- operation and maintenance costs;
- TAPS tariff; and
- present worth of operating costs.

Offshore pipeline capital costs are totalled. These costs include the pipeline materials, logistics, trenching and installation costs, previously calculated, and pump station costs based on the computed pipeline operating pressure. Project services and contingency costs are added as 15 and 25 percent, respectively, of the cost subtotals.

The overland pipeline cost is calculated assuming the same diameter is installed onshore as is used for the offshore pipeline. Overland pipeline and production structure capital costs are based on cost parameters contained in the program data sections.

The computer programs prompt the user to input whether or not TAPS is used, the pipeline system operating life and the interest rate. The present worth of the pipeline system operating cost is then calculated.

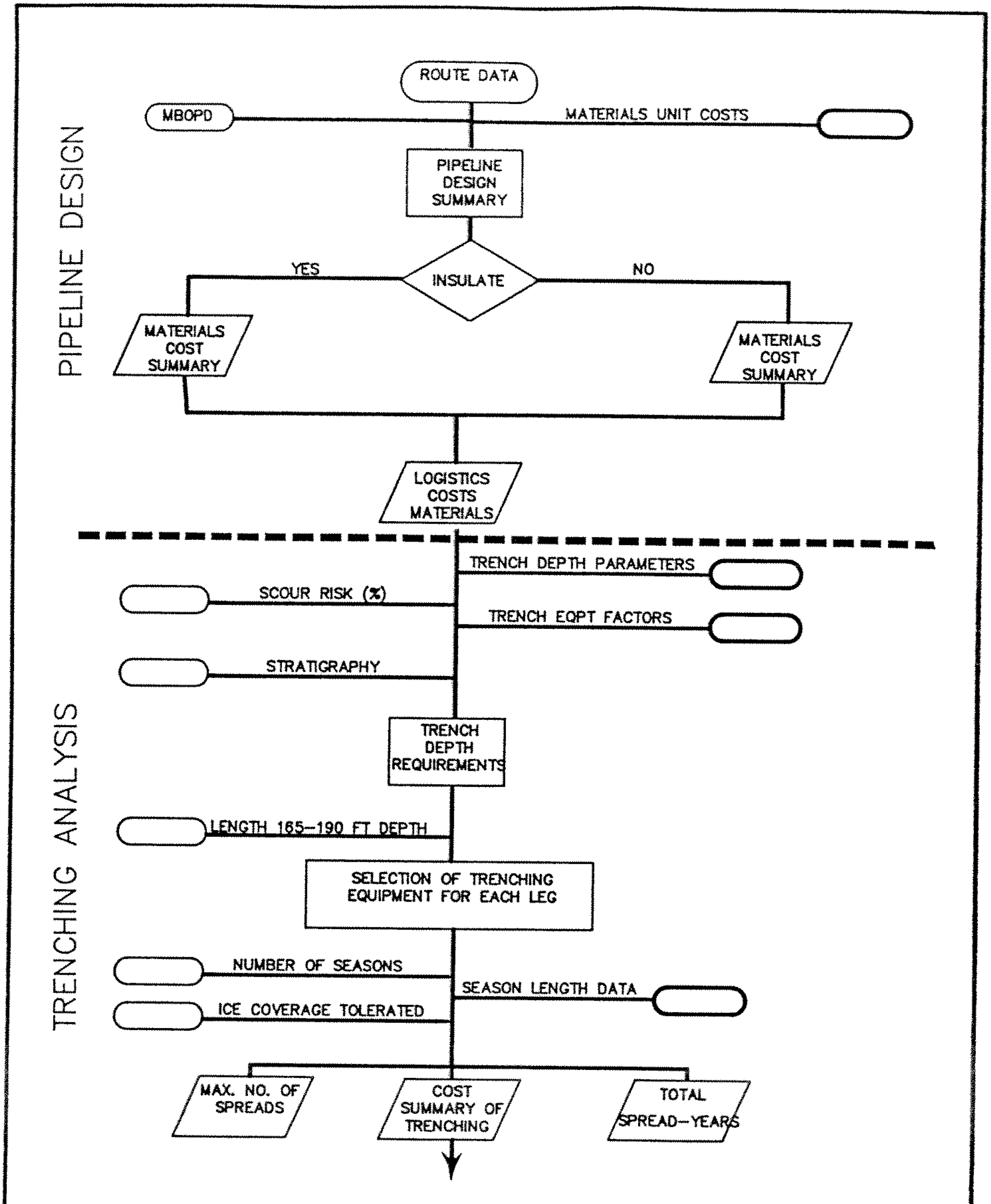
CHAPTER 2 - REFERENCES

Brower, W. A., H. W. Searby, J. L. Wise, H. F. Diaz and A. S. Prechtel, 1977, "Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska," Vols. I, II and III, NOAA, U. S. Department of Commerce.

LaBelle, J. C., J. L. Wise, R. P. Voelker, R. H. Schulze and G. M. Wohl, 1983, Alaska Marine Ice Atlas, Arctic Environmental Information and Data Center, University of Alaska.

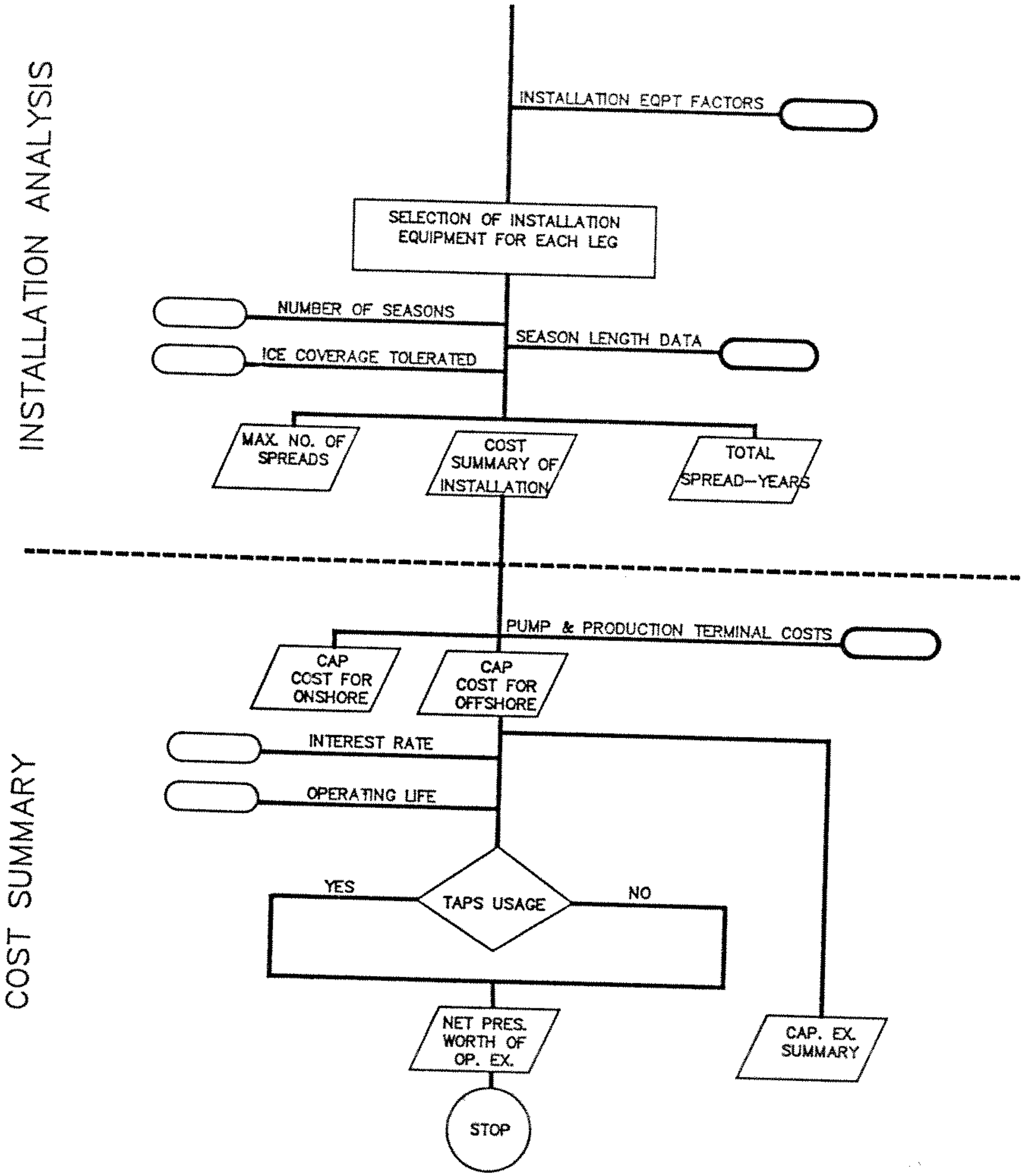
Lewis, C. F. M., 1977, "Bottom Scour by Sea Ice in the Southern Beaufort Sea," Department of Fisheries and the Environment, Beaufort Sea Technical Report 23 (draft), Beaufort Sea Project, Victoria, B.C.

Weeks, W. F., P. W. Barnes, D. M. Rearic and E. Reimnitz, 1983, "Statistical Aspects of Ice Gouging on the Alaskan Shelf of the Beaufort Sea," Cold Regions Research and Engineering Laboratory, U. S. Army Corps of Engineers.



JOINT INDUSTRY STUDY CHUKCHI SEA TRANSPORTATION	PIPELINE EVALUATION PROGRAM FLOW CHART - PART 1

INTEC ENGINEERING, INC.	SCALE NONE	DRAWN BY R. GROBE	DRAWING No 201
	DATE 10-23-86	JOB No. H-046.3	



JOINT INDUSTRY STUDY CHUKCHI SEA TRANSPORTATION	PIPELINE EVALUATION PROGRAM FLOWCHART - PART 2

INTEC ENGINEERING, INC.

SCALE	DRAWN BY	DRAWING No.
NONE	R. GROBE	202
DATE 10-24-86	JOB No. H-046.3	

CHAPTER 3 CHUKPIPE USER'S MANUAL

CHAPTER 3
CHUKPIPE USER'S MANUAL

3.1 PROGRAM INPUT/OUTPUT GUIDE

The computer program CHUKPIPE evaluates Chukchi Sea crude oil pipeline system costs. Program input and output are describe chronologically in the following paragraphs. The sample run described in this chapter has one offshore pipeline leg. Program trenching and installation sections repeat if there is a second offshore leg.

A printed record of all or part of the run can be made by using the "PRINT SCREEN" key while running the program. The program must be run with "Caps Lock" (Capitalization) on.

Load and Run Program

Enter BASIC interpreter. Execute LOAD and RUN commands. Program will output program title and application statement.

Scenario Designation

Program prompt: INPUT ALPHANUMERIC SCENARIO DESIGNATION?

User inputs desired alphanumeric title for run.

Pipeline Length

Program reads route length data and prints a summary. If there are an incorrect number of data points, the program will list the appropriate data statements and stop.

Program prompt: DOES LENGTH DATA SET REQUIRE MODIFICATION (Y or N)?

User inputs "N" if the length data are correct or "Y" if they require modification. If Y is input, the appropriate data statements are listed (lines 1010 to 1070) and the program stops. Modify the length data as indicated by the remark statements using the BASIC file editor and re-run program. If user wants to permanently alter the data statements, use the SAVE command.

Production Rate

Program prompt: INPUT PRODUCTION RATE (MBPD)?

User inputs crude oil throughput rate in thousands of barrels per day. Program will give an opportunity to repeat this step if a low production rate is input.

Pipeline Design

Program lists feasible pipeline design options in terms of pipe outside diameter and approximate Maximum Allowable Operating Pressure (MAOP). These are selected by the program on the basis of flow velocity and pressure drop. Crude oil specific gravity, viscosity and pipe yield strength are contained on lines 1119 to 1150. Values can be modified using the BASIC editor.

Program prompt: SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)?

User inputs pipeline outside diameter. Program will give an opportunity to repeat this step if a small diameter is input.

Program notes if pipe wall thickness is set by an assumed maximum outside diameter/wall thickness ratio of 48 (lines 9585 and 9586).

Program prints pipeline design summary. If the computed MAOP exceeds the desired value, the user has an opportunity to repeat the design section following the materials cost summary.

<u>Pipeline Insulation</u>

Program prompt: ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N)?

User inputs "Y" for yes or "N" for no. All pipelines are assumed to be insulated in water depths less than 20 feet. If neither is input, the question is repeated.

<u>Materials Cost Summary</u>

Program prints materials and materials logistics cost summary.

Program prompt: REPEAT DESIGN AND COST SUMMARY (Y OR N)?

User inputs "Y" to repeat the offshore pipeline design and cost summary; "N" to continue the run.

Trenching Requirements

Program reads trench depth parameters and trenching cost/productivity factors.

Program prompt: INPUT RISK OF ICE KEEL DAMAGE FOR ENTIRE PIPELINE ONCE IN 10 YEARS (%)?

User inputs risk for pipeline leg under investigation (1 percent suggested).

Program prompt: INPUT - CAN SOIL STRATA BE CONSIDERED TO CONSIST OF 6-8 FT OF LOOSE MATERIAL OVERLYING STIFF, SCOUR-RESISTANT MATERIAL (Y OR N)?

User inputs "Y" for yes (effects noted in program output) or "N" for no. See Transportation Study report Chapter 6 for further explanation.

Program prints trench depth summary.

Program prompt: RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)?

User inputs "Y" to repeat trench depth analysis.

Water Depth Profile

Program prompt: INPUT LENGTH OF ROUTE WHICH IS IN DEPTH RANGE = 165 TO 190 ON LEG 1?

User inputs length of offshore pipeline route leg 1 (leg 2 if the second leg of a 2-leg case is being analyzed) in statute miles between 165 and 190 ft water depths. This is necessary because of the maximum dredging depth for some trenching equipment.

Trenching Equipment Selection

Program prompt: FEASIBLE EQPT FOR OBTAINING XX.X FT TRENCH IN WATER DEPTH OF YY-YY FT:

0 - THROUGH-ICE TRENCH/LAY
1 - CUTTER SUCTION DREDGE
2 - CUTTER SUCTION DREDGE W/DOUBLE SWING WIRES
3 - LINEAR DREDGE
4 - TRAILING SUCTION HOPPER DREDGE
5 - SINGLE PASS PLOW
6 - MULTI-PASS PLOW
7 - MECHANICAL TRENCHER
8 - CONVENTIONAL HIGH PRESSURE JETTING
9 - TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS ONLY)

ENTER YOUR CHOICE (BY NUMBER)

Where:

XX.X = pipeline trench depth (original seabed to bottom of trench); and
YY-YY = water depth range.

Only equipment types feasible for the specified combination of trench depth and water depth are prompted.

User inputs "0" through "9" to select the corresponding equipment type and the program then prompts for the next water depth range. The user should confine the equipment selection to the options listed by the program.

Soil Type

If the trench depths are not based on a loose soil layer overlaying a hard soil layer, the program will prompt:

INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C = CLAY S = SAND)?

User inputs "C" if the soil is clay or "S" if the soil is sand. If neither is input, the question repeats.

Trenching Spread Times

The program calculates the required operating time for each trenching spread selected and prints a summary.

Program prompt: RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N)?

User inputs "Y" to re-run trenching equipment selection.

Number of Trenching Seasons

Program prompt: INPUT MAX. NO OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG?

User inputs the maximum number of seasons devoted to trenching.

Ice Condition

Program prompt: INPUT MAX. ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)

User inputs "A", "B" or "C" for ice conditions defined in Transportation Study report Table 6.3. If neither A, B or C is input, the question repeats.

Construction Season Duration

The program calculates the average construction season duration along pipeline route leg and prints results.

Program prompt: DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N)?

User inputs "N" to use the program's calculated season duration or "Y" to input the season duration based on site specific data. If this question is answered with Y, the program will prompt for the season duration input.

Trenching Cost Summary

The program calculates the cost for each trenching spread and total trenching cost, and prints the results. For each trenching equipment type selected, the project peak number of spreads and total equipment spread-seasons are printed. This information is helpful to the user in evaluating the equipment/ice condition selection.

Program prompt: RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS (Y OR N)?

User inputs "Y" to repeat ice coverage definition or "N" to continue run.

Installation Equipment Selection

The program reads installation equipment cost and productivity factors.

Program prompt: FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF LL

1 - CONVENTIONAL LAYBARGE
2 - 3RD GENERATION LAYBARGE
3 - ARCTIC LAYBARGE
4 - BOTTOM TOW
5 - BOTTOM PULL

ENTER YOUR CHOICE (BY NUMBER)

Where:

LL = offshore pipeline length to be installed in statute miles

Only equipment types considered feasible for the specified pipeline length are prompted.

User inputs "1" through "5" to select the corresponding installation equipment type.

Installation Spread Time

The program calculates the required operating time for the selected installation spread and prints a summary.

Program prompt: RE-RUN INSTALLATION EQUIPMENT SELECTION (Y OR N)?

User inputs "Y" to re-run installation equipment selection.

Number of Installation Seasons

Program prompt: INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG

User inputs the maximum number of seasons devoted to installation.

Ice Condition

Program prompt: INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)

User inputs "A", "B", or "C" for corresponding ice condition.

Construction Season Duration

Program calculates average installation construction season duration. If desired, user can input season duration as described for pipeline trenching.

Installation Cost Summary

The program calculates the pipeline installation cost using the selected installation equipment type and prints the results. The project peak number of installation equipment spreads and total equipment spread-seasons are output.

Program prompt: RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)?

User inputs "Y" to repeat ice coverage definition and cost results or "N" to continue run.

Capital Cost Summary

The program calculates offshore pipeline pump station, production structure and overland pipeline capital costs and prints the total cost summary.

Program prompt: RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N)?

User inputs "Y" to repeat cost summary table or "N" to continue run.

TAPS Usage

Program prompt: DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N)?

User inputs "Y" if the pipeline scenario under consideration uses the Trans Alaska Pipeline System or "N" if it does not. The TAPS tariff is taken as $3.00 per barrel of throughput (line 5950).

Pipeline System Life

Program prompt: LIFE OF PIPELINE SYSTEM (YEARS)?

User inputs pipeline system operating life in years. This is used for calculating the total present worth of pipeline system operating costs.

Interest Rate

Program prompt: INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS?

User inputs interest rate in percent used for operating cost present worth calculations.

Pipeline System Operating Costs

The program calculates the offshore and onshore pipeline operating costs and the TAPS tariff (if any) for years 1 through the specified pipeline system operating life. The present worth of these costs are calculated for each year and the results are printed for every other year. The total operating cost present worth for all years is calculated and printed.

Total Pipeline System Present Worth Cost

The program adds the total pipeline system operating cost present worth and the total capital cost and prints the result.

Program prompt: RE-RUN OPERATING COST CALCULATION (Y OR N)?

User inputs "Y" to re-run the operating cost calculations or "N" to end the run.

CHAPTER 3 - CHUKPIPE USER'S MANUAL

3.2 PROGRAM LISTING

```
10 PRINT"***********************************************************************
********"
20 PRINT"**                     INTEC ENGINEERING PROGRAM CHUKPIPE - (REV. 0)
     **"
30 PRINT "**                    CHUKCHI SEA PIPELINE COST EVALUATION
     **"
31 PRINT "**     This program allows rapid cost estimate preparation for crude o
il      **"
32 PRINT "**     pipelines in the Chukchi Sea and the evaluation of total offsho
re      **"
33 PRINT "**     and onshore Alaskan pipeline transportation costs.  It is inten
ded     **"
34 PRINT "**     to be used only by Participants in the Chukchi Sea Transportati
on      **"
35 PRINT "**     Feasibility and Cost Evaluation Joint Industry Study - Phase 2.
        **"
36 PRINT "**     Although the cost model used herein will allow rapid assessment
 of     **"
37 PRINT "**     the cost impact of various design, installation and trenching
        **"
38 PRINT "**     options available, the user should inspect the results at the e
nd      **"
39 PRINT "**     of each stage for validity.
        **"
40 PRINT "**********************************************************************
*********"
41 '   REVISED OCTOBER 21, 1986
42 '   INTEC ENGINEERING, INC. 16801 GREENSPOINT PARK DRIVE, SUITE 105, HOUSTON,
       TEXAS 77060.
43 '   REMARKS 1) SEE PROGRAM DOCUMENTATION
               2) TAPS TARIFF =$3/BBL.
44 '           3) PIPELINE DESIGN BASED ON CRUDE PROPERTIES AND PRESSURE DROP ON
                  LONGEST OFFSHORE PIPELINE SEGMENT.
60 DIM ROUTLEN(2,3,4):REM LENGTH OF OFFSHORE PIPELINES (2 LEGS,3 DEPTHS,4 LATITU
DES)
65 DIM ETTIME(2,9):REM ELAPSED TIME FOR TRENCHING EQUIPMENT
67 DIM TRENCHYRS(2,8):REM NO. OF YEARS FOR EACH TYPE OF EQPT
68 DIM TRENCOST(2,8):REM NET COST FOR EACH TRENCHING EQUIPMENT
70 DIM MAXTREN(2,4):REM MAXIMUM TRENCH DEPTH (2 LEGS, 4 LATITUDES)
80 INPUT"   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?   ",S$
105 PRINT
110 PRINT"READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO          LINE   1
010"
120 READ NOFROUT:REM NUMBER OF OFFSHORE LEGS IN POUTE
130 IF NOFROUT>2 THEN PRINT"******** A MAXIMUM OF 2 OFFSHORE ROUTES PERMITTED, R
EDEFINE AND RE-RUN PROGRAM":STOP
135    FOR I =1 TO NOFROUT
140 PRINT"READING SEG. LENGTHS IN EACH DEPTH & LAT. ZONE FOR ROUTE ";I;" ROUTLEN
 1020-1040"
150       FOR J=1 TO 3:REM READ LENGTH IN EACH WATER DEPTH
155          FOR K=0 TO 4:REM READ LENGTH IN EACH LATITUDE ZONE
160          READ ROUTLEN(I,J,K)
162          NETLEN(I)=NETLEN(I)+ROUTLEN(I,J,K):REM NET LENGTH OF EACH LEG
165          NEXT K
170       NEXT J
175    NEXT I
```

```
177 IF NOFROUT=1 THEN RESTORE 1040
180 REM READ TESTDATA TO CHECK DATA
185 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN OFFS
HORE ROUTE DATA, CHECK LINES 1010-1040 AND RE-RUN PROGRAM":LIST 1010-1040:STOP
200 PRINT "READING NUMBER OF ONSHORE ROUTES IN SCENARIO                    ROUTLEN1
 1050"
210 READ NONROUT:REM NUMBER OF ONSHORE ROUTE LEGS  IN SCENARIO
230 IF NONROUT>2 THEN PRINT"******** A MAXIMUM OF 2 ONSHORE ROUTES PERMITTED, RE
DEFINE AND RE-RUN PROGRAM":STOP
232 IF NONROUT=0 THEN RESTORE 1080:GOTO 280
235     FOR I =1 TO NONROUT
240 PRINT"READING ONSHORE ROUTE LENGTH FOR ROUTE ";I;"                      ROUTLEN
1 1050-1070"
250     READ ROUTLEN1(I):REM LENGTH OF ONSHORE ROUTE
275     NEXT I
277 IF NONROUT=1 THEN RESTORE 1080
280 REM READ TESTDAT TO CHECK DATA
290 READ TESTDAT
292 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN ONSHORE ROUTE DAT
A, CHECK AND RE-RUN PROGRAM":STOP
300 REM CALC. TOTAL LENGTH OF EACH OFFSHORE ROUTE AND TOTAL PIPELINE LENGTH
305     FOR I=1 TO NOFROUT
307     TOTLEN=TOTLEN+NETLEN(I)
309     NEXT I
310     FOR I=1 TO NONROUT
312     TOTLEN=TOTLEN+ROUTLEN1(I)
315     NEXT I
320 PRINT"              PIPELINE LENGTH SUMMARY FOR SCENARIO ";S$;"   (MILES)"
324 PRINT"                        LEG 1           LEG 2          TOTAL"
326 PRINT" OFFSHORE";TAB(17);NETLEN(1);TAB(32);NETLEN(2);TAB(49);NETLEN(1)+NETLE
N(2)
328 PRINT" ONSHORE";TAB(17);ROUTLEN1(1);TAB(32);ROUTLEN1(2);TAB(49);ROUTLEN1(1)+
ROUTLEN1(2)
330 PRINT:PRINT"TOTAL PIPELINE LENGTH ALL ROUTES ";TAB(49);TOTLEN
335 INPUT"   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  ",A$
340 IF A$="Y" THEN PRINT"******* CORRECT ROUTE DATA SET (LINES 1010-1070) AND RE
-RUN PROGRAM":LIST 1010-1070:STOP
342 PRINT:PRINT"READING UNIT COSTS FOR MATERIALS                     LINES  1100-110
9
343   FOR I=1 TO 5:READ UCOST(I):NEXT I
344 READ TESTDAT
345 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN UNIT COST DATA LINES 1
100-1108:LIST 1100-1108
350 REM COMPUTE LONGEST OFFSHORE SEGMENT FOR DIAMETER SIZING
355 LONGEST=NETLEN(1):IF NETLEN(2)>LONGEST THEN LONGEST = NETLEN(2)
360 INPUT "   INPUT PRODUCTION RATE (MBPD) ?   ",PRODUCT
375 IF (PRODUCT<25)+(PRODUCT>800) THEN PRINT"**** ARE YOUR SURE? (Y OR N)";:INPU
T A$:IF A$="N" THEN 360
380 CUFOOT=PRODUCT*1000*6.498E-05:REM CONVERT PRODUCTION TO CUBIC FT. PER SEC.
400 REM BEGIN PIPE SIZING
402 DIM IDVAL(26)      'POSSIBLE RANGE OF PIPE INSIDE DIAMETERS
403 DIM ODVAL(26)
404 REM READ PIPE DESIGN DATA
405 READ CRUDESG:REM READ CRUDE SPECIFIC GRAVITY
410 READ VISCOS:REM CRUDE VISCOSITY
415 READ YIELD:REM PIPE SPECIFIED MINIMUM YIELD STRESS
```

```
417 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN PIPE
 DESIGN DATA, CHECK AND RE-RUN PROGRAM":LIST 1119-1150:STOP
418 PRINT:PRINT"CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT"
420 GOSUB 9000          ' GO TO PIPELINE SIZING SUBROUTINE
480 PRINT "CALCULATING MATERIAL QUANTITIES"
482 REM CALCULATE LINE PIPE TONNAGE
484 WPF=2.68*(ODPIPE^2-(ODPIPE-2*WALL)^2)
486 REM IF PIPE IS INSULATED MATERIALS COSTS ARE BASED ON A PIPE IN A PIPE
487 REM CASING WALL THICKNESS OF .375 IN ASSUMED
488 WPFI=2.68*((ODPIPE+6)^2-(ODPIPE+6-2*.375)^2)
492 REM CALCULATE SURFACE AREA OF LINE PIPE
494 SFCLP=3.14*ODPIPE/12:REM SQ. FT. PER LINEAL FT.
496 SFCCP=3.14*(ODPIPE+6)/12:REM SURFACE AREA OF CASING PIPE
500 REM DETERMINE CONCRETE THICKNESS
502 REM CONCRETE TH. IS DETERMINED BASED ON A SPGR OF 1.15 EMPTY
504 TEMP=SQR((WPF+WPFI-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI
=(TEMP-(ODPIPE+6))/2
506 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
508 CONCRETI=.00545*190*((ODPIPE+6+2*CONCTHI)^2-(ODPIPE+6)^2):REM INSULATED PIPE
 CONCRETE WEIGHT PER FOOT
510 CONCRET=.00545*190*((ODPIPE+2*CONCTH)^2-(ODPIPE)^2):REM  PIPE CONCRETE WEIGH
T PER FOOT
512 REM CALC ZINC ANODE REQUIREMENTS BASED ON 350 AMP-HRS/LB, 10% HOLIDAY AND 6
MA/SQ FT FOR BURIED PIPELINES AND 20 YEAR LIFE
514 ANODEI=.05*SFCCP*.002*20*365*24/350:REM ANODE WEIGHT PER FOOT FOR INSULATED
515 TEMP=SQR((WPF-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI=(TEM
P-(ODPIPE+6))/2
516 ANODE=.05*SFCLP*.002*20*365*24/350:REM ANODE WT/FT FOR NON-INSULATED LINES
517 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
518 REM CALC INSULATION VOLUME IF REQUIRED
520 INSVOL=.00545*((ODPIPE+6)^2-ODPIPE^2)
525 PRINT"                              OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO ";S$
526 PRINT"                                 PIPE DIAMETER ";TAB(49);:PRINT USING "##.###";OD
PIPE;:PRINT"   IN"
527 PRINT"                                 PIPE WALL THICKNESS ";TAB(49);:PRINT USING "##.#
##";WALL;:PRINT"   IN"
528 PRINT"                                 PIPE STEEL GRADE ";TAB(49);:PRINT USING "##.#";Y
IELD;:PRINT"     KSI"
529 PRINT"                                 PIPELINE MAOP ";TAB(47);:PRINT USING "####.#";MA
OP;:PRINT"     PSIG"
530 PRINT"                                 CASING DIA. (WHERE REQD) ";TAB(49);:PRINT USING
"##.###";ODPIPE+6;:PRINT "   IN"
531 PRINT"                                 CASING WALL                   0.375   IN"
 "
540 PRINT"                                 CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTH;:PRINT "   NON-INSULATED"
541 PRINT"                                 CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTHI;:PRINT "   INSULATED PIPE"
550 REM COMPUTE NET MATERIALS COSTS
552 INPUT"     ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N
)? ",I$:IF (I$="Y")+(I$="N")=0 THEN GOTO 552
554    FOR I=1 TO NOFROUT
555    LESHOR(I)=0
556       FOR J= 0 TO 4
```

```
558        LESHOR(I)=LESHOR(I)+ROUTLEN(I,1,J)
560        NEXT J
562     NEXT I
564     FOR I=1 TO NOFROUT
566     LEDEEP(I)=NETLEN(I)-LESHOR(I)
567     NEXT I
570 REM COMPUTE MATERIALS COST FOR NEARSHORE LENGTH ASSUMING THIS SECTION IS INS
ULATED
571 REM MATERIALS UNIT COST DATA FROM LINES 1100-1109
572     FOR I=1 TO NOFROUT
574     PRINT:PRINT"          MATERIAL COST SUMMARY FOR OFFSHORE LEG ";I;" SCENARIO
 ";S$
576     PRINT"                          (ALL COSTS IN 1986 $ MILLIONS) "
577     PRINT"  ITEM                     DEPTH<20 FT      DEPTH>20 FT      TOTAL"
579     TCOST=0
580     TEMP1=WPF*UCOST(1)*LESHOR(I)*5280:TEMP2=WPF*UCOST(1)*LEDEEP(I)*5280:LPCST
(I)=TEMP1+TEMP2
582 PRINT"LINE PIPE";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!;TEMP
2/1000000!;LPCST(I)/1000000!:TCOST=TCOST+LPCST(I)
584     TEMP1=WPFI*UCOST(1)*LESHOR(I)*5280:TEMP2=-WPFI*UCOST(1)*LEDEEP(I)*5280*(I
$="Y"):CPCST(I)=TEMP1+TEMP2
586 PRINT"CASING PIPE";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!;TE
MP2/1000000!;CPCST(I)/1000000!:TCOST=TCOST+CPCST(I)
588     TEMP1=(SFCLP+SCFCP)*UCOST(2)*LESHOR(I)*5280:TEMP2= (SFCLP-SFCCP*(I$="Y"))
*UCOST(2)*LEDEEP(I)*5280:CORCST(I)=TEMP1+TEMP2
590 PRINT"CORROSION COAT";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!
;TEMP2/1000000!;CORCST(I)/1000000!:TCOST=TCOST+CORCST(I)
592     TEMP1=(CONCRETI)*UCOST(3)*LESHOR(I)*5280:TEMP2= (CONCRET)*UCOST(3)*LEDEEP
(I)*5280:IF I$="Y" THEN TEMP2=TEMP2*(CONCRETI/CONCRET)
593 CONCST(I)=TEMP1+TEMP2
594 PRINT"CONCRETE COAT";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!;
TEMP2/1000000!;CONCST(I)/1000000!:TCOST=TCOST+CONCST(I)
596     TEMP1=(ANODEI)*UCOST(4)*LESHOR(I)*5280:TEMP2= (ANODE)*UCOST(4)*LEDEEP(I)*
5280:IF I$="Y" THEN TEMP2=TEMP2*(ANODEI/ANODE)
598 ANCST(I)=TEMP1+TEMP2
600 PRINT"ANODES     ";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!;TEM
P2/1000000!;ANCST(I)/1000000!:TCOST=TCOST+ANCST(I)
602     TEMP1=INSVOL*UCOST(5)*LESHOR(I)*5280:TEMP2= -INSVOL*UCOST(5)*LEDEEP(I)*52
80*(I$="Y"):INSCST(I)=TEMP1+TEMP2
604 PRINT"INSULATION   ";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!;
TEMP2/1000000!;INSCST(I)/1000000!:TCOST=TCOST+INSCST(I)
606 REM CALC COST FOR ANNULAR BULKHEADS AND SPACERS
607     TEMP1=((400+22.8*ODPIPE)/80)*LESHOR(I)*5280:TEMP2= 0:IF I$="Y" THEN TEMP2
=((400+22.8*ODPIPE)/80)*LEDEEP(I)*5280
608 BKDCST(I)=TEMP1+TEMP2
609 PRINT"BULKHEADS    ";TAB(20);:PRINT USING "###.#            ";TEMP1/1000000!;
TEMP2/1000000!;BKDCST(I)/1000000!:TCOST=TCOST+BKDCST(I)
620 PRINT TAB(15);:PRINT "SUBTOTAL - LEG ";I;:PRINT TAB(55);:PRINT USING"####.#
 ";TCOST/1000000!
621 TCOST(I)=TCOST
622 NEXT I
630 PRINT"   TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES             ";:PRINT US
ING"####.# ";(TCOST(1)+TCOST(2))/1000000!
660 REM COMPUTE NET LOGISTICS COST FOR OFFSHORE PIPELINE BASED ON $250/TON
662 TEMP=(LPCST(1)+LPCST(2))/UCOST(1)+(CPCST(1)+CPCST(2))/UCOST(1)
664 TEMP=TEMP+(CONCST(1)+CONCST(2))/UCOST(3)
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666 TEMP=TEMP+(ANCST(1)+ANCST(2))/UCOST(4)
668 NETWT=TEMP/2000:REM NET OFFSHORE MATERIALS WEIGHT (TONS)
669 LOGCST=250*NETWT:PRINT"LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/T
ON =   ";INT(LOGCST/1000000!)
670 INPUT"    REPEAT DESIGN AND COST SUMMARY (Y OR N)?",A$:IF A$="Y" THEN 418
680 PRINT"**********************************************************************
*********"
690 PRINT"BEGIN PIPELINE TRENCHING EVALUATION"
700 REM CALC. TRENCHING REQUIREMENTS FOR OFFSHORE LINES
705 PRINT"READING TRENCH DEPTH PARAMETERS A & B                LINES 1200-1204"
710 FOR I=1 TO 4:READ TRENA(I):NEXT I
712 FOR I=1 TO 4:READ TRENB(I):NEXT I
714 PRINT "READING COST, PRODUCTIVITY FACTORS FOR TRENCHING     LINES 1300-1330"

715    FOR L=0 TO 8
716    READ C1A(L),C1B(L),C1C(L),C2(L),C3(L),V1(L),V2A(L),V2B(L),V2C(L),W(L),CLA
Y(L),SAND(L),WAVE(L),MECH(L),P1(L),P2(L):NEXT L
717 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN TRENCHING
 FACTORS DATA SET- LINES 1314-1330. CHECK AND RE-RUN":LIST 1310-1330:STOP
719    FOR I= 1 TO NOFROUT
720  INPUT"     INPUT RISK OF ICE KEEL DAMAGE FOR ENTIRE PIPELINE ONCE IN 10 YEA
RS (%) ? ",PROB
722 PROB=PROB/100
726        FOR K= 1 TO 4
727        TEMP=(ROUTLEN(I,1,K)+ROUTLEN(I,2,K))*(8/5):IF TEMP=0 THEN 736
729        PROB(K)=PROB*(ROUTLEN(I,1,K)+ROUTLEN(I,2,K))/(NETLEN(I)-ROUTLEN(I,3,1)
-ROUTLEN(I,3,2)-ROUTLEN(I,3,3)-ROUTLEN(I,3,4)-ROUTLEN(I,1,0)-ROUTLEN(I,2,0)-ROUT
LEN(I,3,0)):REM ADJUST PROB TO EACH ZONE BY LENGTH RATIOS
730        TEMP=1-(1-PROB(K))^(1/TEMP)
732        COVER(I,K)=TRENB(K)+LOG(TEMP)/(-TRENA(K))
734        COVER(I,K)=COVER(I,K)*3.281:REM CONVERT TO FT OF DEPTH
735        IF COVER(I,K)>19 THEN COVER(I,K)=19:REM LIMIT MAX. COVER DEPTH
736        NEXT K
739 PRINT"     INPUT -CAN SOIL STRATA BE CONSIDERED TO CONSIST OF 6-8 FT OF LOOS
E ":PRINT"     MATERIAL OVERLYING STIFF, SCOUR-RESISTANT MATERIAL (Y OR N) ";:IN
PUT STRATA$:IF (STRATA$="Y")+(STRATA$="N")=0 THEN 739
740 IF STRATA$="Y" THEN PRINT" ***  NOTE THIS ASSUMPTION WILL REDUCE REQUIRED TR
ENCH DEPTH IN WATER ***":PRINT " ***  DEPTHS OF 20-190 FT"
741 PRINT
742 REM PRINT "                TRENCH DEPTH REQUIREMENTS FOR EACH LEG"
750    COVER(I,0)=4:REM SET MINIMUM DEPTH OF COVER SOUTH OF 69 DEG LAT
752        FOR J=1 TO 3
755        FOR K=0 TO 4
760        TRENDEP(I,J,K)=-(J<3)*COVER(I,K)+ODPIPE/12
762 IF J=3 THEN TRENDEP(I,J,K)=6:REM DEFINE 6 FT TRENCH IN DEPTH>190
765        NEXT K
770        NEXT J
779    PRINT"                    OFFSHORE PIPELINE LEG ";I;"  SCENARIO ";S$
780    PRINT" DEPTH   <69°N  69-70°N   70-71°N   71-72°N   72-73°N"
782    PRINT" (FEET)"
783    FOR J=1 TO 3
784        FOR K=0 TO 4:IF (J=1)*(TRENDEP(I,J,K)>10)=1 THEN TRENDEP(I,J,K)=10:REM
 CUTOFF TRENCH AT 10 FT. IN SHALLOW WATER
785        NEXT K
786    IF J=1 THEN PRINT"   <20 ";TAB(10);:FOR K=0 TO 4:TRENDEP(I,J,K)=TRENDEP(I
,J,K)*(-(ROUTLEN(I,J,K)>0)):PRINT USING "##.       ";TRENDEP(I,J,K);:NEXT K
```

```
788     IF J=2 THEN PRINT"20-190";TAB(10);:FOR K=0 TO 4:TRENDEP(I,J,K)=TRENDEP(I,
J,K)*(-(ROUTLEN(I,J,K)>0)):IF STRATA$="Y" THEN TRENDEP(I,J,K)=(8+ODPIPE/12)*(-(R
OUTLEN(I,J,K)>0))
789 IF J=2 THEN PRINT USING"##.        ";TRENDEP(I,J,K);:NEXT K
790     IF J=3 THEN PRINT"  >190";TAB(10);:FOR K=0 TO 4:TRENDEP(I,J,K)=TRENDEP(I,
J,K)*(-(ROUTLEN(I,J,K)>0)):PRINT USING "##.        ";TRENDEP(I,J,K);:NEXT K
792     PRINT:NEXT J
796 INPUT"RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)? ",A$:IF A$="Y" THEN 720
800 REM
810 TR$(0)="THROUGH-ICE TRENCH/LAY"
820 TR$(1)="CUTTER SUCTION DREDGE "
821 TR$(2)="CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES"
822 TR$(3)="LINEAR DREDGE"
823 TR$(4)="TRAILING SUCTION HOPPER DREDGE"
824 TR$(5)="SINGLE PASS PLOW "
826 TR$(6)="MULTI-PASS PLOW "
827 TR$(7)="MECHANICAL TRENCHER"
828 TR$(8)="CONVENTIONAL HIGH PRESSURE JETTING"
829 TR$(9)="TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS O
NLY)"
830 REM BEGIN INVESTIGATION INTO BEST TRENCHING METHOD
833   LGT190(I)=0 :REM DEFINE THE PORTION OF THE ROUTE IN DEPTH >190
834      FOR K=0 TO 4:LGT190(I)=LGT190(I)+ROUTLEN(I,3,K):NEXT K
836   REM DEFINE MAXIMUM TRENCH DEPTH ALONG LEG I IN EACH WATER DEPTH ZONE
837   TEMP=0
838      FOR K=0 TO 4
840      IF TEMP<TRENDEP(I,1,K) THEN TEMP=TRENDEP(I,1,K)
842      NEXT K
844   MAXTREN(I,1)=TEMP
846   TEMP=0
848      FOR K=0 TO 4
850      IF TEMP<TRENDEP(I,2,K) THEN TEMP=TRENDEP(I,2,K)
852      NEXT K
854   MAXTREN(I,2)=TEMP
856   TEMP=0
858      FOR K=0 TO 4
860      IF TEMP<TRENDEP(I,3,K) THEN TEMP=TRENDEP(I,3,K)
862      NEXT K
864   MAXTREN(I,4)=TEMP
865  MAXTREN(I,0)=0:FOR W=1 TO 3:IF MAXTREN(I,W)>MAXTREN(I,0) THEN MAXTREN(I,0)=
MAXTREN(I,W):NEXT W:REM DEFINE MAX. TRENCH DEPTH OVERALL
866   IF MAXTREN(I,2)<>0 THEN PRINT" INPUT LENGTH OF ROUTE WHICH IS IN DEPTH RAN
GE=165 TO 190 ON LEG ";I; ELSE 877:REM PROVIDE FURTHER BREAKDOWN OF WATER DEPTH
867   INPUT LGT165(I):IF LGT165(I)>LEDEEP(I)-LGT190(I) THEN PRINT" MAXIMUM POSSI
BLE LENGTH BETWEEN 165 AND 190 FT IS ";LEDEEP(I)-LGT190(I):GOTO 866
868   IF LGT165(I)>0 THEN MAXTREN(I,3)=MAXTREN(I,2)
870   IF LGT165(I)=0 THEN MAXTREN(I,3)=0
872   IF LGT165(I)=LEDEEP(I)-LGT190(I) THEN MAXTREN(I,2)=0
875 GOTO 880
877  MAXTREN(I,3)=0:REM IF NO TRENCH EXISTS IN DEPTH 20-190 THEN NONE IN 165-190

880 REM DEVELOP TRENCHER SELECTION
881 PRINT"*************   OFFSHORE PIPELINE LEG  ";I;" SCENARIO ";S$;" ****"
882   FOR W=1 TO 4
883   IF W>1 THEN 889
884   IF MAXTREN(I,1)=0 THEN 920
```

```
885 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 0-20 FT:"
886    IF MAXTREN(I,1)<=6 THEN PRINT "0-";TR$(0):PRINT"1-";TR$(1):PRINT"2-";TR$(2
):PRINT"5-";TR$(5):PRINT"6-";TR$(6):INPUT"          ENTER YOUR CHOICE (BY NUMBER)",
T:TRENCHER(W)=T:IF (T=0)+(T=1)+(T=2)+(T=5)+(T=6)=0 THEN 886 ELSE 920
887    IF MAXTREN(I,1)<=10 THEN PRINT"0-";TR$(0):PRINT"1-";TR$(1):PRINT"2-";TR$(2
):PRINT"6-";TR$(6):INPUT"          ENTER YOUR CHOICE (BY NUMBER)",T:TRENCHER(W)=T:I
F (T=0)+(T=1)+(T=2)+(T=6)=0 THEN 887 ELSE 920
888   PRINT"1-";TR$(1):PRINT"2-";TR$(2):INPUT"          ENTER YOUR CHOICE (BY NUMBER
)",TRENCHER(W):GOTO 920
889 IF W>2 THEN 901
890    IF MAXTREN(I,2)=0 THEN 920
891 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 20-165 FT:"
892    IF MAXTREN(I,2)<=6 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"3-";TR$(3)
:PRINT"4-";TR$(4):PRINT "5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";
TR$(8)
893 IF MAXTREN(I,2)<=6 THEN INPUT"          ENTER YOUR CHOICE (BY NUMBER)",TRENCHER
(W):GOTO 920
894    IF (MAXTREN(I,2)<=10)*(STRATA$="N")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):PRINT "6-";TR$(6):PRINT"7-";TR$(7):PRINT"8
-";TR$(8)
895    IF (MAXTREN(I,2)<=10)*(STRATA$="Y")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"9-";TR$(9)
896 IF MAXTREN(I,2)<=10 THEN INPUT"          ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
897    IF (MAXTREN(I,2)<=13)*(STRATA$="N")=1 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(
2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8)
898    IF (MAXTREN(I,2)<=13)*(STRATA$="Y")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"9-";TR$(9)
899 IF MAXTREN(I,2)<=13 THEN INPUT"          ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
900    PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):INPUT"
     ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
901    IF W>3 THEN 909
902    IF MAXTREN(I,3)=0 THEN 920
903 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH 165-190 FT:"
904    IF MAXTREN(I,3)<=6 THEN PRINT"4-";TR$(4):PRINT"5-";TR$(5):PRINT"6-";TR$(6)
:PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"          ENTER YOUR CHOICE (BY NUMBER)",T
RENCHER(W):GOTO 920
905    IF (MAXTREN(I,3)<=10)*(STRATA$="N")=1 THEN PRINT"4-";TR$(4):PRINT"6-";TR$(
6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"          ENTER YOUR CHOICE (BY NUMBER)"
,TRENCHER(W):GOTO 920
906    IF MAXTREN(I,3)<=13 THEN PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8
):INPUT"          ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
907    PRINT"4-";TR$(4):INPUT"          ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):I
F (TRENCHER(W)=4)=0 THEN 907 ELSE GOTO 920
909    IF MAXTREN(I,4)=0 THEN 920
910 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH   >190 FT:"
911    IF MAXTREN(I,4)<=6 THEN PRINT"5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7)
:PRINT"8-";TR$(8):INPUT"          ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 9
20
912 PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"          ENTER YOUR C
HOICE (BY NUMBER)",TRENCHER(W):GOTO 920
```

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920 NEXT W
980 REM GOTO TRENCHING COST SECTION -LINE 2000
982 GOTO 2000
1000 REM THIS IS DATA SECTION
1010 DATA 1:REM THIS IS NUMBER OF OFFSHORE LEGS IN SCENARIO
1020 REM THIS IS LENGTH DATA FOR 1ST OFFSHORE LEG IN STATUTE MILES
1022 REM  <69    69-70  70-71  71-72  72-73   LATITUDE ZONES
1024 DATA   0,      0,   1,      0,      0 :REM WATER DEPTH <20 FT
1026 DATA  0,       0,   71,     71,     0 :REM WATER DEPTH 20-190 FT
1028 DATA  0,       0,    0,      0,     0 :REM WATER DEPTH >190 FT
1030 REM THIS IS LENGTH DATA FOR 2ND OFFSHORE LEG IN STAT. MILES  (OPTIONAL)
1032 DATA  0,       0,  18,      49,     0 :REM <20 FT
1034 DATA  0,       0, 102,      30,     0 :REM 20-190 FT
1036 DATA  0,       0,  0,        0,     0 :REM >190 FT
1040 DATA 999:REM DATA CHECK
1050 DATA 1:REM THIS IS NUMBER OF ONSHORE LEGS IN SCENARIO
1060 DATA 309:REM LENGTH IN STATUTE MILES OF 1ST ONSHORE LEG
1070 DATA 000:REM LENGTH OF 2ND ONSHORE LEG (OPTIONAL)
1080 DATA 999:REM TEST DATA
1100 REM UNIT COST FOR MATERIALS
1102 DATA .38:REM X-65 PIPE $/LB
1104 DATA .60:REM FBE $/SQFT (APPLIED)
1106 DATA .15:REM CONCRETE WEIGHT COATING (APPLIED)
1108 DATA 1.6:REM ZINC ANODES $/LB
1109 DATA 2.0:REM POLYURETHANE FOAM INSULATION $/CUFT
1110 DATA 999
1119 REM PIPE DESIGN DATA
1120 DATA .89      :REM CRUDE OIL SPECIFIC GRAVITY
1130 DATA 7.3E-04 :REM KINEMATIC VISCOSITY (FT^2/SEC) AT MEAN FLOWING TEMP.
1140 DATA 65      :REM PIPE YIELD STRENGTH (KSI)
1150 DATA 999:REM TEST DATA
1200 REM TRENCH DEPTH PARAMETERS BASED ON ICE SCOUR STATISTICS
1202 DATA 6.91,4.52,2.66,.99:REM A-FACTOR FOR EACH LATITUDE ZONE IN 1/M
1204 DATA .3,.3,.3,.1:REM B-FACTOR IN METERS
1300 REM COST AND PRODUCTION RATE FACTORS FOR TRENCHING EQUIPMENT
1310 REM  C1A  C1B C1C C2 C3 V1 V2A V2B  V2C  W  CLAY SAND WAVE MECH P1 P2
1314 DATA 6,6,6,0,17,1.5,0,0,0,0,1,1,.9,.95,1,0:REM THROUGH-ICE TRENCH/LAY
1315 DATA 15.6,17,24.2,4,15,.5,.8,1.8,6.8,3,.6,1,.61,.8,5.80,.7:REM S/C DREDGE
1316 DATA 15.6,17,24.2,4,20,.5,.8,1.8,6.8,3,.6,1,.61,.7,29,1.2:REM MOD SC DREDGE

1318 DATA 31.1,32.5,39.1,4,0,.8,.8,1.8,6.4,3,.6,1,.79,.8,20.5,.9:REM LINEAR DRDG

1320 DATA 14.7,16.8,23.7,4,5,.4,.5,1.9,6.8,3,.4,1,.97,.95,53,1.6:REM HOPPER
1322 DATA 1.2,3.7,9.3,2,12,0,.9,2.6,6.5,0,1,1,.97,.95,15,0:REM 1 PASS PLOW
1324 DATA .7,1.8,7.1,2,15,0,.5,1.2,5,2,1,1,.97,.95,118,1.2:REM MULTI-PASS PLOW
1326 DATA 10.7,11.8,19.7,4,2,.4,.5,1.2,6.5,3,1,.3,.8,.5,32,1:REM MECH TRENCHER
1328 DATA 21.1,22.5,29.7,4,0,.7,.8,1.8,6.5,3,.4,1,.8,.65,133,2:REM JETTING
1330 DATA 999:REM TESTDAT
1400 REM COST AND PRODUCTION RATE FACTORS FOR INSTALLATION EQUIPMENT
1410 REM  LC1A  LC1B LC1C LC2 LC3 LV1 LV2A LV2B  LV2C  LW LWAVE LMECH LP1 LP2
1420 DATA 31.7,34.1,39.9,10,7,.8,1.2,3.1,6.9,5,.90,.8,57,.65:REM CONV. BARGE
1430 DATA 37,39.5,44.9,11,15,1.3,1.4,3.1,6.9,5,.95,.8,114,.65:REM 3RD GEN BRGE
1440 DATA 1.8,4.1,9.9,11,210,1.3,1.3,2.9,6.9,5,.90,.8,20.8,0:REM ARCT. LBG
1450 DATA 1.4,4.3,10.9,.6,15,.6,0.7,2.2,5.5,0,.97,.95,5.0,0:REM BOTTOM TOW
1460 DATA 3.3,6.1,12.3,.8,15,.9,1.0,2.5,6.0,.2,.94,.95,2.0,0:REM BOTTOM PULL
1470 DATA 999
```

```
1500 REM UNIT COST DATA FOR PUMP STATIONS AND OFFSHORE PRODUCTION STRUCTURE
1510 DATA .0012: COST PER PUMP HORSEPOWER IN MILLIONS
1520 DATA 482:REM FIXED COST FOR OFFSHORE PRODUCTION STRUCTURE
1550 DATA 3.5,.06:REM ONSHORE PIPELINE FIXED COST PER MILE, COST/IN DIA-MI
2000 REM PRINT"CALCULATING TRENCHING TIMES FOR SPREAD SPECIFIED FOR LEG ";I
2005 IF STRATA$="N" THEN INPUT"     INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (
C=CLAY S=SAND) ?  ",PST$
2006 IF STRATA$="Y" THEN PST$="S"
2007 IF (PST$="S")+(PST$="C")=0 THEN 2005
2008 FOR W=1 TO 4:TTIME(W)=0:NEXT W
2010 REM CALC. COST FOR DEPTH RANGE 0-20 FT
2020 IF MAXTREN(I,1)=0 THEN 2100:REM NO PIPE IN THIS DEPTH
2025 PROD=P1(TRENCHER(1))/(MAXTREN(I,1)^P2(TRENCHER(1)))
2050 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(1))
2055 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(1))
2060 PROD(1)=PROD*WAVE(TRENCHER(1))*MECH(TRENCHER(1))
2070 TTIME(1)=LESHOR(I)/PROD(1)
2100 IF MAXTREN(I,2)=0 THEN 2200:REM NO PIPE IN DEPTH 20-165
2110 IF TRENCHER(2)<>9 THEN 2125
2112 PROD=P1(4)/(6^P2(4))
2114 PROD(2)=PROD*SAND(4)*WAVE(4)*MECH(4)
2116 GOTO 2165
2125 PROD=P1(TRENCHER(2))/(MAXTREN(I,2)^P2(TRENCHER(2)))
2150 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(2))
2155 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(2))
2160 PROD(2)=PROD*WAVE(TRENCHER(2))*MECH(TRENCHER(2))
2165 REM
2170 TTIME(2)=(LEDEEP(I)-LGT165(I)-LGT190(I))/PROD(2)
2200 IF MAXTREN(I,3)=0 THEN 2300:REM NO PIPE IN DEPTH 165-190
2210 IF TRENCHER(3)<>9 THEN 2225
2212 PROD=P1(4)/(6^P2(4))
2214 PROD(3)=PROD*SAND(4)*WAVE(4)*MECH(4)
2216 GOTO 2265
2225 PROD=P1(TRENCHER(3))/(MAXTREN(I,3)^P2(TRENCHER(3)))
2250 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(3))
2255 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(3))
2260 PROD(3)=PROD*WAVE(TRENCHER(3))*MECH(TRENCHER(3))
2265 REM
2270 TTIME(3)=LGT165(I)/PROD(3)
2300 IF MAXTREN(I,4)=0 THEN 2400:REM NO PIPE IN DEPTH  >190
2325 PROD=P1(TRENCHER(4))/(MAXTREN(I,4)^P2(TRENCHER(4)))
2350 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(4))
2355 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(4))
2360 PROD(4)=PROD*WAVE(TRENCHER(4))*MECH(TRENCHER(4))
2370 TTIME(4)=LGT190(I)/PROD(4)
2400 REM COMPUTE NET WEEKS FOR EACH COMPONENT REQUIRED
2410 FOR L=0 TO 9:ETTIME(I,L)=0:NEXT L:REM RESET ALL TO 0
2420     FOR W= 1 TO 4
2425     IF TRENCHER(W)<>9 THEN 2430:REM IF PLOW/DREDGE COMBI. IS NOT USED GO ON
2426     ETTIME(I,4)=ETTIME(I,4)+TTIME(W)
2427     IF W=2 THEN ETTIME(I,6)=ETTIME(I,6)+(LEDEEP(I)-LGT165(I)-LGT190(I))/((P1
(6)/(6^P2(6)))*CLAY(6)*WAVE(6)*MECH(6))
2428     IF W=3 THEN ETTIME(I,6)=ETTIME(I,6)+(LGT165(I))/((P1(6)/(6^P2(6)))*CLAY(
6)*WAVE(6)*MECH(6))
2429 GOTO 2440
2430     ETTIME(I,TRENCHER(W))=ETTIME(I,TRENCHER(W))+TTIME(W)
```

```
2440     NEXT W
2445 PRINT"**********    EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
2450 FOR L=0 TO 8
2460 IF ETTIME(I,L)<>0 THEN PRINT TR$(L);"- ";TAB(65);:PRINT USING "###.#";ETTIM
E(I,L);:PRINT"WEEKS"
2470 NEXT L
2500 INPUT"      RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? ",A$
2510 IF A$="Y" THEN 880
2550 PRINT"*****************************************************************
**********":PRINT "COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG ";I;
2560   IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT PROCEDURE FOR LEG 2"
2600 NEXT I
2700 PRINT "CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED"
2705 PRINT"    INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG";:IN
PUT MSTC
2710 INPUT"    INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C
=10/10)",ICE$:IF (ICE$="A")+(ICE$="B")+(ICE$="C")=0 THEN 2710
2715     FOR I=1 TO NOFROUT
2720     REM COMPUTE AVERAGE SEASON LENGTH FOR ICE COVERAGE SPECIFIED
2730    L69=ROUTLEN(I,1,0)+ROUTLEN(I,2,0)+ROUTLEN(I,3,0)
2740    L70=ROUTLEN(I,1,1)+ROUTLEN(I,2,1)+ROUTLEN(I,3,1)
2750    L71=ROUTLEN(I,1,2)+ROUTLEN(I,2,2)+ROUTLEN(I,3,2)
2760    L72=ROUTLEN(I,1,3)+ROUTLEN(I,2,3)+ROUTLEN(I,3,3)
2770    L73=ROUTLEN(I,1,4)+ROUTLEN(I,2,4)+ROUTLEN(I,3,4)
2780    LAVG=(L69*68.5+L70*69.5+L71*70.5+L72*71.5+L73*72.5)/(L69+L70+L71+L72+L73)
2790   IF LAVG<69 THEN SEASON=19:GOTO 2800
2791   IF LAVG<69.5 THEN SEASON=18!:GOTO 2800
2792   IF LAVG<70! THEN SEASON=17!:GOTO 2800
2793   IF LAVG<70.5 THEN SEASON=15!:GOTO 2800
2794   IF LAVG<71.1 THEN SEASON=10!:GOTO 2800
2796   IF LAVG<71.5 THEN SEASON=8!:GOTO 2800
2797   IF LAVG<72! THEN SEASON=6!:GOTO 2800
2798   IF LAVG<73 THEN SEASON=4!:GOTO 2800
2800   LSEASON(I)=SEASON:REM SAVE THIS VALUE FOR LATER USE IN INSTALLATION EVAL
2810   IF ICE$="B" THEN SEASON=SEASON+4
2820   IF ICE$="C" THEN SEASON=SEASON+8
2825   PRINT"COMPUTED MARINE CONST. SEASON LENGTH ALONG ROUTE LEG ";I;" = ";SEASO
N;" WEEKS"
2840 INPUT"    DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  ",SEASON$
2850 IF SEASON$="Y" THEN INPUT"    INPUT CONSTRUCTION SEASON DURATION (WEEKS) ? "
,SEASON
2860 IF (SEASON$="Y")*(SEASON<=1)=1 THEN INPUT"ARE YOU SURE (Y OR N) ?  ",SCHECK
$ : IF SCHECK$="N" THEN 2840
2870 IF TRENCHER(1)=0 THEN PRINT"WINTER CONSTRUCTION SEASON FOR DEPTHS <20 FT =
15 WEEKS"
2890     PRINT:PRINT"********** TRENCHING COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
2900   REM COMPUTE NUMBER OF SEASON FOR EACH TRENCHING EQUIPMENT
2905     TOTRENCST(I)=0
2910     FOR L=0 TO 8
2915     IF ETTIME(I,L)=0 THEN 2970
2920     TRENCHYRS(I,L)=ETTIME(I,L)/SEASON
2925 IF L=0 THEN TRENCHYRS(I,L)=ETTIME(I,L)/15:REM ASSUME 15 WKS/YR FOR WINTER
2930     IF ICE$="A" THEN TEMP=V2A(L):TEMP2=C1A(L)
2932     IF ICE$="B" THEN TEMP=V2B(L):TEMP2=C1B(L)
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2934     IF ICE$="C" THEN TEMP=V2C(L):TEMP2=C1C(L)
2935 TEMP3=INT(TRENCHYRS(I,L))+1
2936 PEAKNO=INT(TEMP3/MSTC)-((TEMP3/MSTC)>INT(TEMP3/MSTC)):REM DEFINE PEAK NO. I
N SPREAD
2940     TRENCOST(I,L)=(INT(TRENCHYRS(I,L))+1)*(TEMP2+W(L))+(C2(L)+C3(L))*PEAKNO
2950     TRENCOST(I,L)=TRENCOST(I,L)+ETTIME(I,L)*(V1(L)+TEMP)
2960     PRINT TR$(L);"(PROJECT PEAK=";PEAKNO;") ";INT(TRENCHYRS(I,L))+1;"EQPMNT-
SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";TRENCOST(I,L)
2965     TOTRENCST(I)=TOTRENCST(I)+TRENCOST(I,L) :REM ADD ALL EQPT
2970     NEXT L
2975     PRINT"   TOTAL TRENCHING COST FOR LEG ";I;"= ";:PRINT TAB(73);:PRINT USI
NG "####.#";TOTRENCST(I):PRINT
2990 NEXT I
3000 INPUT"   RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS? (Y OR N)",A$
3010 IF A$="Y" THEN 2700
4000 REM BEGIN PIPE INSTALLATION SECTION
4001 PRINT"******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS
 *********":PRINT
4010 IN$(1)="CONVENTIONAL LAYBARGE "
4020 IN$(2)="3RD GENERATION LAYBARGE"
4030 IN$(3)="ARCTIC LAYBARGE"
4040 IN$(4)="BOTTOM TOW"
4050 IN$(5)="BOTTOM PULL"
4100 PRINT"READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION          1400-147
0"
4110   FOR L=1 TO 5
4120   READ LC1A(L),LC1B(L),LC1C(L),LC2(L),LC3(L),LV1(L),LV2A(L),LV2B(L),LV2C(L)
,LW(L),LWAVE(L),LMECH(L),LP1(L),LP2(L):NEXT L
4130 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NUMBER OF VALUES IN INSTA
LLATION VESSEL DATA FILE, CHECK AND RE-RUN":STOP
4140   FOR I =1 TO NOFROUT
4145   ANETLEN=NETLEN(I)
4150   REM DEVELOP INSTALLATION METHOD SELECTION
4155   IF (LESHOR(I)>0)*(TRENCHER(1)=0)=1 THEN ANETLEN=NETLEN(I)-LESHOR(I)
4160 PRINT:PRINT"FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF ";:PRINT USI
NG "###.#";ANETLEN
4165   IF ANETLEN=0 THEN GOTO 4445
4170  IF ANETLEN<=15 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):PRI
NT"4-";IN$(4):PRINT"5-";IN$(5):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",INSTA
LLER(I):GOTO 4200
4175  IF ANETLEN<=30 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):PRI
NT"4-";IN$(4):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200

4180  PRINT "1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):INPUT"       ENTER YOU
R CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200
4200 REM INSTALLATION COST SECTION
4210 REM CALC. PRODUCTION RATE (MI/WEEK)
4220 LPROD=LP1(INSTALLER(I))/(ODPIPE^LP2(INSTALLER(I)))
4240 LPROD(I)=LPROD*LWAVE(INSTALLER(I))*LMECH(INSTALLER(I))
4400 REM COMPUTE WEEKS FOR EACH LEG
4430 LETTIME(I)=ANETLEN/LPROD(I):REM LAYING ELAPSED TIME FOR LEG I
4435 IF (INSTALLER(I)=4)+(INSTALLER(I)=5)<0 THEN 4445
4437 IF I$="Y" THEN LETTIME(I)=1.25*LETTIME(I):REM REDUCE PRODUCTION RATE BY 25%
 IF PIPE IS INSULATED.  THIS IS BASED ON USE OF PIPE IN PIPE WITH PREFABRICATED
END FORGINGS ALLOWING 1 CIRCUMFERENTIAL WELD ON BARGE
4440 LETTIME(I)=LETTIME(I)+1.43:REM 1.43 WKS FOR TIE-INS
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4445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
4450    IF ANETLEN=0 THEN PRINT "***** ENTIRE LEG ";I;" IS INSTALLED DURING THROU
GH-ICE TRENCHING IN WINTER":GOTO 4590
4460 PRINT IN$(INSTALLER(I));"- ";TAB(65);:PRINT USING "###.#";LETTIME(I);:PRINT
"WEEKS"
4575    INPUT"     RE-RUN INSTALLATION EQUIPMENT SELECTION ?(Y OR N) ",A$
4580    IF A$="Y" THEN 4150
4590    PRINT"*****************************************************************
*************":PRINT "COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG ";I;
4592    IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT FOR LEG 2"
4600 NEXT I
4700 PRINT"CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED"
4712 INPUT"   INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG ",MSL
C
4713 INPUT"   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C
=10/10)",ICE$:IF (ICE$="A")+(ICE$="B")+(ICE$="C")=0 THEN 4713
4715   FOR I=1 TO NOFROUT
4747 REM RECALL AVERAGE INSTALLATION SEASON FROM TRENCHING EVALUATION
4749  IF ICE$="A" THEN LSEASON=LSEASON(I)
4750  IF ICE$="B" THEN LSEASON=LSEASON(I)+4
4760  IF ICE$="C" THEN LSEASON=LSEASON(I)+8
4761  PRINT"COMPUTED MARINE CONST. SEASON ALONG ROUTE LEG ";I;" = ";LSEASON;" WE
EKS"
4762 INPUT"   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  ",SEASON$
4763 IF SEASON$="Y" THEN INPUT"   INPUT CONSTRUCTION SEASON DURATION (WEEKS) ? "
,SEASON
4764 IF (SEASON$="Y")*(SEASON<=1)=1 THEN INPUT"ARE YOU SURE (Y OR N) ?  ",SICHEC
K$ : IF SICHECK$="N" THEN 4762
4765    PRINT:PRINT"********INSTALLATION COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
4770  REM COMPUTE NUMBER OF SEASON FOR INSTALLATION EQUIPMENT
4780     LAYRS(I)=LETTIME(I)/LSEASON
4790     IF ICE$="A" THEN TEMP=LV2A(INSTALLER(I)):TEMP2=LC1A(INSTALLER(I))
4792     IF ICE$="B" THEN TEMP=LV2B(INSTALLER(I)):TEMP2=LC1B(INSTALLER(I))
4794     IF ICE$="C" THEN TEMP=LV2C(INSTALLER(I)):TEMP2=LC1C(INSTALLER(I))
4796 TEMP3=INT(LAYRS(I))+1
4798 PEAKNO=INT(TEMP3/MSLC)-((TEMP3/MSLC)>INT(TEMP3/MSLC))
4800     LAYCOST(I)=(INT(LAYRS(I))+1)*(TEMP2+LW(INSTALLER(I)))+(LC2(INSTALLER(I))
+LC3(INSTALLER(I)))*PEAKNO
4810     LAYCOST(I)=LAYCOST(I)+LETTIME(I)*(LV1(INSTALLER(I))+TEMP)
4850     PRINT IN$(INSTALLER(I));"(PROJECT PEAK=";PEAKNO;") ";INT(LAYRS(I))+1;"EQ
PMNT-SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";LAYCOST(I)
4900 NEXT I
4950 INPUT"  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)",A$:IF A$="Y" THEN GOTO
 4700
5000 PRINT"READING PUMP AND PRODUCTION TERMINAL COSTS           1500-1520"
5005 READ PMPCST,PTERCST
5008 PRINT"CALCULATING PUMP STATION AND TERMINAL COSTS"
5020     PUMPPWR(1)=.022*PRODUCT*MAOP*(-(NOFROUT<>0))
5030     PUMPPWR(2)=PUMPPWR(1)*(NETLEN(2)/NETLEN(1))
5040     PUMPCOST(1)=PMPCST*PUMPPWR(1)
5050     PUMPCOST(2)=PMPCST*PUMPPWR(2)
5060 IF NOFROUT=0 THEN PTERCOST=0:IF NO OFFSHORE LEG IS INCL. THEN NO PROD. STRU
CTURE
5100 PRINT "READING ONSHORE PIPELINE COST FACTORS              1550"
5210 READ LNDPL1,LNDPL2
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5220 LNDPLCST=LNDPL1+ODPIPE*LNDPL2
5240 IF NOFROUT=0 THEN 5300
5250 FOR I=1 TO NOFROUT
5270 NEXT I
5500 REM ACCUMULATE ALL PIPELINE COSTS AND DISPLAY RESULTS
5505 PRINT"****************** CAPITAL COST SUMMARY - SCENARIO ";S$;"  *******":
PRINT"                              (1986 MILLIONS OF $)":PRINT
5510 IF NOFROUT=0 THEN 5700
5520 IF NOFROUT>=1 THEN PRINT "OFFSHORE PIPELINE (CHUKCHI SEA)"
5530 IF NOFROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5531 PRINT"   MATERIALS";
5532 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";TCOST(1)/1000000!;
5535 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";TCOST(2)/1000000!;
5545 PRINT TAB(65);:PRINT USING "###.#";(TCOST(1)+TCOST(2))/1000000!;
5547     TEMP=(TCOST(1)+TCOST(2))/1000000!
5550 PRINT"   MATERIALS LOGISTICS";TAB(65);:PRINT USING"###.#";LOGCST/1000000!
5552     TEMP=TEMP+LOGCST/1000000!
5555 PRINT "   TRENCHING";
5560 IF NOFROUT=2 THEN PRINT TAB(44);:PRINT USING"####.#";TOTRENCST(1);
5565 IF NOFROUT=2 THEN  PRINT TAB(56);:PRINT USING"####.#";TOTRENCST(2);
5570 PRINT TAB(64);:PRINT USING "####.#";TOTRENCST(1)+TOTRENCST(2)
5572     TEMP=TEMP+TOTRENCST(1)+TOTRENCST(2)
5575 PRINT "   INSTALLATION, TIE-INS/ SHORE CROSSINGS";
5580 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING "###.#";LAYCOST(1);
5585 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";LAYCOST(2);
5590 PRINT TAB(65);:PRINT USING "###.#";LAYCOST(1)+LAYCOST(2)
5592     TEMP=TEMP+LAYCOST(1)+LAYCOST(2)
5600 PRINT"   PUMP STATION(S)";
5610 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";PUMPCOST(1);
5620 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";PUMPCOST(2);
5625 PRINT TAB(65);:PRINT USING "###.#";PUMPCOST(1)+PUMPCOST(2):TEMP=TEMP+PUMPCO
ST(1)+PUMPCOST(2)
5640 PRINT"  PROJECT SERVICES (15%) :";TAB(65);:PRINT USING "###.#";.15*TEMP
5650    TEMP=1.15*TEMP
5660 PRINT"  CONTINGENCY (25%):";TAB(65);:PRINT USING "###.#";.25*TEMP
5670    TEMP=TEMP*1.25
5680 PRINT "      TOTAL OFFSHORE PIPELINE CAPITAL COSTS:";TAB(70);:PRINT USING "#
###.#";TEMP:OFCAPEX=TEMP
5700 IF NONROUT=0 THEN 5800
5705 PRINT
5710 IF NONROUT>=1 THEN PRINT "ONSHORE PIPELINE COSTS"
5730 IF NONROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5732 IF NONROUT=2 THEN PRINT TAB(45);:PRINT USING"####.#";LNDPLCST*ROUTLEN1(1);
5735 IF NONROUT=2 THEN PRINT TAB(57);:PRINT USING"###.#";LNDPLCST*ROUTLEN1(2);
5745 PRINT TAB(65);:PRINT USING "####.#";LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2)):ONCA
PEX=LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5800 PRINT"PRODUCTION STRUCTURE COSTS:";TAB(65);:PRINT USING"###.#";PTERCST
5802      TEMP=TEMP+PTERCST
5810 TEMP=TEMP+LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5815 PRINT
5820 PRINT"    TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE ";TAB(70
);:PRINT USING"####.#";TEMP
5850 REM
5855 INPUT"  RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? ",A$
5857 IF A$="Y" THEN 5500
5860 PRINT"CALCULATING OPERATING COSTS"
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5900 REM OPERATING COSTS FOR OFFSHORE PIPELINE ARE TAKEN AS 2% OF CAPEX
5910 REM OPERATING COSTS FOR ONSHORE PIPELINE ARE TAKEN AS 3.5% OF CAPEX
5920 OFOPEX=.02*OFCAPEX
5930 ONOPEX=.035*ONCAPEX
5940 INPUT"   DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? ",A$
5945 TAPSTAR=0
5950 IF A$="Y" THEN TAPSTAR=3*365*PRODUCT/1000!
5960 INPUT"   LIFE OF PIPELINE SYSTEM (YEARS)? ",LIFE
5970 INPUT"   INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  ",CIF
5980 CIF=CIF/100
5985 PRINT
5990 PRINT"         PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYS
TEM "
5995 PRINT"                                        YEAR (SCENARIO ";S$;" )"
6000 PRINT" ACCOUNT   ";:FOR J=1 TO LIFE STEP 2:PRINT TAB(9+3*J);:PRINT J;:NEXT
J:PRINT
6010 PRINT:TEMP1=0:TEMP2=0:TEMP3=0
6020 IF NOFROUT<=0 THEN 6030 ELSE PRINT"OFFSHORE PL";:FOR J=1 TO LIFE :TEMP1=TEM
P1 +OFOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";OFOPEX*(1/((1+CIF)^(J-1)));
6025 NEXT J:PRINT
6030 IF NONROUT<=0 THEN 6040 ELSE PRINT"ONSHORE PL ";:FOR J=1 TO LIFE:TEMP2=TEMP
2+ONOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT US
ING "###  ";ONOPEX*(1/((1+CIF)^(J-1)));
6035 NEXT J:PRINT
6040 IF TAPSTAR<=0 THEN 6050 ELSE PRINT"TAPS TARIFF";:FOR J=1 TO LIFE :TEMP3=TEM
P3+TAPSTAR*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";TAPSTAR*(1/((1+CIF)^(J-1)));
6045 NEXT J:PRINT
6050 PRINT:PRINT"  NET PRESENT VALUE OF OPERATING COSTS = ";:PRINT USING "#####.
#";(TEMP1+TEMP2+TEMP3)
6055 PRINT"  TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)= ";TEMP+TEMP1+
TEMP2+TEMP3;" MILLION $"
6060 INPUT"  RE-RUN OPERATING COST CALCULATION (Y OR N)   ";A$
6070 IF A$="Y" THEN 5970
6080 PRINT"**************  END OF INTEC ENGINEERING PROGRAM CHUKPIPE  **********
**********"
8999 END
9000 REM
                    PIPELINE SIZING SUBROUTINE
    REM
9020 FRICT=.026  '    STARTING VALUE FOR FRICTION FACTOR & APPROX. MAOP
9023 PRINT "PIPELINE DESIGN OPTIONS INCLUDE:"
9024 PRINT "                    PIPE OD (IN)      APPROX. MAOP (PSIG)"
9030    IDVAL(1)=6!: ODVAL(1)=6.625
9040    IDVAL(2)=8!: ODVAL(2)=8.625
9050    IDVAL(3)=10!: ODVAL(3)=10.75
9060    IDVAL(4)=12!: ODVAL(4)=12.75
9070    IDVAL(5)=13!: ODVAL(5)=14!
9080    FOR I=1 TO 25     'LIST PIPE DESIGN OPTIONS
9090    FLOWVEL=CUFOOT/(3.1416*((IDVAL(I)/12)^2)/4)
9100    IF FLOWVEL>20 GOTO 9160    'REJECT HIGH FLOW VELOCITY CASES, >20 FT/SEC
9110    IF (FLOWVEL<3)  AND (IDVAL(I)>13) GOTO 9160  ' REJECT LOW VELOCITIES
9115    IF FLOWVEL<1.5 GOTO 9160
9117    '     CALCULATE APPROX. PRESSURE DROP
9120    HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDVAL(I)/12)*2*32.2)
```

```
9130     DELTP=HF*62.4*CRUDESG/144
9140     IF DELTP>2500 GOTO 9160   '    REJECT HIGH PRESSURE DROP CASES
9150     PRINT TAB(20); ODVAL(I); TAB(40); USING"####."; (DELTP+50)
9160     IF I>=5 THEN ODVAL(I+1)=ODVAL(I)+2
9170     IF I>=5 THEN IDVAL(I+1)=ODVAL(I+1)-(2*ODVAL(I+1)/48)
9300     NEXT I
9400 KS=.00015   '      ROUGHNESS FOR STEEL PIPE (FT)
9430 WALL=.5              'STARTING VALUE
9435 INPUT"SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? ",ODPIPE
9437 DOT$="N"
9438      'ITERATE TO FIND WALL THICKNESS
9440     IDPIPE=ODPIPE-(2*WALL)
9450     FLOWVEL=CUFOOT/(3.1416*((IDPIPE/12)^2)/4)
9455     IF FLOWVEL>25 THEN PRINT"***** ARE YOU SURE? (Y OR N)";:INPUT F$:IF F$="
N" THEN 9430
9460     REYNOLDS=FLOWVEL*(IDPIPE/12)/VISCOS
9465        'ITERATE TO FIND FRICTION FACTOR
9470        TEMP=FRICT
9480        FRICT=(2.51/(REYNOLDS*(SQR(FRICT))))+(KS/(3.7*(IDPIPE/12)))
9490        FRICT=(-2*(.4342945*LOG(FRICT)))^(-2)
9500        IF (ABS(TEMP-FRICT)) >.0001 THEN GOTO 9470
9530     HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDPIPE/12)*2*32.2)
9540     DELTP=HF*62.4*CRUDESG/144
9550     MAOP=DELTP+50      'ADD 50 PSI FOR STATION LOSSES ETC.
9555     IF DOT$="Y" THEN GOTO 9600               'WT SET BY OD/WT RATIO
9560     TEMP=WALL
9570     WALL=.5*MAOP*ODPIPE/(.72*YIELD*1000)
9580     IF (ABS(TEMP-WALL))>.001 THEN GOTO 9440
9585 IF (ODPIPE/WALL)<=48 THEN GOTO 9600      'CHECK OD/WT RATIO
9586 WALL=(ODPIPE/48):DOT$="Y":GOTO 9440   'ASSUMED MAX. OD/WT RATIO FOR ARCTIC

9600 WALL=(INT((WALL-.0001)*32)+1)/32
9625 IF DOT$="Y" THEN PRINT"   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/
WT RATIO OF 48.  **********"
9627 PRINT
9650 RETURN
```

CHAPTER 3 - CHUKPIPE USER'S MANUAL

3.3 SAMPLE RUN

```
LOAD"CHUKPIPE
Ok
RUN
*****************************************************************************
**                 INTEC ENGINEERING PROGRAM CHUKPIPE - (REV. 0)             **
**                  CHUKCHI SEA PIPELINE COST EVALUATION                     **
**      This program allows rapid cost estimate preparation for crude oil    **
**      pipelines in the Chukchi Sea and the evaluation of total offshore    **
**      and onshore Alaskan pipeline transportation costs.  It is intended   **
**      to be used only by Participants in the Chukchi Sea Transportation    **
**      Feasibility and Cost Evaluation Joint Industry Study - Phase 2.      **
**      Although the cost model used herein will allow rapid assessment of   **
**      the cost impact of various design, installation and trenching        **
**      options available, the user should inspect the results at the end    **
**      of each stage for validity.                                          **
*****************************************************************************
   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?   CHUKPIPE 1B-C

READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO            LINE   1010
READING SEG. LENGTHS IN EACH DEPTH & LAT. ZONE FOR ROUTE  1  ROUTLEN  1020-1040
READING NUMBER OF ONSHORE ROUTES IN SCENARIO                 ROUTLEN1  1050
READING ONSHORE ROUTE LENGTH FOR ROUTE  1                    ROUTLEN1 1050-1070
          PIPELINE LENGTH SUMMARY FOR SCENARIO CHUKPIPE 1B-C   (MILES)
                 LEG 1            LEG 2            TOTAL
 OFFSHORE        143              0                 143
 ONSHORE         309              0                 309

TOTAL PIPELINE LENGTH ALL ROUTES                     452
   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  N

READING UNIT COSTS FOR MATERIALS                    LINES  1100-1109
   INPUT PRODUCTION RATE (MBPD) ?   400

CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT
PIPELINE DESIGN OPTIONS INCLUDE:
                 PIPE OD (IN)       APPROX. MAOP (PSIG)
                    28                   2353
                    30                   1681
                    32                   1231
                    34                    922
                    36                    706
                    38                    550
                    40                    437
SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? 30
   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/WT RATIO OF 48.  **********

CALCULATING MATERIAL QUANTITIES
                  OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO CHUKPIPE 1B-C
                    PIPE DIAMETER                 30.000    IN
                    PIPE WALL THICKNESS            0.625    IN
                    PIPE STEEL GRADE              65.0      KSI
                    PIPELINE MAOP               1704.1      PSIG
                    CASING DIA. (WHERE REQD)     36.000     IN
                    CASING WALL                    0.375    IN
                    CONCRETE THICKNESS             2.025    NON-INSULATED
                    CONCRETE THICKNESS             3.250    INSULATED PIPE
```

ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N)? N

MATERIAL COST SUMMARY FOR OFFSHORE LEG 1 SCENARIO CHUKPIPE 1B-C
(ALL COSTS IN 1986 $ MILLIONS)

ITEM	DEPTH<20 FT	DEPTH>20 FT	TOTAL
LINE PIPE	0.4	56.1	56.5
CASING PIPE	0.3	0.0	0.3
CORROSION COAT	0.0	3.5	3.6
CONCRETE COAT	0.2	30.2	30.4
ANODES	0.0	0.5	0.5
INSULATION	0.0	0.0	0.0
BULKHEADS	0.1	0.0	0.1
SUBTOTAL - LEG 1			91.3

TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES 91.3
LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/TON = 44
REPEAT DESIGN AND COST SUMMARY (Y OR N)?N
****
BEGIN PIPELINE TRENCHING EVALUATION
READING TRENCH DEPTH PARAMETERS A & B LINES 1200-1204
READING COST, PRODUCTIVITY FACTORS FOR TRENCHING LINES 1300-1330
INPUT RISK OF ICE KEEL DAMAGE FOR ENTIRE PIPELINE ONCE IN 10 YEARS (%) ? 1
INPUT -CAN SOIL STRATA BE CONSIDERED TO CONSIST OF 6-8 FT OF LOOSE
MATERIAL OVERLYING STIFF, SCOUR-RESISTANT MATERIAL (Y OR N) ? Y
*** NOTE THIS ASSUMPTION WILL REDUCE REQUIRED TRENCH DEPTH IN WATER ***
*** DEPTHS OF 20-190 FT

OFFSHORE PIPELINE LEG 1 SCENARIO CHUKPIPE 1B-C

DEPTH (FEET)	<69°N	69-70°N	70-71°N	71-72°N	72-73°N
<20	0.	0.	10	0.	0.
20-190	0.	0.	11	11	0.
>190	0.	0.	0.	0.	0.

RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)? N
INPUT LENGTH OF ROUTE WHICH IS IN DEPTH RANGE=165 TO 190 ON LEG 1 ? 0
************** OFFSHORE PIPELINE LEG 1 SCENARIO CHUKPIPE 1B-C ****

FEASIBLE EQPT FOR OBTAINING 10.0 FT TRENCH IN WATER DEPTH OF 0-20 FT:
0-THROUGH-ICE TRENCH/LAY
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
6-MULTI-PASS PLOW
ENTER YOUR CHOICE (BY NUMBER)1

FEASIBLE EQPT FOR OBTAINING 10.5 FT TRENCH IN WATER DEPTH OF 20-165 FT:
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
3-LINEAR DREDGE
9-TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS ONLY)
ENTER YOUR CHOICE (BY NUMBER)9
********** EQUIPMENT SUMMARY LEG 1 SCENARIO CHUKPIPE 1B-C ****

CUTTER SUCTION DREDGE - 1.8WEEKS
TRAILING SUCTION HOPPER DREDGE- 51.1WEEKS
MULTI-PASS PLOW - 11.2WEEKS
RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? N
****

```
COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG  1
CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED
   INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG? 3
   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)A
COMPUTED MARINE CONST. SEASON LENGTH ALONG ROUTE LEG  1  =  10  WEEKS
   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  N

********** TRENCHING COST RESULTS FOR LEG  1  SCENARIO CHUKPIPE 1B-C ****
CUTTER SUCTION DREDGE (PROJECT PEAK= 1 )  1 EQPMNT-SEASON(S)=              39.9
TRAILING SUCTION HOPPER DREDGE(PROJECT PEAK= 2 )  6 EQPMNT-SEASON(S)=    170.2
MULTI-PASS PLOW (PROJECT PEAK= 1 )  2 EQPMNT-SEASON(S)=                    28.0
   TOTAL TRENCHING COST FOR LEG  1 =                                       238.1

   RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS? (Y OR N)N
******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS  *********

READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION        1400-1470

FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF 143.0
1-CONVENTIONAL LAYBARGE
2-3RD GENERATION LAYBARGE
3-ARCTIC LAYBARGE
       ENTER YOUR CHOICE (BY NUMBER)2
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO CHUKPIPE 1B-C ****

3RD GENERATION LAYBARGE-
     RE-RUN INSTALLATION EQUIPMENT SELECTION ?(Y OR N) N      16.5WEEKS
*****************************************************************************
COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG  1
CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED
   INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG 2
   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)A
COMPUTED MARINE CONST. SEASON ALONG ROUTE LEG  1  =  10  WEEKS
   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  N

********INSTALLATION COST RESULTS FOR LEG  1  SCENARIO CHUKPIPE 1B-C ****
3RD GENERATION LAYBARGE(PROJECT PEAK= 1 )  2 EQPMNT-SEASON(S)=          154.5
  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)N
READING PUMP AND PRODUCTION TERMINAL COSTS          1500-1520
CALCULATING PUMP STATION AND TERMINAL COSTS
READING ONSHORE PIPELINE COST FACTORS               1550
****************** CAPITAL COST SUMMARY - SCENARIO CHUKPIPE 1B-C  *******
                          (1986 MILLIONS OF $)

OFFSHORE PIPELINE (CHUKCHI SEA)
   MATERIALS                                                  91.3
   MATERIALS LOGISTICS                                        44.1
   TRENCHING                                                 238.1
   INSTALLATION, TIE-INS/ SHORE CROSSINGS                    154.5
   PUMP STATION(S)                                            18.0
  PROJECT SERVICES (15%) :                                    81.9
  CONTINGENCY (25%):                                         157.0
     TOTAL OFFSHORE PIPELINE CAPITAL COSTS:                        784.9

ONSHORE PIPELINE COSTS
                                                            1637.7
```

```
PRODUCTION STRUCTURE COSTS:
                                                                        482.0

    TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE              2904.6
  RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? N
CALCULATING OPERATING COSTS
   DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? Y
   LIFE OF PIPELINE SYSTEM (YEARS)? 20
   INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  10

       PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYSTEM
                             YEAR (SCENARIO CHUKPIPE 1B-C )
 ACCOUNT     1     3     5     7     9    11    13    15    17    19

OFFSHORE PL 16    13    11     9     7     6     5     4     3     3
ONSHORE PL  57    47    39    32    27    22    18    15    12    10
TAPS TARIFF438   362   299   247   204   169   140   115    95    79

  NET PRESENT VALUE OF OPERATING COSTS =  4785.6
  TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)=  7690.268  MILLION $
  RE-RUN OPERATING COST CALCULATION (Y OR N)  ? N
**************  END OF INTEC ENGINEERING PROGRAM CHUKPIPE  *******************
Ok
```

CHAPTER 3
CHUKPIPE USER'S MANUAL

3.1 PROGRAM INPUT/OUTPUT GUIDE

The computer program CHUKPIPE evaluates Chukchi Sea crude oil pipeline system costs. Program input and output are describe chronologically in the following paragraphs. The sample run described in this chapter has one offshore pipeline leg. Program trenching and installation sections repeat if there is a second offshore leg.

A printed record of all or part of the run can be made by using the "PRINT SCREEN" key while running the program. The program must be run with "Caps Lock" (Capitalization) on.

Load and Run Program

Enter BASIC interpreter. Execute LOAD and RUN commands. Program will output program title and application statement.

Scenario Designation

Program prompt: INPUT ALPHANUMERIC SCENARIO DESIGNATION?

User inputs desired alphanumeric title for run.

Pipeline Length

Program reads route length data and prints a summary. If there are an incorrect number of data points, the program will list the appropriate data statements and stop.

Program prompt: DOES LENGTH DATA SET REQUIRE MODIFICATION (Y or N)?

User inputs "N" if the length data are correct or "Y" if they require modification. If Y is input, the appropriate data statements are listed (lines 1010 to 1070) and the program stops. Modify the length data as indicated by the remark statements using the BASIC file editor and re-run program. If user wants to permanently alter the data statements, use the SAVE command.

Production Rate

Program prompt: INPUT PRODUCTION RATE (MBPD)?

User inputs crude oil throughput rate in thousands of barrels per day. Program will give an opportunity to repeat this step if a low production rate is input.

Pipeline Design

Program lists feasible pipeline design options in terms of pipe outside diameter and approximate Maximum Allowable Operating Pressure (MAOP). These are selected by the program on the basis of flow velocity and pressure drop. Crude oil specific gravity, viscosity and pipe yield strength are contained on lines 1119 to 1150. Values can be modified using the BASIC editor.

Program prompt: SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)?

User inputs pipeline outside diameter. Program will give an opportunity to repeat this step if a small diameter is input.

Program notes if pipe wall thickness is set by an assumed maximum outside diameter/wall thickness ratio of 48 (lines 9585 and 9586).

Program prints pipeline design summary. If the computed MAOP exceeds the desired value, the user has an opportunity to repeat the design section following the materials cost summary.

Pipeline Insulation

Program prompt: ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N)?

User inputs "Y" for yes or "N" for no. All pipelines are assumed to be insulated in water depths less than 20 feet. If neither is input, the question is repeated.

Materials Cost Summary

Program prints materials and materials logistics cost summary.

Program prompt: REPEAT DESIGN AND COST SUMMARY (Y OR N)?

User inputs "Y" to repeat the offshore pipeline design and cost summary; "N" to continue the run.

Trenching Requirements

Program reads trench depth parameters and trenching cost/productivity factors.

Program prompt: INPUT RISK OF ICE KEEL DAMAGE FOR ENTIRE PIPELINE ONCE IN 10 YEARS (%)?

User inputs risk for pipeline leg under investigation (1 percent suggested).

Program prompt: INPUT - CAN SOIL STRATA BE CONSIDERED TO CONSIST OF 6-8 FT OF LOOSE MATERIAL OVERLYING STIFF, SCOUR-RESISTANT MATERIAL (Y OR N)?

User inputs "Y" for yes (effects noted in program output) or "N" for no. See Transportation Study report Chapter 6 for further explanation.

Program prints trench depth summary.

Program prompt: RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)?

User inputs "Y" to repeat trench depth analysis.

Water Depth Profile

Program prompt: INPUT LENGTH OF ROUTE WHICH IS IN DEPTH RANGE = 165 TO 190 ON LEG 1?

User inputs length of offshore pipeline route leg 1 (leg 2 if the second leg of a 2-leg case is being analyzed) in statute miles between 165 and 190 ft water depths. This is necessary because of the maximum dredging depth for some trenching equipment.

Trenching Equipment Selection

Program prompt: FEASIBLE EQPT FOR OBTAINING XX.X FT TRENCH IN WATER DEPTH OF YY-YY FT:

0 - THROUGH-ICE TRENCH/LAY
1 - CUTTER SUCTION DREDGE
2 - CUTTER SUCTION DREDGE W/DOUBLE SWING WIRES
3 - LINEAR DREDGE
4 - TRAILING SUCTION HOPPER DREDGE
5 - SINGLE PASS PLOW
6 - MULTI-PASS PLOW
7 - MECHANICAL TRENCHER
8 - CONVENTIONAL HIGH PRESSURE JETTING
9 - TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS ONLY)

ENTER YOUR CHOICE (BY NUMBER)

Where:

XX.X = pipeline trench depth (original seabed to bottom of trench); and
YY-YY = water depth range.

Only equipment types feasible for the specified combination of trench depth and water depth are prompted.

User inputs "0" through "9" to select the corresponding equipment type and the program then prompts for the next water depth range. The user should confine the equipment selection to the options listed by the program.

Soil Type

If the trench depths are not based on a loose soil layer overlaying a hard soil layer, the program will prompt:

INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C = CLAY S = SAND)?

User inputs "C" if the soil is clay or "S" if the soil is sand. If neither is input, the question repeats.

Trenching Spread Times

The program calculates the required operating time for each trenching spread selected and prints a summary.

Program prompt: RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N)?

User inputs "Y" to re-run trenching equipment selection.

Number of Trenching Seasons

Program prompt: INPUT MAX. NO OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG?

User inputs the maximum number of seasons devoted to trenching.

Ice Condition

Program prompt: INPUT MAX. ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)

User inputs "A", "B" or "C" for ice conditions defined in Transportation Study report Table 6.3. If neither A, B or C is input, the question repeats.

Construction Season Duration

The program calculates the average construction season duration along pipeline route leg and prints results.

Program prompt: DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N)?

User inputs "N" to use the program's calculated season duration or "Y" to input the season duration based on site specific data. If this question is answered with Y, the program will prompt for the season duration input.

Trenching Cost Summary

The program calculates the cost for each trenching spread and total trenching cost, and prints the results. For each trenching equipment type selected, the project peak number of spreads and total equipment spread-seasons are printed. This information is helpful to the user in evaluating the equipment/ice condition selection.

Program prompt: RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS (Y OR N)?

User inputs "Y" to repeat ice coverage definition or "N" to continue run.

Installation Equipment Selection

The program reads installation equipment cost and productivity factors.

Program prompt: FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF LL

1 - CONVENTIONAL LAYBARGE
2 - 3RD GENERATION LAYBARGE
3 - ARCTIC LAYBARGE
4 - BOTTOM TOW
5 - BOTTOM PULL

ENTER YOUR CHOICE (BY NUMBER)

Where:

LL = offshore pipeline length to be installed in statute miles

Only equipment types considered feasible for the specified pipeline length are prompted.

User inputs "1" through "5" to select the corresponding installation equipment type.

Installation Spread Time

The program calculates the required operating time for the selected installation spread and prints a summary.

Program prompt: RE-RUN INSTALLATION EQUIPMENT SELECTION (Y OR N)?

User inputs "Y" to re-run installation equipment selection.

Number of Installation Seasons

Program prompt: INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG

User inputs the maximum number of seasons devoted to installation.

Ice Condition

Program prompt: INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)

User inputs "A", "B", or "C" for corresponding ice condition.

Construction Season Duration

Program calculates average installation construction season duration. If desired, user can input season duration as described for pipeline trenching.

Installation Cost Summary

The program calculates the pipeline installation cost using the selected installation equipment type and prints the results. The project peak number of installation equipment spreads and total equipment spread-seasons are output.

Program prompt: RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)?

User inputs "Y" to repeat ice coverage definition and cost results or "N" to continue run.

Capital Cost Summary

The program calculates offshore pipeline pump station, production structure and overland pipeline capital costs and prints the total cost summary.

Program prompt: RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N)?

User inputs "Y" to repeat cost summary table or "N" to continue run.

TAPS Usage

Program prompt: DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N)?

User inputs "Y" if the pipeline scenario under consideration uses the Trans Alaska Pipeline System or "N" if it does not. The TAPS tariff is taken as $3.00 per barrel of throughput (line 5950).

Pipeline System Life

Program prompt: LIFE OF PIPELINE SYSTEM (YEARS)?

User inputs pipeline system operating life in years. This is used for calculating the total present worth of pipeline system operating costs.

Interest Rate

Program prompt: INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS?

User inputs interest rate in percent used for operating cost present worth calculations.

Pipeline System Operating Costs

The program calculates the offshore and onshore pipeline operating costs and the TAPS tariff (if any) for years 1 through the specified pipeline system operating life. The present worth of these costs are calculated for each year and the results are printed for every other year. The total operating cost present worth for all years is calculated and printed.

Total Pipeline System Present Worth Cost

The program adds the total pipeline system operating cost present worth and the total capital cost and prints the result.

Program prompt: RE-RUN OPERATING COST CALCULATION (Y OR N)?

User inputs "Y" to re-run the operating cost calculations or "N" to end the run.

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3.2 PROGRAM LISTING

```
10 PRINT"***********************************************************************
********"
20 PRINT"**                    INTEC ENGINEERING PROGRAM CHUKPIPE - (REV. 0)
     **"
30 PRINT "**                    CHUKCHI SEA PIPELINE COST EVALUATION
     **"
31 PRINT "**     This program allows rapid cost estimate preparation for crude o
il      **"
32 PRINT "**     pipelines in the Chukchi Sea and the evaluation of total offsho
re      **"
33 PRINT "**     and onshore Alaskan pipeline transportation costs.  It is inten
ded     **"
34 PRINT "**     to be used only by Participants in the Chukchi Sea Transportati
on      **"
35 PRINT "**     Feasibility and Cost Evaluation Joint Industry Study - Phase 2.
        **"
36 PRINT "**     Although the cost model used herein will allow rapid assessment
 of     **"
37 PRINT "**     the cost impact of various design, installation and trenching
        **"
38 PRINT "**     options available, the user should inspect the results at the e
nd      **"
39 PRINT "**     of each stage for validity.
        **"
40 PRINT "**********************************************************************
*********"
41 '   REVISED OCTOBER 21, 1986
42 '   INTEC ENGINEERING, INC. 16801 GREENSPOINT PARK DRIVE, SUITE 105, HOUSTON,
       TEXAS 77060.
43 '   REMARKS 1) SEE PROGRAM DOCUMENTATION
               2) TAPS TARIFF =$3/BBL.
44 '           3) PIPELINE DESIGN BASED ON CRUDE PROPERTIES AND PRESSURE DROP ON
                  LONGEST OFFSHORE PIPELINE SEGMENT.
60 DIM ROUTLEN(2,3,4):REM LENGTH OF OFFSHORE PIPELINES (2 LEGS,3 DEPTHS,4 LATITU
DES)
65 DIM ETTIME(2,9):REM ELAPSED TIME FOR TRENCHING EQUIPMENT
67 DIM TRENCHYRS(2,8):REM NO. OF YEARS FOR EACH TYPE OF EQPT
68 DIM TRENCOST(2,8):REM NET COST FOR EACH TRENCHING EQUIPMENT
70 DIM MAXTREN(2,4):REM MAXIMUM TRENCH DEPTH (2 LEGS, 4 LATITUDES)
80 INPUT"   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?   ",S$
105 PRINT
110 PRINT"READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO          LINE   1
010"
120 READ NOFROUT:REM NUMBER OF OFFSHORE LEGS IN POUTE
130 IF NOFROUT>2 THEN PRINT"******** A MAXIMUM OF 2 OFFSHORE ROUTES PERMITTED, R
EDEFINE AND RE-RUN PROGRAM":STOP
135    FOR I =1 TO NOFROUT
140 PRINT"READING SEG. LENGTHS IN EACH DEPTH & LAT. ZONE FOR ROUTE ";I;" ROUTLEN
  1020-1040"
150        FOR J=1 TO 3:REM READ LENGTH IN EACH WATER DEPTH
155           FOR K=0 TO 4:REM READ LENGTH IN EACH LATITUDE ZONE
160           READ ROUTLEN(I,J,K)
162           NETLEN(I)=NETLEN(I)+ROUTLEN(I,J,K):REM NET LENGTH OF EACH LEG
165           NEXT K
170        NEXT J
175    NEXT I
```

```
177 IF NOFROUT=1 THEN RESTORE 1040
180 REM READ TESTDATA TO CHECK DATA
185 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN OFFS
HORE ROUTE DATA, CHECK LINES 1010-1040 AND RE-RUN PROGRAM":LIST 1010-1040:STOP
200 PRINT "READING NUMBER OF ONSHORE ROUTES IN SCENARIO                     ROUTLEN1
 1050"
210 READ NONROUT:REM NUMBER OF ONSHORE ROUTE LEGS  IN SCENARIO
230 IF NONROUT>2 THEN PRINT"******** A MAXIMUM OF 2 ONSHORE ROUTES PERMITTED, RE
DEFINE AND RE-RUN PROGRAM":STOP
232 IF NONROUT=0 THEN RESTORE 1080:GOTO 280
235     FOR I =1 TO NONROUT
240 PRINT"READING ONSHORE ROUTE LENGTH FOR ROUTE ";I;"                      ROUTLEN
1 1050-1070"
250     READ ROUTLEN1(I):REM LENGTH OF ONSHORE ROUTE
275     NEXT I
277 IF NONROUT=1 THEN RESTORE 1080
280 REM READ TESTDAT TO CHECK DATA
290 READ TESTDAT
292 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN ONSHORE ROUTE DAT
A, CHECK AND RE-RUN PROGRAM":STOP
300 REM CALC. TOTAL LENGTH OF EACH OFFSHORE ROUTE AND TOTAL PIPELINE LENGTH
305     FOR I=1 TO NOFROUT
307     TOTLEN=TOTLEN+NETLEN(I)
309     NEXT I
310     FOR I=1 TO NONROUT
312     TOTLEN=TOTLEN+ROUTLEN1(I)
315     NEXT I
320 PRINT"              PIPELINE LENGTH SUMMARY FOR SCENARIO ";S$;"   (MILES)"
324 PRINT"                     LEG 1          LEG 2          TOTAL"
326 PRINT" OFFSHORE";TAB(17);NETLEN(1);TAB(32);NETLEN(2);TAB(49);NETLEN(1)+NETLE
N(2)
328 PRINT" ONSHORE";TAB(17);ROUTLEN1(1);TAB(32);ROUTLEN1(2);TAB(49);ROUTLEN1(1)+
ROUTLEN1(2)
330 PRINT:PRINT"TOTAL PIPELINE LENGTH ALL ROUTES ";TAB(49);TOTLEN
335 INPUT"   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  ",A$
340 IF A$="Y" THEN PRINT"******* CORRECT ROUTE DATA SET (LINES 1010-1070) AND RE
-RUN PROGRAM":LIST 1010-1070:STOP
342 PRINT:PRINT"READING UNIT COSTS FOR MATERIALS                    LINES  1100-110
9
343   FOR I=1 TO 5:READ UCOST(I):NEXT I
344 READ TESTDAT
345 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN UNIT COST DATA LINES 1
100-1108:LIST 1100-1108
350 REM COMPUTE LONGEST OFFSHORE SEGMENT FOR DIAMETER SIZING
355 LONGEST=NETLEN(1):IF NETLEN(2)>LONGEST THEN LONGEST = NETLEN(2)
360 INPUT "   INPUT PRODUCTION RATE (MBPD) ?   ",PRODUCT
375 IF (PRODUCT<25)+(PRODUCT>800) THEN PRINT"**** ARE YOUR SURE? (Y OR N)";:INPU
T A$:IF A$="N" THEN 360
380 CUFOOT=PRODUCT*1000*6.498E-05:REM CONVERT PRODUCTION TO CUBIC FT. PER SEC.
400 REM BEGIN PIPE SIZING
402 DIM IDVAL(26)     'POSSIBLE RANGE OF PIPE INSIDE DIAMETERS
403 DIM ODVAL(26)
404 REM READ PIPE DESIGN DATA
405 READ CRUDESG:REM READ CRUDE SPECIFIC GRAVITY
410 READ VISCOS:REM CRUDE VISCOSITY
415 READ YIELD:REM PIPE SPECIFIED MINIMUM YIELD STRESS
```

```
417 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN PIPE
 DESIGN DATA, CHECK AND RE-RUN PROGRAM":LIST 1119-1150:STOP
418 PRINT:PRINT"CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT"
420 GOSUB 9000          ' GO TO PIPELINE SIZING SUBROUTINE
480 PRINT "CALCULATING MATERIAL QUANTITIES"
482 REM CALCULATE LINE PIPE TONNAGE
484 WPF=2.68*(ODPIPE^2-(ODPIPE-2*WALL)^2)
486 REM IF PIPE IS INSULATED MATERIALS COSTS ARE BASED ON A PIPE IN A PIPE
487 REM CASING WALL THICKNESS OF .375 IN ASSUMED
488 WPFI=2.68*((ODPIPE+6)^2-(ODPIPE+6-2*.375)^2)
492 REM CALCULATE SURFACE AREA OF LINE PIPE
494 SFCLP=3.14*ODPIPE/12:REM SQ. FT. PER LINEAL FT.
496 SFCCP=3.14*(ODPIPE+6)/12:REM SURFACE AREA OF CASING PIPE
500 REM DETERMINE CONCRETE THICKNESS
502 REM CONCRETE TH. IS DETERMINED BASED ON A SPGR OF 1.15 EMPTY
504 TEMP=SQR((WPF+WPFI-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI
=(TEMP-(ODPIPE+6))/2
506 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
508 CONCRETI=.00545*190*((ODPIPE+6+2*CONCTHI)^2-(ODPIPE+6)^2):REM INSULATED PIPE
 CONCRETE WEIGHT PER FOOT
510 CONCRET=.00545*190*((ODPIPE+2*CONCTH)^2-(ODPIPE)^2):REM  PIPE CONCRETE WEIGH
T PER FOOT
512 REM CALC ZINC ANODE REQUIREMENTS BASED ON 350 AMP-HRS/LB, 10% HOLIDAY AND 6
MA/SQ FT FOR BURIED PIPELINES AND 20 YEAR LIFE
514 ANODEI=.05*SFCCP*.002*20*365*24/350:REM ANODE WEIGHT PER FOOT FOR INSULATED
515 TEMP=SQR((WPF-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI=(TEM
P-(ODPIPE+6))/2
516 ANODE=.05*SFCLP*.002*20*365*24/350:REM ANODE WT/FT FOR NON-INSULATED LINES
517 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
518 REM CALC INSULATION VOLUME IF REQUIRED
520 INSVOL=.00545*((ODPIPE+6)^2-ODPIPE^2)
525 PRINT"                         OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO ";S$
526 PRINT"                             PIPE DIAMETER ";TAB(49);:PRINT USING "##.###";OD
PIPE;:PRINT"   IN"
527 PRINT"                             PIPE WALL THICKNESS ";TAB(49);:PRINT USING "##.#
##";WALL;:PRINT"   IN"
528 PRINT"                             PIPE STEEL GRADE ";TAB(49);:PRINT USING "##.#";Y
IELD;:PRINT"     KSI"
529 PRINT"                             PIPELINE MAOP ";TAB(47);:PRINT USING "####.#";MA
OP;:PRINT"     PSIG"
530 PRINT"                             CASING DIA. (WHERE REQD) ";TAB(49);:PRINT USING
"##.###";ODPIPE+6;:PRINT "   IN"
531 PRINT"                             CASING WALL                    0.375   IN"
 "
540 PRINT"                             CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTH;:PRINT "   NON-INSULATED"
541 PRINT"                             CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTHI;:PRINT "   INSULATED PIPE"
550 REM COMPUTE NET MATERIALS COSTS
552 INPUT"     ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N
)? ",I$:IF (I$="Y")+(I$="N")=0 THEN GOTO 552
554     FOR I=1 TO NOFROUT
555     LESHOR(I)=0
556         FOR J= 0 TO 4
```

```
558        LESHOR(I)=LESHOR(I)+ROUTLEN(I,1,J)
560        NEXT J
562     NEXT I
564     FOR I=1 TO NOFROUT
566     LEDEEP(I)=NETLEN(I)-LESHOR(I)
567     NEXT I
570 REM COMPUTE MATERIALS COST FOR NEARSHORE LENGTH ASSUMING THIS SECTION IS INS
ULATED
571 REM MATERIALS UNIT COST DATA FROM LINES 1100-1109
572     FOR I=1 TO NOFROUT
574     PRINT:PRINT"          MATERIAL COST SUMMARY FOR OFFSHORE LEG ";I;" SCENARIO
 ";S$
576     PRINT"                          (ALL COSTS IN 1986 $ MILLIONS) "
577     PRINT"  ITEM                     DEPTH<20 FT       DEPTH>20 FT       TOTAL"
579     TCOST=0
580     TEMP1=WPF*UCOST(1)*LESHOR(I)*5280:TEMP2=WPF*UCOST(1)*LEDEEP(I)*5280:LPCST
(I)=TEMP1+TEMP2
582 PRINT"LINE PIPE";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!;TEMP
2/1000000!;LPCST(I)/1000000!:TCOST=TCOST+LPCST(I)
584     TEMP1=WPFI*UCOST(1)*LESHOR(I)*5280:TEMP2=-WPFI*UCOST(1)*LEDEEP(I)*5280*(I
$="Y"):CPCST(I)=TEMP1+TEMP2
586 PRINT"CASING PIPE";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!;TE
MP2/1000000!;CPCST(I)/1000000!:TCOST=TCOST+CPCST(I)
588     TEMP1=(SFCLP+SCFCP)*UCOST(2)*LESHOR(I)*5280:TEMP2= (SFCLP-SFCCP*(I$="Y"))
*UCOST(2)*LEDEEP(I)*5280:CORCST(I)=TEMP1+TEMP2
590 PRINT"CORROSION COAT";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!
;TEMP2/1000000!;CORCST(I)/1000000!:TCOST=TCOST+CORCST(I)
592     TEMP1=(CONCRETI)*UCOST(3)*LESHOR(I)*5280:TEMP2= (CONCRET)*UCOST(3)*LEDEEP
(I)*5280:IF I$="Y" THEN TEMP2=TEMP2*(CONCRETI/CONCRET)
593 CONCST(I)=TEMP1+TEMP2
594 PRINT"CONCRETE COAT";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!;
TEMP2/1000000!;CONCST(I)/1000000!:TCOST=TCOST+CONCST(I)
596     TEMP1=(ANODEI)*UCOST(4)*LESHOR(I)*5280:TEMP2= (ANODE)*UCOST(4)*LEDEEP(I)*
5280:IF I$="Y" THEN TEMP2=TEMP2*(ANODEI/ANODE)
598 ANCST(I)=TEMP1+TEMP2
600 PRINT"ANODES      ";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!;TEM
P2/1000000!;ANCST(I)/1000000!:TCOST=TCOST+ANCST(I)
602     TEMP1=INSVOL*UCOST(5)*LESHOR(I)*5280:TEMP2= -INSVOL*UCOST(5)*LEDEEP(I)*52
80*(I$="Y"):INSCST(I)=TEMP1+TEMP2
604 PRINT"INSULATION   ";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!;
TEMP2/1000000!;INSCST(I)/1000000!:TCOST=TCOST+INSCST(I)
606 REM CALC COST FOR ANNULAR BULKHEADS AND SPACERS
607     TEMP1=((400+22.8*ODPIPE)/80)*LESHOR(I)*5280:TEMP2= 0:IF I$="Y" THEN TEMP2
=((400+22.8*ODPIPE)/80)*LEDEEP(I)*5280
608 BKDCST(I)=TEMP1+TEMP2
609 PRINT"BULKHEADS    ";TAB(20);:PRINT USING "###.#              ";TEMP1/1000000!;
TEMP2/1000000!;BKDCST(I)/1000000!:TCOST=TCOST+BKDCST(I)
620 PRINT TAB(15);:PRINT "SUBTOTAL - LEG ";I;:PRINT TAB(55);:PRINT USING"####.#
 ";TCOST/1000000!
621 TCOST(I)=TCOST
622 NEXT I
630 PRINT"   TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES              ";:PRINT US
ING"####.# ";(TCOST(1)+TCOST(2))/1000000!
660 REM COMPUTE NET LOGISTICS COST FOR OFFSHORE PIPELINE BASED ON $250/TON
662 TEMP=(LPCST(1)+LPCST(2))/UCOST(1)+(CPCST(1)+CPCST(2))/UCOST(1)
664 TEMP=TEMP+(CONCST(1)+CONCST(2))/UCOST(3)
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666 TEMP=TEMP+(ANCST(1)+ANCST(2))/UCOST(4)
668 NETWT=TEMP/2000:REM NET OFFSHORE MATERIALS WEIGHT (TONS)
669 LOGCST=250*NETWT:PRINT"LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/T
ON =   ";INT(LOGCST/1000000!)
670 INPUT"    REPEAT DESIGN AND COST SUMMARY (Y OR N)?",A$:IF A$="Y" THEN 418
680 PRINT"*****************************************************************
*********"
690 PRINT"BEGIN PIPELINE TRENCHING EVALUATION"
700 REM CALC. TRENCHING REQUIREMENTS FOR OFFSHORE LINES
705 PRINT"READING TRENCH DEPTH PARAMETERS A & B                    LINES 1200-1204"
710 FOR I=1 TO 4:READ TRENA(I):NEXT I
712 FOR I=1 TO 4:READ TRENB(I):NEXT I
714 PRINT "READING COST, PRODUCTIVITY FACTORS FOR TRENCHING     LINES 1300-1330"

715     FOR L=0 TO 8
716     READ C1A(L),C1B(L),C1C(L),C2(L),C3(L),V1(L),V2A(L),V2B(L),V2C(L),W(L),CLA
Y(L),SAND(L),WAVE(L),MECH(L),P1(L),P2(L):NEXT L
717 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN TRENCHING
 FACTORS DATA SET- LINES 1314-1330. CHECK AND RE-RUN":LIST 1310-1330:STOP
719     FOR I= 1 TO NOFROUT
720  INPUT"     INPUT RISK OF ICE KEEL DAMAGE FOR ENTIRE PIPELINE ONCE IN 10 YEA
RS (%) ? ",PROB
722 PROB=PROB/100
726         FOR K= 1 TO 4
727         TEMP=(ROUTLEN(I,1,K)+ROUTLEN(I,2,K))*(8/5):IF TEMP=0 THEN 736
729         PROB(K)=PROB*(ROUTLEN(I,1,K)+ROUTLEN(I,2,K))/(NETLEN(I)-ROUTLEN(I,3,1)
-ROUTLEN(I,3,2)-ROUTLEN(I,3,3)-ROUTLEN(I,3,4)-ROUTLEN(I,1,0)-ROUTLEN(I,2,0)-ROUT
LEN(I,3,0)):REM ADJUST PROB TO EACH ZONE BY LENGTH RATIOS
730         TEMP=1-(1-PROB(K))^(1/TEMP)
732         COVER(I,K)=TRENB(K)+LOG(TEMP)/(-TRENA(K))
734         COVER(I,K)=COVER(I,K)*3.281:REM CONVERT TO FT OF DEPTH
735         IF COVER(I,K)>19 THEN COVER(I,K)=19:REM LIMIT MAX. COVER DEPTH
736         NEXT K
739 PRINT"     INPUT -CAN SOIL STRATA BE CONSIDERED TO CONSIST OF 6-8 FT OF LOOS
E ":PRINT"     MATERIAL OVERLYING STIFF, SCOUR-RESISTANT MATERIAL (Y OR N) ";:IN
PUT STRATA$:IF (STRATA$="Y")+(STRATA$="N")=0 THEN 739
740 IF STRATA$="Y" THEN PRINT" ***  NOTE THIS ASSUMPTION WILL REDUCE REQUIRED TR
ENCH DEPTH IN WATER ***":PRINT " ***  DEPTHS OF 20-190 FT"
741 PRINT
742 REM PRINT "                TRENCH DEPTH REQUIREMENTS FOR EACH LEG"
750    COVER(I,0)=4:REM SET MINIMUM DEPTH OF COVER SOUTH OF 69 DEG LAT
752        FOR J=1 TO 3
755        FOR K=0 TO 4
760        TRENDEP(I,J,K)=-(J<3)*COVER(I,K)+ODPIPE/12
762 IF J=3 THEN TRENDEP(I,J,K)=6:REM DEFINE 6 FT TRENCH IN DEPTH>190
765        NEXT K
770        NEXT J
779    PRINT"                    OFFSHORE PIPELINE LEG ";I;"  SCENARIO ";S$
780    PRINT" DEPTH   <69°N  69-70°N   70-71°N   71-72°N   72-73°N"
782    PRINT" (FEET)"
783    FOR J=1 TO 3
784        FOR K=0 TO 4:IF (J=1)*(TRENDEP(I,J,K)>10)=1 THEN TRENDEP(I,J,K)=10:REM
 CUTOFF TRENCH AT 10 FT. IN SHALLOW WATER
785        NEXT K
786    IF J=1 THEN PRINT"   <20 ";TAB(10);:FOR K=0 TO 4:TRENDEP(I,J,K)=TRENDEP(I
,J,K)*(-(ROUTLEN(I,J,K)>0)):PRINT USING "##.       ";TRENDEP(I,J,K);:NEXT K
```

```
788     IF J=2 THEN PRINT"20-190";TAB(10);:FOR K=0 TO 4:TRENDEP(I,J,K)=TRENDEP(I,
J,K)*(-(ROUTLEN(I,J,K)>0)):IF STRATA$="Y" THEN TRENDEP(I,J,K)=(8+ODPIPE/12)*(-(R
OUTLEN(I,J,K)>0))
789 IF J=2 THEN PRINT USING"##.        ";TRENDEP(I,J,K);:NEXT K
790     IF J=3 THEN PRINT"  >190";TAB(10);:FOR K=0 TO 4:TRENDEP(I,J,K)=TRENDEP(I,
J,K)*(-(ROUTLEN(I,J,K)>0)):PRINT USING "##.        ";TRENDEP(I,J,K);:NEXT K
792     PRINT:NEXT J
796 INPUT"RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)? ",A$:IF A$="Y" THEN 720
800 REM
810 TR$(0)="THROUGH-ICE TRENCH/LAY"
820 TR$(1)="CUTTER SUCTION DREDGE "
821 TR$(2)="CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES"
822 TR$(3)="LINEAR DREDGE"
823 TR$(4)="TRAILING SUCTION HOPPER DREDGE"
824 TR$(5)="SINGLE PASS PLOW "
826 TR$(6)="MULTI-PASS PLOW "
827 TR$(7)="MECHANICAL TRENCHER"
828 TR$(8)="CONVENTIONAL HIGH PRESSURE JETTING"
829 TR$(9)="TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS O
NLY)"
830 REM BEGIN INVESTIGATION INTO BEST TRENCHING METHOD
833   LGT190(I)=0 :REM DEFINE THE PORTION OF THE ROUTE IN DEPTH >190
834      FOR K=0 TO 4:LGT190(I)=LGT190(I)+ROUTLEN(I,3,K):NEXT K
836   REM DEFINE MAXIMUM TRENCH DEPTH ALONG LEG I IN EACH WATER DEPTH ZONE
837   TEMP=0
838      FOR K=0 TO 4
840      IF TEMP<TRENDEP(I,1,K) THEN TEMP=TRENDEP(I,1,K)
842      NEXT K
844   MAXTREN(I,1)=TEMP
846   TEMP=0
848      FOR K=0 TO 4
850      IF TEMP<TRENDEP(I,2,K) THEN TEMP=TRENDEP(I,2,K)
852      NEXT K
854   MAXTREN(I,2)=TEMP
856   TEMP=0
858      FOR K=0 TO 4
860      IF TEMP<TRENDEP(I,3,K) THEN TEMP=TRENDEP(I,3,K)
862      NEXT K
864   MAXTREN(I,4)=TEMP
865  MAXTREN(I,0)=0:FOR W=1 TO 3:IF MAXTREN(I,W)>MAXTREN(I,0) THEN MAXTREN(I,0)=
MAXTREN(I,W):NEXT W:REM DEFINE MAX. TRENCH DEPTH OVERALL
866   IF MAXTREN(I,2)<>0 THEN PRINT" INPUT LENGTH OF ROUTE WHICH IS IN DEPTH RAN
GE=165 TO 190 ON LEG ";I; ELSE 877:REM PROVIDE FURTHER BREAKDOWN OF WATER DEPTH
867   INPUT LGT165(I):IF LGT165(I)>LEDEEP(I)-LGT190(I) THEN PRINT" MAXIMUM POSSI
BLE LENGTH BETWEEN 165 AND 190 FT IS ";LEDEEP(I)-LGT190(I):GOTO 866
868   IF LGT165(I)>0 THEN MAXTREN(I,3)=MAXTREN(I,2)
870   IF LGT165(I)=0 THEN MAXTREN(I,3)=0
872   IF LGT165(I)=LEDEEP(I)-LGT190(I) THEN MAXTREN(I,2)=0
875 GOTO 880
877  MAXTREN(I,3)=0:REM IF NO TRENCH EXISTS IN DEPTH 20-190 THEN NONE IN 165-190

880 REM DEVELOP TRENCHER SELECTION
881 PRINT"**************   OFFSHORE PIPELINE LEG  ";I;" SCENARIO ";S$;" ****"
882   FOR W=1 TO 4
883   IF W>1 THEN 889
884   IF MAXTREN(I,1)=0 THEN 920
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```
885 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 0-20 FT:"
886   IF MAXTREN(I,1)<=6 THEN PRINT "0-";TR$(0):PRINT"1-";TR$(1):PRINT"2-";TR$(2
):PRINT"5-";TR$(5):PRINT"6-";TR$(6):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",
T:TRENCHER(W)=T:IF (T=0)+(T=1)+(T=2)+(T=5)+(T=6)=0 THEN 886 ELSE 920
887   IF MAXTREN(I,1)<=10 THEN PRINT"0-";TR$(0):PRINT"1-";TR$(1):PRINT"2-";TR$(2
):PRINT"6-";TR$(6):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",T:TRENCHER(W)=T:I
F (T=0)+(T=1)+(T=2)+(T=6)=0 THEN 887 ELSE 920
888  PRINT"1-";TR$(1):PRINT"2-";TR$(2):INPUT"        ENTER YOUR CHOICE (BY NUMBER
)",TRENCHER(W):GOTO 920
889 IF W>2 THEN 901
890   IF MAXTREN(I,2)=0 THEN 920
891 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 20-165 FT:"
892   IF MAXTREN(I,2)<=6 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"3-";TR$(3)
:PRINT"4-";TR$(4):PRINT "5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";
TR$(8)
893 IF MAXTREN(I,2)<=6 THEN INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER
(W):GOTO 920
894   IF (MAXTREN(I,2)<=10)*(STRATA$="N")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):PRINT "6-";TR$(6):PRINT"7-";TR$(7):PRINT"8
-";TR$(8)
895   IF (MAXTREN(I,2)<=10)*(STRATA$="Y")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"9-";TR$(9)
896 IF MAXTREN(I,2)<=10 THEN INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
897   IF (MAXTREN(I,2)<=13)*(STRATA$="N")=1 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(
2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8)
898   IF (MAXTREN(I,2)<=13)*(STRATA$="Y")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"9-";TR$(9)
899 IF MAXTREN(I,2)<=13 THEN INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
900   PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):INPUT"
        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
901   IF W>3 THEN 909
902   IF MAXTREN(I,3)=0 THEN 920
903 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH 165-190 FT:"
904   IF MAXTREN(I,3)<=6 THEN PRINT"4-";TR$(4):PRINT"5-";TR$(5):PRINT"6-";TR$(6)
:PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",T
RENCHER(W):GOTO 920
905   IF (MAXTREN(I,3)<=10)*(STRATA$="N")=1 THEN PRINT"4-";TR$(4):PRINT"6-";TR$(
6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"        ENTER YOUR CHOICE (BY NUMBER)"
,TRENCHER(W):GOTO 920
906   IF MAXTREN(I,3)<=13 THEN PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8
):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
907   PRINT"4-";TR$(4):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):I
F (TRENCHER(W)=4)=0 THEN 907 ELSE GOTO 920
909   IF MAXTREN(I,4)=0 THEN 920
910 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH   >190 FT:"
911   IF MAXTREN(I,4)<=6 THEN PRINT"5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7)
:PRINT"8-";TR$(8):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 9
20
912 PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"        ENTER YOUR C
HOICE (BY NUMBER)",TRENCHER(W):GOTO 920
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920 NEXT W
980 REM GOTO TRENCHING COST SECTION -LINE 2000
982 GOTO 2000
1000 REM THIS IS DATA SECTION
1010 DATA 1:REM THIS IS NUMBER OF OFFSHORE LEGS IN SCENARIO
1020 REM THIS IS LENGTH DATA FOR 1ST OFFSHORE LEG IN STATUTE MILES
1022 REM  <69    69-70  70-71  71-72  72-73   LATITUDE ZONES
1024 DATA   0,      0,   1,      0,      0 :REM WATER DEPTH <20 FT
1026 DATA  0,       0,   71,     71,     0 :REM WATER DEPTH 20-190 FT
1028 DATA  0,       0,    0,      0,     0 :REM WATER DEPTH >190 FT
1030 REM THIS IS LENGTH DATA FOR 2ND OFFSHORE LEG IN STAT. MILES  (OPTIONAL)
1032 DATA  0,       0,  18,      49,     0 :REM <20 FT
1034 DATA  0,       0, 102,      30,     0 :REM 20-190 FT
1036 DATA  0,       0,  0,        0,     0 :REM >190 FT
1040 DATA 999:REM DATA CHECK
1050 DATA 1:REM THIS IS NUMBER OF ONSHORE LEGS IN SCENARIO
1060 DATA 309:REM LENGTH IN STATUTE MILES OF 1ST ONSHORE LEG
1070 DATA 000:REM LENGTH OF 2ND ONSHORE LEG (OPTIONAL)
1080 DATA 999:REM TEST DATA
1100 REM UNIT COST FOR MATERIALS
1102 DATA .38:REM X-65 PIPE $/LB
1104 DATA .60:REM FBE $/SQFT (APPLIED)
1106 DATA .15:REM CONCRETE WEIGHT COATING (APPLIED)
1108 DATA 1.6:REM ZINC ANODES $/LB
1109 DATA 2.0:REM POLYURETHANE FOAM INSULATION $/CUFT
1110 DATA 999
1119 REM PIPE DESIGN DATA
1120 DATA .89      :REM CRUDE OIL SPECIFIC GRAVITY
1130 DATA 7.3E-04 :REM KINEMATIC VISCOSITY (FT^2/SEC) AT MEAN FLOWING TEMP.
1140 DATA 65      :REM PIPE YIELD STRENGTH (KSI)
1150 DATA 999:REM TEST DATA
1200 REM TRENCH DEPTH PARAMETERS BASED ON ICE SCOUR STATISTICS
1202 DATA 6.91,4.52,2.66,.99:REM A-FACTOR FOR EACH LATITUDE ZONE IN 1/M
1204 DATA .3,.3,.3,.1:REM B-FACTOR IN METERS
1300 REM COST AND PRODUCTION RATE FACTORS FOR TRENCHING EQUIPMENT
1310 REM   C1A  C1B C1C C2 C3 V1 V2A V2B  V2C  W  CLAY SAND WAVE MECH P1 P2
1314 DATA 6,6,6,0,17,1.5,0,0,0,0,1,1,.9,.95,1,0:REM THROUGH-ICE TRENCH/LAY
1315 DATA 15.6,17,24.2,4,15,.5,.8,1.8,6.8,3,.6,1,.61,.8,5.80,.7:REM S/C DREDGE
1316 DATA 15.6,17,24.2,4,20,.5,.8,1.8,6.8,3,.6,1,.61,.7,29,1.2:REM MOD SC DREDGE

1318 DATA 31.1,32.5,39.1,4,0,.8,.8,1.8,6.4,3,.6,1,.79,.8,20.5,.9:REM LINEAR DRDG

1320 DATA 14.7,16.8,23.7,4,5,.4,.5,1.9,6.8,3,.4,1,.97,.95,53,1.6:REM HOPPER
1322 DATA 1.2,3.7,9.3,2,12,0,.9,2.6,6.5,0,1,1,.97,.95,15,0:REM 1 PASS PLOW
1324 DATA .7,1.8,7.1,2,15,0,.5,1.2,5,2,1,1,.97,.95,118,1.2:REM MULTI-PASS PLOW
1326 DATA 10.7,11.8,19.7,4,2,.4,.5,1.2,6.5,3,1,.3,.8,.5,32,1:REM MECH TRENCHER
1328 DATA 21.1,22.5,29.7,4,0,.7,.8,1.8,6.5,3,.4,1,.8,.65,133,2:REM JETTING
1330 DATA 999:REM TESTDAT
1400 REM COST AND PRODUCTION RATE FACTORS FOR INSTALLATION EQUIPMENT
1410 REM   LC1A  LC1B LC1C LC2 LC3 LV1 LV2A LV2B  LV2C  LW LWAVE LMECH LP1 LP2
1420 DATA 31.7,34.1,39.9,10,7,.8,1.2,3.1,6.9,5,.90,.8,57,.65:REM CONV. BARGE
1430 DATA 37,39.5,44.9,11,15,1.3,1.4,3.1,6.9,5,.95,.8,114,.65:REM 3RD GEN BRGE
1440 DATA 1.8,4.1,9.9,11,210,1.3,1.3,2.9,6.9,5,.90,.8,20.8,0:REM ARCT. LBG
1450 DATA 1.4,4.3,10.9,.6,15,.6,0.7,2.2,5.5,0,.97,.95,5.0,0:REM BOTTOM TOW
1460 DATA 3.3,6.1,12.3,.8,15,.9,1.0,2.5,6.0,.2,.94,.95,2.0,0:REM BOTTOM PULL
1470 DATA 999
```

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1500 REM UNIT COST DATA FOR PUMP STATIONS AND OFFSHORE PRODUCTION STRUCTURE
1510 DATA .0012: COST PER PUMP HORSEPOWER IN MILLIONS
1520 DATA 482:REM FIXED COST FOR OFFSHORE PRODUCTION STRUCTURE
1550 DATA 3.5,.06:REM ONSHORE PIPELINE FIXED COST PER MILE, COST/IN DIA-MI
2000 REM PRINT"CALCULATING TRENCHING TIMES FOR SPREAD SPECIFIED FOR LEG ";I
2005 IF STRATA$="N" THEN INPUT"     INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (
C=CLAY S=SAND) ?  ",PST$
2006 IF STRATA$="Y" THEN PST$="S"
2007 IF (PST$="S")+(PST$="C")=0 THEN 2005
2008 FOR W=1 TO 4:TTIME(W)=0:NEXT W
2010 REM CALC. COST FOR DEPTH RANGE 0-20 FT
2020 IF MAXTREN(I,1)=0 THEN 2100:REM NO PIPE IN THIS DEPTH
2025 PROD=P1(TRENCHER(1))/(MAXTREN(I,1)^P2(TRENCHER(1)))
2050 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(1))
2055 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(1))
2060 PROD(1)=PROD*WAVE(TRENCHER(1))*MECH(TRENCHER(1))
2070 TTIME(1)=LESHOR(I)/PROD(1)
2100 IF MAXTREN(I,2)=0 THEN 2200:REM NO PIPE IN DEPTH 20-165
2110 IF TRENCHER(2)<>9 THEN 2125
2112 PROD=P1(4)/(6^P2(4))
2114 PROD(2)=PROD*SAND(4)*WAVE(4)*MECH(4)
2116 GOTO 2165
2125 PROD=P1(TRENCHER(2))/(MAXTREN(I,2)^P2(TRENCHER(2)))
2150 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(2))
2155 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(2))
2160 PROD(2)=PROD*WAVE(TRENCHER(2))*MECH(TRENCHER(2))
2165 REM
2170 TTIME(2)=(LEDEEP(I)-LGT165(I)-LGT190(I))/PROD(2)
2200 IF MAXTREN(I,3)=0 THEN 2300:REM NO PIPE IN DEPTH 165-190
2210 IF TRENCHER(3)<>9 THEN 2225
2212 PROD=P1(4)/(6^P2(4))
2214 PROD(3)=PROD*SAND(4)*WAVE(4)*MECH(4)
2216 GOTO 2265
2225 PROD=P1(TRENCHER(3))/(MAXTREN(I,3)^P2(TRENCHER(3)))
2250 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(3))
2255 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(3))
2260 PROD(3)=PROD*WAVE(TRENCHER(3))*MECH(TRENCHER(3))
2265 REM
2270 TTIME(3)=LGT165(I)/PROD(3)
2300 IF MAXTREN(I,4)=0 THEN 2400:REM NO PIPE IN DEPTH  >190
2325 PROD=P1(TRENCHER(4))/(MAXTREN(I,4)^P2(TRENCHER(4)))
2350 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(4))
2355 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(4))
2360 PROD(4)=PROD*WAVE(TRENCHER(4))*MECH(TRENCHER(4))
2370 TTIME(4)=LGT190(I)/PROD(4)
2400 REM COMPUTE NET WEEKS FOR EACH COMPONENT REQUIRED
2410 FOR L=0 TO 9:ETTIME(I,L)=0:NEXT L:REM RESET ALL TO 0
2420     FOR W= 1 TO 4
2425     IF TRENCHER(W)<>9 THEN 2430:REM IF PLOW/DREDGE COMBI. IS NOT USED GO ON
2426     ETTIME(I,4)=ETTIME(I,4)+TTIME(W)
2427     IF W=2 THEN ETTIME(I,6)=ETTIME(I,6)+(LEDEEP(I)-LGT165(I)-LGT190(I))/((P1
(6)/(6^P2(6)))*CLAY(6)*WAVE(6)*MECH(6))
2428     IF W=3 THEN ETTIME(I,6)=ETTIME(I,6)+(LGT165(I))/((P1(6)/(6^P2(6)))*CLAY(
6)*WAVE(6)*MECH(6))
2429 GOTO 2440
2430     ETTIME(I,TRENCHER(W))=ETTIME(I,TRENCHER(W))+TTIME(W)
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2440    NEXT W
2445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
2450 FOR L=0 TO 8
2460 IF ETTIME(I,L)<>0 THEN PRINT TR$(L);"- ";TAB(65);:PRINT USING "###.#";ETTIM
E(I,L);:PRINT"WEEKS"
2470 NEXT L
2500 INPUT"      RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? ",A$
2510 IF A$="Y" THEN 880
2550 PRINT"*********************************************************************
**********":PRINT "COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG ";I;
2560   IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT PROCEDURE FOR LEG 2"
2600 NEXT I
2700 PRINT "CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED"
2705 PRINT"    INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG";:IN
PUT MSTC
2710 INPUT"    INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C
=10/10)",ICE$:IF (ICE$="A")+(ICE$="B")+(ICE$="C")=0 THEN 2710
2715     FOR I=1 TO NOFROUT
2720     REM COMPUTE AVERAGE SEASON LENGTH FOR ICE COVERAGE SPECIFIED
2730    L69=ROUTLEN(I,1,0)+ROUTLEN(I,2,0)+ROUTLEN(I,3,0)
2740    L70=ROUTLEN(I,1,1)+ROUTLEN(I,2,1)+ROUTLEN(I,3,1)
2750    L71=ROUTLEN(I,1,2)+ROUTLEN(I,2,2)+ROUTLEN(I,3,2)
2760    L72=ROUTLEN(I,1,3)+ROUTLEN(I,2,3)+ROUTLEN(I,3,3)
2770    L73=ROUTLEN(I,1,4)+ROUTLEN(I,2,4)+ROUTLEN(I,3,4)
2780    LAVG=(L69*68.5+L70*69.5+L71*70.5+L72*71.5+L73*72.5)/(L69+L70+L71+L72+L73)
2790   IF LAVG<69 THEN SEASON=19:GOTO 2800
2791   IF LAVG<69.5 THEN SEASON=18!:GOTO 2800
2792   IF LAVG<70! THEN SEASON=17!:GOTO 2800
2793   IF LAVG<70.5 THEN SEASON=15!:GOTO 2800
2794   IF LAVG<71.1 THEN SEASON=10!:GOTO 2800
2796   IF LAVG<71.5 THEN SEASON=8!:GOTO 2800
2797   IF LAVG<72! THEN SEASON=6!:GOTO 2800
2798   IF LAVG<73 THEN SEASON=4!:GOTO 2800
2800   LSEASON(I)=SEASON:REM SAVE THIS VALUE FOR LATER USE IN INSTALLATION EVAL
2810   IF ICE$="B" THEN SEASON=SEASON+4
2820   IF ICE$="C" THEN SEASON=SEASON+8
2825   PRINT"COMPUTED MARINE CONST. SEASON LENGTH ALONG ROUTE LEG ";I;" = ";SEASO
N;" WEEKS"
2840 INPUT"    DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  ",SEASON$
2850 IF SEASON$="Y" THEN INPUT"   INPUT CONSTRUCTION SEASON DURATION (WEEKS) ? "
,SEASON
2860 IF (SEASON$="Y")*(SEASON<=1)=1 THEN INPUT"ARE YOU SURE (Y OR N) ?  ",SCHECK
$ : IF SCHECK$="N" THEN 2840
2870 IF TRENCHER(1)=0 THEN PRINT"WINTER CONSTRUCTION SEASON FOR DEPTHS <20 FT =
15 WEEKS"
2890     PRINT:PRINT"********** TRENCHING COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
2900   REM COMPUTE NUMBER OF SEASON FOR EACH TRENCHING EQUIPMENT
2905     TOTRENCST(I)=0
2910     FOR L=0 TO 8
2915     IF ETTIME(I,L)=0 THEN 2970
2920     TRENCHYRS(I,L)=ETTIME(I,L)/SEASON
2925 IF L=0 THEN TRENCHYRS(I,L)=ETTIME(I,L)/15:REM ASSUME 15 WKS/YR FOR WINTER
2930     IF ICE$="A" THEN TEMP=V2A(L):TEMP2=C1A(L)
2932     IF ICE$="B" THEN TEMP=V2B(L):TEMP2=C1B(L)
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2934     IF ICE$="C" THEN TEMP=V2C(L):TEMP2=C1C(L)
2935 TEMP3=INT(TRENCHYRS(I,L))+1
2936 PEAKNO=INT(TEMP3/MSTC)-((TEMP3/MSTC)>INT(TEMP3/MSTC)):REM DEFINE PEAK NO. I
N SPREAD
2940     TRENCOST(I,L)=(INT(TRENCHYRS(I,L))+1)*(TEMP2+W(L))+(C2(L)+C3(L))*PEAKNO
2950     TRENCOST(I,L)=TRENCOST(I,L)+ETTIME(I,L)*(V1(L)+TEMP)
2960     PRINT TR$(L);"(PROJECT PEAK=";PEAKNO;") ";INT(TRENCHYRS(I,L))+1;"EQPMNT-
SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";TRENCOST(I,L)
2965     TOTRENCST(I)=TOTRENCST(I)+TRENCOST(I,L) :REM ADD ALL EQPT
2970     NEXT L
2975     PRINT"   TOTAL TRENCHING COST FOR LEG ";I;"= ";:PRINT TAB(73);:PRINT USI
NG "####.#";TOTRENCST(I):PRINT
2990 NEXT I
3000 INPUT"   RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS? (Y OR N)",A$
3010 IF A$="Y" THEN 2700
4000 REM BEGIN PIPE INSTALLATION SECTION
4001 PRINT"******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS
 *********":PRINT
4010 IN$(1)="CONVENTIONAL LAYBARGE "
4020 IN$(2)="3RD GENERATION LAYBARGE"
4030 IN$(3)="ARCTIC LAYBARGE"
4040 IN$(4)="BOTTOM TOW"
4050 IN$(5)="BOTTOM PULL"
4100 PRINT"READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION              1400-147
0"
4110   FOR L=1 TO 5
4120   READ LC1A(L),LC1B(L),LC1C(L),LC2(L),LC3(L),LV1(L),LV2A(L),LV2B(L),LV2C(L)
,LW(L),LWAVE(L),LMECH(L),LP1(L),LP2(L):NEXT L
4130 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NUMBER OF VALUES IN INSTA
LLATION VESSEL DATA FILE, CHECK AND RE-RUN":STOP
4140   FOR I =1 TO NOFROUT
4145   ANETLEN=NETLEN(I)
4150   REM DEVELOP INSTALLATION METHOD SELECTION
4155   IF (LESHOR(I)>0)*(TRENCHER(1)=0)=1 THEN ANETLEN=NETLEN(I)-LESHOR(I)
4160 PRINT:PRINT"FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF ";:PRINT USI
NG "###.#";ANETLEN
4165   IF ANETLEN=0 THEN GOTO 4445
4170  IF ANETLEN<=15 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):PRI
NT"4-";IN$(4):PRINT"5-";IN$(5):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",INSTA
LLER(I):GOTO 4200
4175  IF ANETLEN<=30 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):PRI
NT"4-";IN$(4):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200

4180  PRINT "1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):INPUT"       ENTER YOU
R CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200
4200 REM INSTALLATION COST SECTION
4210 REM CALC. PRODUCTION RATE (MI/WEEK)
4220 LPROD=LP1(INSTALLER(I))/(ODPIPE^LP2(INSTALLER(I)))
4240 LPROD(I)=LPROD*LWAVE(INSTALLER(I))*LMECH(INSTALLER(I))
4400 REM COMPUTE WEEKS FOR EACH LEG
4430 LETTIME(I)=ANETLEN/LPROD(I):REM LAYING ELAPSED TIME FOR LEG I
4435 IF (INSTALLER(I)=4)+(INSTALLER(I)=5)<0 THEN 4445
4437 IF I$="Y" THEN LETTIME(I)=1.25*LETTIME(I):REM REDUCE PRODUCTION RATE BY 25%
 IF PIPE IS INSULATED.  THIS IS BASED ON USE OF PIPE IN PIPE WITH PREFABRICATED
END FORGINGS ALLOWING 1 CIRCUMFERENTIAL WELD ON BARGE
4440 LETTIME(I)=LETTIME(I)+1.43:REM 1.43 WKS FOR TIE-INS
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4445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
4450   IF ANETLEN=0 THEN PRINT "***** ENTIRE LEG ";I;" IS INSTALLED DURING THROU
GH-ICE TRENCHING IN WINTER":GOTO 4590
4460 PRINT IN$(INSTALLER(I));"- ";TAB(65);:PRINT USING "###.#";LETTIME(I);:PRINT
"WEEKS"
4575    INPUT"     RE-RUN INSTALLATION EQUIPMENT SELECTION ?(Y OR N) ",A$
4580    IF A$="Y" THEN 4150
4590    PRINT"***********************************************************************
*************":PRINT "COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG ";I;
4592    IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT FOR LEG 2"
4600 NEXT I
4700 PRINT"CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED"
4712 INPUT"   INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG ",MSL
C
4713 INPUT"   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C
=10/10)",ICE$:IF (ICE$="A")+(ICE$="B")+(ICE$="C")=0 THEN 4713
4715   FOR I=1 TO NOFROUT
4747 REM RECALL AVERAGE INSTALLATION SEASON FROM TRENCHING EVALUATION
4749  IF ICE$="A" THEN LSEASON=LSEASON(I)
4750  IF ICE$="B" THEN LSEASON=LSEASON(I)+4
4760  IF ICE$="C" THEN LSEASON=LSEASON(I)+8
4761  PRINT"COMPUTED MARINE CONST. SEASON ALONG ROUTE LEG ";I;" = ";LSEASON;" WE
EKS"
4762 INPUT"   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  ",SEASON$
4763 IF SEASON$="Y" THEN INPUT"   INPUT CONSTRUCTION SEASON DURATION (WEEKS) ? "
,SEASON
4764 IF (SEASON$="Y")*(SEASON<=1)=1 THEN INPUT"ARE YOU SURE (Y OR N) ?  ",SICHEC
K$ : IF SICHECK$="N" THEN 4762
4765    PRINT:PRINT"*******INSTALLATION COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
4770  REM COMPUTE NUMBER OF SEASON FOR INSTALLATION EQUIPMENT
4780    LAYRS(I)=LETTIME(I)/LSEASON
4790    IF ICE$="A" THEN TEMP=LV2A(INSTALLER(I)):TEMP2=LC1A(INSTALLER(I))
4792    IF ICE$="B" THEN TEMP=LV2B(INSTALLER(I)):TEMP2=LC1B(INSTALLER(I))
4794    IF ICE$="C" THEN TEMP=LV2C(INSTALLER(I)):TEMP2=LC1C(INSTALLER(I))
4796 TEMP3=INT(LAYRS(I))+1
4798 PEAKNO=INT(TEMP3/MSLC)-((TEMP3/MSLC)>INT(TEMP3/MSLC))
4800    LAYCOST(I)=(INT(LAYRS(I))+1)*(TEMP2+LW(INSTALLER(I)))+(LC2(INSTALLER(I))
+LC3(INSTALLER(I)))*PEAKNO
4810    LAYCOST(I)=LAYCOST(I)+LETTIME(I)*(LV1(INSTALLER(I))+TEMP)
4850    PRINT IN$(INSTALLER(I));"(PROJECT PEAK=";PEAKNO;") ";INT(LAYRS(I))+1;"EQ
PMNT-SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";LAYCOST(I)
4900 NEXT I
4950 INPUT"  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)",A$:IF A$="Y" THEN GOTO
 4700
5000 PRINT"READING PUMP AND PRODUCTION TERMINAL COSTS          1500-1520"
5005 READ PMPCST,PTERCST
5008 PRINT"CALCULATING PUMP STATION AND TERMINAL COSTS"
5020    PUMPPWR(1)=.022*PRODUCT*MAOP*(-(NOFROUT<>0))
5030    PUMPPWR(2)=PUMPPWR(1)*(NETLEN(2)/NETLEN(1))
5040    PUMPCOST(1)=PMPCST*PUMPPWR(1)
5050    PUMPCOST(2)=PMPCST*PUMPPWR(2)
5060 IF NOFROUT=0 THEN PTERCOST=0:IF NO OFFSHORE LEG IS INCL. THEN NO PROD. STRU
CTURE
5100 PRINT "READING ONSHORE PIPELINE COST FACTORS           1550"
5210 READ LNDPL1,LNDPL2
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5220 LNDPLCST=LNDPL1+ODPIPE*LNDPL2
5240 IF NOFROUT=0 THEN 5300
5250 FOR I=1 TO NOFROUT
5270 NEXT I
5500 REM ACCUMULATE ALL PIPELINE COSTS AND DISPLAY RESULTS
5505 PRINT"****************** CAPITAL COST SUMMARY - SCENARIO ";S$;"  *******":
PRINT"                               (1986 MILLIONS OF $)":PRINT
5510 IF NOFROUT=0 THEN 5700
5520 IF NOFROUT>=1 THEN PRINT "OFFSHORE PIPELINE (CHUKCHI SEA)"
5530 IF NOFROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5531 PRINT"  MATERIALS";
5532 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";TCOST(1)/1000000!;
5535 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";TCOST(2)/1000000!;
5545 PRINT TAB(65);:PRINT USING "###.#";(TCOST(1)+TCOST(2))/1000000!
5547     TEMP=(TCOST(1)+TCOST(2))/1000000!
5550 PRINT"  MATERIALS LOGISTICS";TAB(65);:PRINT USING"###.#";LOGCST/1000000!
5552     TEMP=TEMP+LOGCST/1000000!
5555 PRINT "  TRENCHING";
5560 IF NOFROUT=2 THEN PRINT TAB(44);:PRINT USING"####.#";TOTRENCST(1);
5565 IF NOFROUT=2 THEN  PRINT TAB(56);:PRINT USING"####.#";TOTRENCST(2);
5570 PRINT TAB(64);:PRINT USING "####.#";TOTRENCST(1)+TOTRENCST(2)
5572     TEMP=TEMP+TOTRENCST(1)+TOTRENCST(2)
5575 PRINT "  INSTALLATION, TIE-INS/ SHORE CROSSINGS";
5580 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING "###.#";LAYCOST(1);
5585 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";LAYCOST(2);
5590 PRINT TAB(65);:PRINT USING "###.#";LAYCOST(1)+LAYCOST(2)
5592     TEMP=TEMP+LAYCOST(1)+LAYCOST(2)
5600 PRINT"  PUMP STATION(S)";
5610 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";PUMPCOST(1);
5620 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";PUMPCOST(2);
5625 PRINT TAB(65);:PRINT USING "###.#";PUMPCOST(1)+PUMPCOST(2):TEMP=TEMP+PUMPCO
ST(1)+PUMPCOST(2)
5640 PRINT"  PROJECT SERVICES (15%) :";TAB(65);:PRINT USING "###.#";.15*TEMP
5650    TEMP=1.15*TEMP
5660 PRINT"  CONTINGENCY (25%):";TAB(65);:PRINT USING "###.#";.25*TEMP
5670    TEMP=TEMP*1.25
5680 PRINT "     TOTAL OFFSHORE PIPELINE CAPITAL COSTS:";TAB(70);:PRINT USING "#
###.#";TEMP:OFCAPEX=TEMP
5700 IF NONROUT=0 THEN 5800
5705 PRINT
5710 IF NONROUT>=1 THEN PRINT "ONSHORE PIPELINE COSTS"
5730 IF NONROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5732 IF NONROUT=2 THEN PRINT TAB(45);:PRINT USING"####.#";LNDPLCST*ROUTLEN1(1);
5735 IF NONROUT=2 THEN PRINT TAB(57);:PRINT USING"###.#";LNDPLCST*ROUTLEN1(2);
5745 PRINT TAB(65);:PRINT USING "####.#";LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2)):ONCA
PEX=LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5800 PRINT"PRODUCTION STRUCTURE COSTS:";TAB(65);:PRINT USING"###.#";PTERCST
5802      TEMP=TEMP+PTERCST
5810 TEMP=TEMP+LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5815 PRINT
5820 PRINT"   TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE ";TAB(70
);:PRINT USING"####.#";TEMP
5850 REM
5855 INPUT"  RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? ",A$
5857 IF A$="Y" THEN 5500
5860 PRINT"CALCULATING OPERATING COSTS"
```

```
5900 REM OPERATING COSTS FOR OFFSHORE PIPELINE ARE TAKEN AS 2% OF CAPEX
5910 REM OPERATING COSTS FOR ONSHORE PIPELINE ARE TAKEN AS 3.5% OF CAPEX
5920 OFOPEX=.02*OFCAPEX
5930 ONOPEX=.035*ONCAPEX
5940 INPUT"   DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? ",A$
5945 TAPSTAR=0
5950 IF A$="Y" THEN TAPSTAR=3*365*PRODUCT/1000!
5960 INPUT"   LIFE OF PIPELINE SYSTEM (YEARS)? ",LIFE
5970 INPUT"   INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  ",CIF
5980 CIF=CIF/100
5985 PRINT
5990 PRINT"         PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYS
TEM "
5995 PRINT"                                        YEAR (SCENARIO ";S$;" )"
6000 PRINT" ACCOUNT   ";:FOR J=1 TO LIFE STEP 2:PRINT TAB(9+3*J);:PRINT J;:NEXT
J:PRINT
6010 PRINT:TEMP1=0:TEMP2=0:TEMP3=0
6020 IF NOFROUT<=0 THEN 6030 ELSE PRINT"OFFSHORE PL";:FOR J=1 TO LIFE :TEMP1=TEM
P1 +OFOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";OFOPEX*(1/((1+CIF)^(J-1)));
6025 NEXT J:PRINT
6030 IF NONROUT<=0 THEN 6040 ELSE PRINT"ONSHORE PL ";:FOR J=1 TO LIFE:TEMP2=TEMP
2+ONOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT US
ING "###  ";ONOPEX*(1/((1+CIF)^(J-1)));
6035 NEXT J:PRINT
6040 IF TAPSTAR<=0 THEN 6050 ELSE PRINT"TAPS TARIFF";:FOR J=1 TO LIFE :TEMP3=TEM
P3+TAPSTAR*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";TAPSTAR*(1/((1+CIF)^(J-1)));
6045 NEXT J:PRINT
6050 PRINT:PRINT"  NET PRESENT VALUE OF OPERATING COSTS = ";:PRINT USING "#####.
#";(TEMP1+TEMP2+TEMP3)
6055 PRINT"  TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)= ";TEMP+TEMP1+
TEMP2+TEMP3;" MILLION $"
6060 INPUT"  RE-RUN OPERATING COST CALCULATION (Y OR N)   ";A$
6070 IF A$="Y" THEN 5970
6080 PRINT"**************  END OF INTEC ENGINEERING PROGRAM CHUKPIPE  **********
**********"
8999 END
9000 REM
                    PIPELINE SIZING SUBROUTINE
    REM
9020 FRICT=.026  '    STARTING VALUE FOR FRICTION FACTOR & APPROX. MAOP
9023 PRINT "PIPELINE DESIGN OPTIONS INCLUDE:"
9024 PRINT "                      PIPE OD (IN)      APPROX. MAOP (PSIG)"
9030    IDVAL(1)=6!: ODVAL(1)=6.625
9040    IDVAL(2)=8!: ODVAL(2)=8.625
9050    IDVAL(3)=10!: ODVAL(3)=10.75
9060    IDVAL(4)=12!: ODVAL(4)=12.75
9070    IDVAL(5)=13!: ODVAL(5)=14!
9080    FOR I=1 TO 25     'LIST PIPE DESIGN OPTIONS
9090    FLOWVEL=CUFOOT/(3.1416*((IDVAL(I)/12)^2)/4)
9100    IF FLOWVEL>20 GOTO 9160     'REJECT HIGH FLOW VELOCITY CASES, >20 FT/SEC
9110    IF (FLOWVEL<3)  AND (IDVAL(I)>13) GOTO 9160  ' REJECT LOW VELOCITIES
9115    IF FLOWVEL<1.5 GOTO 9160
9117    '     CALCULATE APPROX. PRESSURE DROP
9120    HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDVAL(I)/12)*2*32.2)
```

```
9130     DELTP=HF*62.4*CRUDESG/144
9140     IF DELTP>2500 GOTO 9160   '    REJECT HIGH PRESSURE DROP CASES
9150     PRINT TAB(20); ODVAL(I); TAB(40); USING"####."; (DELTP+50)
9160     IF I>=5 THEN ODVAL(I+1)=ODVAL(I)+2
9170     IF I>=5 THEN IDVAL(I+1)=ODVAL(I+1)-(2*ODVAL(I+1)/48)
9300     NEXT I
9400 KS=.00015   '      ROUGHNESS FOR STEEL PIPE (FT)
9430 WALL=.5               'STARTING VALUE
9435 INPUT"SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? ",ODPIPE
9437 DOT$="N"
9438      'ITERATE TO FIND WALL THICKNESS
9440     IDPIPE=ODPIPE-(2*WALL)
9450     FLOWVEL=CUFOOT/(3.1416*((IDPIPE/12)^2)/4)
9455     IF FLOWVEL>25 THEN PRINT"***** ARE YOU SURE? (Y OR N)";:INPUT F$:IF F$="
N" THEN 9430
9460     REYNOLDS=FLOWVEL*(IDPIPE/12)/VISCOS
9465        'ITERATE TO FIND FRICTION FACTOR
9470        TEMP=FRICT
9480        FRICT=(2.51/(REYNOLDS*(SQR(FRICT))))+(KS/(3.7*(IDPIPE/12)))
9490        FRICT=(-2*(.4342945*LOG(FRICT)))^(-2)
9500        IF (ABS(TEMP-FRICT)) >.0001 THEN GOTO 9470
9530     HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDPIPE/12)*2*32.2)
9540     DELTP=HF*62.4*CRUDESG/144
9550     MAOP=DELTP+50     'ADD 50 PSI FOR STATION LOSSES ETC.
9555     IF DOT$="Y" THEN GOTO 9600             'WT SET BY OD/WT RATIO
9560     TEMP=WALL
9570     WALL=.5*MAOP*ODPIPE/(.72*YIELD*1000)
9580     IF (ABS(TEMP-WALL))>.001 THEN GOTO 9440
9585 IF (ODPIPE/WALL)<=48 THEN GOTO 9600      'CHECK OD/WT RATIO
9586 WALL=(ODPIPE/48):DOT$="Y":GOTO 9440   'ASSUMED MAX. OD/WT RATIO FOR ARCTIC

9600 WALL=(INT((WALL-.0001)*32)+1)/32
9625 IF DOT$="Y" THEN PRINT"   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/
WT RATIO OF 48.  **********"
9627 PRINT
9650 RETURN
```

CHAPTER 3 - CHUKPIPE USER'S MANUAL

3.3 SAMPLE RUN

```
LOAD"CHUKPIPE
Ok
RUN
*****************************************************************************
**              INTEC ENGINEERING PROGRAM CHUKPIPE - (REV. 0)               **
**                CHUKCHI SEA PIPELINE COST EVALUATION                      **
**     This program allows rapid cost estimate preparation for crude oil    **
**     pipelines in the Chukchi Sea and the evaluation of total offshore    **
**     and onshore Alaskan pipeline transportation costs.  It is intended   **
**     to be used only by Participants in the Chukchi Sea Transportation    **
**     Feasibility and Cost Evaluation Joint Industry Study - Phase 2.      **
**     Although the cost model used herein will allow rapid assessment of   **
**     the cost impact of various design, installation and trenching        **
**     options available, the user should inspect the results at the end    **
**     of each stage for validity.                                          **
*****************************************************************************
   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?   CHUKPIPE 1B-C

 READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO                LINE   1010
 READING SEG. LENGTHS IN EACH DEPTH & LAT. ZONE FOR ROUTE  1   ROUTLEN  1020-1040
 READING NUMBER OF ONSHORE ROUTES IN SCENARIO                  ROUTLEN1  1050
 READING ONSHORE ROUTE LENGTH FOR ROUTE  1                     ROUTLEN1 1050-1070
              PIPELINE LENGTH SUMMARY FOR SCENARIO CHUKPIPE 1B-C   (MILES)
                    LEG 1             LEG 2             TOTAL
 OFFSHORE           143               0                  143
 ONSHORE            309               0                  309

 TOTAL PIPELINE LENGTH ALL ROUTES                          452
   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  N

 READING UNIT COSTS FOR MATERIALS                      LINES  1100-1109
   INPUT PRODUCTION RATE (MBPD) ?   400

 CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT
 PIPELINE DESIGN OPTIONS INCLUDE:
                     PIPE OD (IN)      APPROX. MAOP (PSIG)
                        28                  2353
                        30                  1681
                        32                  1231
                        34                   922
                        36                   706
                        38                   550
                        40                   437
 SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? 30
   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/WT RATIO OF 48.  **********

 CALCULATING MATERIAL QUANTITIES
                      OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO CHUKPIPE 1B-C
                        PIPE DIAMETER                30.000    IN
                        PIPE WALL THICKNESS           0.625    IN
                        PIPE STEEL GRADE             65.0      KSI
                        PIPELINE MAOP              1704.1      PSIG
                        CASING DIA. (WHERE REQD)     36.000    IN
                        CASING WALL                   0.375    IN
                        CONCRETE THICKNESS            2.025    NON-INSULATED
                        CONCRETE THICKNESS            3.250    INSULATED PIPE
```

```
ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N)? N
     MATERIAL COST SUMMARY FOR OFFSHORE LEG  1  SCENARIO CHUKPIPE 1B-C
                (ALL COSTS IN 1986 $ MILLIONS)
  ITEM            DEPTH<20 FT         DEPTH>20 FT        TOTAL
LINE PIPE            0.4                 56.1             56.5
CASING PIPE          0.3                  0.0              0.3
CORROSION COAT       0.0                  3.5              3.6
CONCRETE COAT        0.2                 30.2             30.4
ANODES               0.0                  0.5              0.5
INSULATION           0.0                  0.0              0.0
BULKHEADS            0.1                  0.0              0.1
           SUBTOTAL - LEG  1                                    91.3
  TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES                       91.3
LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/TON =         44
    REPEAT DESIGN AND COST SUMMARY (Y OR N)?N
******************************************************************************
BEGIN PIPELINE TRENCHING EVALUATION
READING TRENCH DEPTH PARAMETERS A & B                      LINES 1200-1204
READING COST, PRODUCTIVITY FACTORS FOR TRENCHING            LINES 1300-1330
     INPUT RISK OF ICE KEEL DAMAGE FOR ENTIRE PIPELINE ONCE IN 10 YEARS (%) ? 1
     INPUT -CAN SOIL STRATA BE CONSIDERED TO CONSIST OF 6-8 FT OF LOOSE
     MATERIAL OVERLYING STIFF, SCOUR-RESISTANT MATERIAL (Y OR N) ? Y
 ***  NOTE THIS ASSUMPTION WILL REDUCE REQUIRED TRENCH DEPTH IN WATER ***
 ***  DEPTHS OF 20-190 FT


                 OFFSHORE PIPELINE LEG  1   SCENARIO CHUKPIPE 1B-C
 DEPTH   <69°N  69-70°N   70-71°N   71-72°N   72-73°N
 (FEET)
   <20    0.       0.       10        0.        0.
 20-190   0.       0.       11        0.        0.
  >190    0.       0.       0.        11        0.
                                      0.        0.
RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)? N
 INPUT LENGTH OF ROUTE WHICH IS IN DEPTH RANGE=165 TO 190 ON LEG  1 ? 0
**************   OFFSHORE PIPELINE LEG   1  SCENARIO CHUKPIPE 1B-C ****

FEASIBLE EQPT FOR OBTAINING 10.0 FT TRENCH IN WATER DEPTH OF 0-20 FT:
0-THROUGH-ICE TRENCH/LAY
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
6-MULTI-PASS PLOW
      ENTER YOUR CHOICE (BY NUMBER)1

FEASIBLE EQPT FOR OBTAINING 10.5 FT TRENCH IN WATER DEPTH OF 20-165 FT:
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
3-LINEAR DREDGE
9-TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS ONLY)
      ENTER YOUR CHOICE (BY NUMBER)9
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO CHUKPIPE 1B-C ****

CUTTER SUCTION DREDGE -                                      1.8WEEKS
TRAILING SUCTION HOPPER DREDGE-                             51.1WEEKS
MULTI-PASS PLOW -                                           11.2WEEKS
    RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? N
******************************************************************************
```

```
COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG  1
CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED
   INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG? 3
   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)A
COMPUTED MARINE CONST. SEASON LENGTH ALONG ROUTE LEG  1  =  10  WEEKS
   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  N

********** TRENCHING COST RESULTS FOR LEG  1  SCENARIO CHUKPIPE 1B-C ****
CUTTER SUCTION DREDGE (PROJECT PEAK= 1 )  1 EQPMNT-SEASON(S)=              39.9
TRAILING SUCTION HOPPER DREDGE(PROJECT PEAK= 2 )  6 EQPMNT-SEASON(S)=    170.2
MULTI-PASS PLOW (PROJECT PEAK= 1 )  2 EQPMNT-SEASON(S)=                   28.0
   TOTAL TRENCHING COST FOR LEG  1 =                                     238.1

   RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS? (Y OR N)N
******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS  *********

READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION         1400-1470

FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF 143.0
1-CONVENTIONAL LAYBARGE
2-3RD GENERATION LAYBARGE
3-ARCTIC LAYBARGE
        ENTER YOUR CHOICE (BY NUMBER)2
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO CHUKPIPE 1B-C ****

3RD GENERATION LAYBARGE-
     RE-RUN INSTALLATION EQUIPMENT SELECTION ?(Y OR N) N      16.5WEEKS
*******************************************************************************
COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG  1
CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED
   INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG 2
   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)A
COMPUTED MARINE CONST. SEASON ALONG ROUTE LEG  1  =  10  WEEKS
   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  N

********INSTALLATION COST RESULTS FOR LEG  1  SCENARIO CHUKPIPE 1B-C ****
3RD GENERATION LAYBARGE(PROJECT PEAK= 1 )  2 EQPMNT-SEASON(S)=           154.5
  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)N
READING PUMP AND PRODUCTION TERMINAL COSTS          1500-1520
CALCULATING PUMP STATION AND TERMINAL COSTS
READING ONSHORE PIPELINE COST FACTORS               1550
****************** CAPITAL COST SUMMARY - SCENARIO CHUKPIPE 1B-C  *******
                       (1986 MILLIONS OF $)

OFFSHORE PIPELINE (CHUKCHI SEA)
   MATERIALS                                                    91.3
   MATERIALS LOGISTICS                                          44.1
   TRENCHING                                                   238.1
   INSTALLATION, TIE-INS/ SHORE CROSSINGS                      154.5
   PUMP STATION(S)                                              18.0
  PROJECT SERVICES (15%) :                                      81.9
  CONTINGENCY (25%):                                           157.0
     TOTAL OFFSHORE PIPELINE CAPITAL COSTS:                          784.9

ONSHORE PIPELINE COSTS
                                                              1637.7
```

PRODUCTION STRUCTURE COSTS: 482.0

TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE 2904.6

RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? N

CALCULATING OPERATING COSTS

DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? Y

LIFE OF PIPELINE SYSTEM (YEARS)? 20

INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ? 10

PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYSTEM

YEAR (SCENARIO CHUKPIPE 1B-C)

ACCOUNT	1	3	5	7	9	11	13	15	17	19
OFFSHORE PL	16	13	11	9	7	6	5	4	3	3
ONSHORE PL	57	47	39	32	27	22	18	15	12	10
TAPS TARIFF	438	362	299	247	204	169	140	115	95	79

NET PRESENT VALUE OF OPERATING COSTS = 4785.6

TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)= 7690.268 MILLION $

RE-RUN OPERATING COST CALCULATION (Y OR N) ? N

************** END OF INTEC ENGINEERING PROGRAM CHUKPIPE ********************

Ok

CHAPTER 4 BERPIPE USER'S MANUAL

CHAPTER 4
BERPIPE USER'S MANUAL

4.1 PROGRAM INPUT/OUTPUT GUIDE

The computer program BERPIPE evaluates Bering Sea crude oil pipeline system costs. Program input and output are describe chronologically in the following paragraphs. Reference is made, where possible, to the CHUKPIPE Program Input/Output Guide (Chapter 3). The sample run described in this chapter has one offshore pipeline leg. Program trenching and installation sections repeat if there is a second offshore leg.

A printed record of all or part of the run can be made by using the "PRINT SCREEN" key while running the program. The program must be run with "Caps Lock" (Capitalization) on.

Load and Run Program

Same as for CHUKPIPE.

Scenario Designation

Same as for CHUKPIPE.

Pipeline Location

Program reads pipeline location (line 1005) as either "NORTH" or "SOUTH" of 60°N latitude. If neither is specified, the program lists the appropriate data statement and stops.

The pipeline location is used to define which sets of trenching and installation productivity factors the program reads. To change the pipeline location, use the BASIC file editor. The user can permanently change the pipeline location data statement by using the SAVE command.

Pipeline Length

Same as for CHUKPIPE.

Production Rate

Same as for CHUKPIPE.

Pipeline Design

Same as for CHUKPIPE.

Pipeline Insulation

Same as for CHUKPIPE.

Materials Cost Summary

Same as for CHUKPIPE.

Trenching Requirements

Program reads pipeline depth of cover requirements (lines 1200 to 1240) and trenching cost/productivity factors (noted as either north or south of 60th parallel).

Program adds pipeline outside diameter to determine the depth to bottom of trench and prints a summary.

Trenching Equipment Selection

Program prompt: FEASIBLE EQPT FOR OBTAINING XX.X FT TRENCH IN WATER DEPTH OF YY-YY FT:

0 - THROUGH-ICE TRENCH/LAY
1 - CUTTER SUCTION DREDGE
2 - CUTTER SUCTION DREDGE W/DOUBLE SWING WIRES
3 - LINEAR DREDGE
4 - TRAILING SUCTION HOPPER DREDGE
5 - SINGLE PASS PLOW
6 - MULTI-PASS PLOW
7 - MECHANICAL TRENCHER
8 - CONVENTIONAL HIGH PRESSURE JETTING
9 - TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS ONLY)

ENTER YOUR CHOICE (BY NUMBER)

Where:

XX.X = pipeline trench depth (original seabed to bottom of trench); and
YY-YY = water depth range.

Only equipment types feasible for the specified combination of trench depth and water depth are prompted.

User inputs "1", "2", or "4" through "8" to select the corresponding equipment type and the program then prompts for the next water depth range. The user should confine the equipment selection to the options listed by the program. (Options No. 0, 3 and 9 are not considered feasible for the Bering Sea).

Soil Type

Program prompt: INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C = CLAY S = SAND)?

User inputs "C" if the soil is clay or "S" if the soil is sand. If neither is input, the question repeats.

Trenching Spread Times

Same as for CHUKPIPE.

Number of Trenching Seasons

Same as for CHUKPIPE.

Construction Season Duration

Program uses a summer construction season duration for trenching of 17 weeks (lines 2701 to 2703).

Trenching Cost Summary

The program calculates the cost for each trenching spread and total trenching cost, and prints the results. For each trenching equipment type selected, the project peak number of spreads and total equipment spread-seasons are printed. This information is helpful to the user in evaluating the selected equipment.

Installation Equipment Selection

The program reads installation equipment cost and productivity factors (either north or south of the 60th parallel).

Program prompt: FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF LL

1 - CONVENTIONAL LAYBARGE
2 - 3RD GENERATION LAYBARGE
3 - ARCTIC LAYBARGE
4 - BOTTOM TOW
5 - BOTTOM PULL

ENTER YOUR CHOICE (BY NUMBER)

Where:

LL = offshore pipeline length to be installed in statute miles

Only equipment types considered feasible for the specified pipeline length are prompted. The arctic laybarge is not considered feasible for the Bering Sea.

User inputs "1", "2", "4" or "5" to select the corresponding installation equipment type.

Installation Spread Time

Same as for CHUKPIPE.

Number of Installation Seasons

Same as for CHUKPIPE.

Construction Season Duration

Program uses a summer construction season duration for installation of 17 weeks (lines 2701 to 2703).

Installation Cost Summary

The program calculates the pipeline installation cost using the selected installation equipment type and prints the results. The project peak number of installation equipment spreads and total equipment spread-seasons are output.

Capital Cost Summary

Same as for CHUKPIPE.

TAPS Usage

Same as for CHUKPIPE.

Pipeline System Life

Same as for CHUKPIPE.

Interest Rate

Same as for CHUKPIPE.

Pipeline System Operating Costs

Same as for CHUKPIPE.

Total Pipeline System Present Worth Cost

Same as for CHUKPIPE.

CHAPTER 4 - BERPIPE USER'S MANUAL

4.2 PROGRAM LISTING

```
10 PRINT"*************************************************************************
********"
20 PRINT"**                    INTEC ENGINEERING PROGRAM BERPIPE - (REV. 0)
     **"
30 PRINT"**                       BERING SEA PIPELINE COST EVALUATION
     **"
31 PRINT "**      This program allows rapid cost estimate preparation for crude o
il      **"
32 PRINT "**      pipelines in the Bering Sea and the evaluation of total offshor
e       **"
33 PRINT "**      and onshore Alaskan pipeline transportation costs.  It is inten
ded     **"
34 PRINT "**      to be used only by Participants in the Chukchi Sea Transportati
on      **"
35 PRINT "**      Feasibility and Cost Evaluation Joint industry Study - Phase 2.
     **"
36 PRINT "**      Although the cost model used herein will allow rapid assessment
 of     **"
37 PRINT "**      the cost impact of various design, installation an trenching
     **"
38 PRINT "**      options available, the user should inspect the results at the e
nd      **"
39 PRINT "**      of each stage for validity.
     **"
40 PRINT "***********************************************************************
*********"
41 '   REVISED OCTOBER 21, 1986
42 '   INTEC ENGINEERING, INC. 16801 GREENSPOINT PARK DRIVE, SUITE 105, HOUSTON,
       TEXAS 77060.
43 '   REMARKS 1) SEE PROGRAM DOCUMENTATION
               2) TAPS TARIFF =$3/BBL.
44 '           3) PIPELINE DESIGN BASED ON CRUDE PROPERTIES AND PRESSURE DROP ON
                  LONGEST OFFSHORE PIPELINE SEGMENT.
60 DIM ROUTLEN(2,4):REM LENGTH OF OFFSHORE PIPELINES (2 LEGS,4 DEPTHS)
65 DIM ETTIME(2,9):REM ELAPSED TIME FOR TRENCHING EQUIPMENT
67 DIM TRENCHYRS(2,8):REM NO. OF YEARS FOR EACH TYPE OF EQPT
68 DIM TRENCOST(2,8):REM NET COST FOR EACH TRENCHING EQUIPMENT
70 DIM MAXTREN(2,4):REM MAXIMUM TRENCH DEPTH (2 LEGS, 4 WATER DEPTHS)
80 INPUT"   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?    ",S$
100 PRINT
105 READ LAT$ :REM LATITUDE DESIGNATION NORTH OR SOUTH OF 60TH PARALLEL
107 PRINT"PIPELINE IS LOCATED --";LAT$;"-- OF THE 60TH PARALLEL              LINE
  1005"
108 IF ((LAT$="NORTH")+(LAT$="SOUTH"))=0 THEN PRINT"***** LATITUDE MUST BE SPECI
FIED AS EITHER NORTH OR SOUTH OF THE 60TH PARALLEL. SPELL IT OUT ON LINE 1005 AN
D RE-RUN":LIST 1005:STOP
110 PRINT"READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO            LINE
1010"
120 READ NOFROUT:REM NUMBER OF OFFSHORE LEGS IN POUTE
130 IF NOFROUT>2 THEN PRINT"******** A MAXIMUM OF 2 OFFSHORE ROUTES PERMITTED, R
EDEFINE AND RE-RUN PROGRAM":STOP
135    FOR I =1 TO NOFROUT
140 PRINT"READING SEG. LENGTHS IN EACH DEPTH ZONE FOR ROUTE ";I;"         ROUTLEN
 1020-1040"
150        FOR J=1 TO 4:REM READ LENGTH IN EACH WATER DEPTH
160            READ ROUTLEN(I,J)
```

```
162         NETLEN(I)=NETLEN(I)+ROUTLEN(I,J):REM NET LENGTH OF EACH LEG
170       NEXT J
175     NEXT I
177 IF NOFROUT=1 THEN RESTORE 1040
180 REM READ TESTDATA TO CHECK DATA
185 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN OFFS
HORE ROUTE DATA, CHECK LINES 1010-1005 AND RE-RUN PROGRAM":LIST 1005-1040:STOP
200 PRINT "READING NUMBER OF ONSHORE ROUTES IN SCENARIO                ROUTLEN1
  1050"
210 READ NONROUT:REM NUMBER OF ONSHORE ROUTE LEGS  IN SCENARIO
230 IF NONROUT>2 THEN PRINT"******** A MAXIMUM OF 2 ONSHORE ROUTES PERMITTED, RE
DEFINE AND RE-RUN PROGRAM":STOP
232 IF NONROUT=0 THEN RESTORE 1080:GOTO 280
235     FOR I =1 TO NONROUT
240 PRINT"READING ONSHORE ROUTE LENGTH FOR ROUTE ";I;"                 ROUTLEN
1 1050-1070"
250     READ ROUTLEN1(I):REM LENGTH OF ONSHORE ROUTE
275     NEXT I
277 IF NONROUT=1 THEN RESTORE 1080
280 REM READ TESTDAT TO CHECK DATA
290 READ TESTDAT
292 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN ONSHORE ROUTE DAT
A, CHECK AND RE-RUN PROGRAM":STOP
300 REM CALC. TOTAL LENGTH OF EACH OFFSHORE ROUTE AND TOTAL PIPELINE LENGTH
305     FOR I=1 TO NOFROUT
307     TOTLEN=TOTLEN+NETLEN(I)
309     NEXT I
310     FOR I=1 TO NONROUT
312     TOTLEN=TOTLEN+ROUTLEN1(I)
315     NEXT I
320 PRINT"            PIPELINE LENGTH SUMMARY FOR SCENARIO ";S$;"   (MILES)"
324 PRINT"                   LEG 1         LEG 2         TOTAL"
326 PRINT" OFFSHORE";TAB(17);NETLEN(1);TAB(32);NETLEN(2);TAB(49);NETLEN(1)+NETLE
N(2);"    (";LAT$;" OF 60 DEG. N.)"
328 PRINT" ONSHORE";TAB(17);ROUTLEN1(1);TAB(32);ROUTLEN1(2);TAB(49);ROUTLEN1(1)+
ROUTLEN1(2)
330 PRINT:PRINT"TOTAL PIPELINE LENGTH ALL ROUTES ";TAB(49);TOTLEN
335 INPUT"   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  ",A$
340 IF A$="Y" THEN PRINT"******* CORRECT ROUTE DATA SET (LINES 1005-1070) AND RE
-RUN PROGRAM":LIST 1005-1070:STOP
342 PRINT:PRINT"READING UNIT COSTS FOR MATERIALS                LINES  1100-110
9
343   FOR I=1 TO 5:READ UCOST(I):NEXT I
344 READ TESTDAT
345 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN UNIT COST DATA LINES 1
100-1108:LIST 1100-1108
350 REM COMPUTE LONGEST OFFSHORE SEGMENT FOR DIAMETER SIZING
355 LONGEST=NETLEN(1):IF NETLEN(2)>LONGEST THEN LONGEST = NETLEN(2)
360 INPUT "   INPUT PRODUCTION RATE (MBPD) ?   ",PRODUCT
375 IF (PRODUCT<25)+(PRODUCT>800) THEN PRINT"**** ARE YOUR SURE? (Y OR N)";:INPU
T A$:IF A$="N" THEN 360
380 CUFOOT=PRODUCT*1000*6.498E-05:REM CONVERT PRODUCTION TO CUBIC FT. PER SEC.
400 REM BEGIN PIPE SIZING
402 DIM IDVAL(26)      'POSSIBLE RANGE OF PIPE INSIDE DIAMETERS
403 DIM ODVAL(26)
404 REM READ PIPE DESIGN DATA
```

```
405 READ CRUDESG:REM READ CRUDE SPECIFIC GRAVITY
410 READ VISCOS:REM CRUDE VISCOSITY
415 READ YIELD:REM PIPE SPECIFIED MINIMUM YIELD STRESS
417 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN PIPE
 DESIGN DATA, CHECK AND RE-RUN PROGRAM":LIST 1119-1150:STOP
418 PRINT:PRINT"CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT"
420 GOSUB 9000            'GO TO PIPELINE SIZING SUBROUTINE
480 PRINT "CALCULATING MATERIAL QUANTITIES"
482 REM CALCULATE LINE PIPE TONNAGE
484 WPF=2.68*(ODPIPE^2-(ODPIPE-2*WALL)^2)
486 REM IF PIPE IS INSULATED MATERIALS COSTS ARE BASED ON A PIPE IN A PIPE
487 REM CASING WALL THICKNESS OF .375 IN ASSUMED
488 WPFI=2.68*((ODPIPE+6)^2-(ODPIPE+6-2*.375)^2)
492 REM CALCULATE SURFACE AREA OF LINE PIPE
494 SFCLP=3.14*ODPIPE/12:REM SQ. FT. PER LINEAL FT.
496 SFCCP=3.14*(ODPIPE+6)/12:REM SURFACE AREA OF CASING PIPE
500 REM DETERMINE CONCRETE THICKNESS
502 REM CONCRETE TH. IS DETERMINED BASED ON A SPGR OF 1.15 EMPTY
504 TEMP=SQR((WPF+WPFI-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI
=(TEMP-(ODPIPE+6))/2
506 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
508 CONCRETI=.00545*190*((ODPIPE+6+2*CONCTHI)^2-(ODPIPE+6)^2):REM INSULATED PIPE
 CONCRETE WEIGHT PER FOOT
510 CONCRET=.00545*190*((ODPIPE+2*CONCTH)^2-(ODPIPE)^2):REM  PIPE CONCRETE WEIGH
T PER FOOT
512 REM CALC ZINC ANODE REQUIREMENTS BASED ON 350 AMP-HRS/LB, 10% HOLIDAY AND 6
MA/SQ FT FOR BURIED PIPELINES AND 20 YEAR LIFE
514 ANODEI=.05*SFCCP*.002*20*365*24/350:REM ANODE WEIGHT PER FOOT FOR INSULATED
515 TEMP=SQR((WPF-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI=(TEM
P-(ODPIPE+6))/2
516 ANODE=.05*SFCLP*.002*20*365*24/350:REM ANODE WT/FT FOR NON-INSULATED LINES
517 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
518 REM CALC INSULATION VOLUME IF REQUIRED
520 INSVOL=.00545*((ODPIPE+6)^2-ODPIPE^2)
525 PRINT"                         OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO ";S$
526 PRINT"                           PIPE DIAMETER ";TAB(49);:PRINT USING "##.###";OD
PIPE;:PRINT"   IN"
527 PRINT"                           PIPE WALL THICKNESS ";TAB(49);:PRINT USING "##.#
##";WALL;:PRINT"   IN"
528 PRINT"                           PIPE STEEL GRADE ";TAB(49);:PRINT USING "##.#";Y
IELD;:PRINT"    KSI"
529 PRINT"                           PIPELINE MAOP ";TAB(47);:PRINT USING "####.#";MA
OP;:PRINT"    PSIG"
530 PRINT"                           CASING DIA. (WHERE REQD) ";TAB(49);:PRINT USING
"##.###";ODPIPE+6;:PRINT "   IN"
531 PRINT"                           CASING WALL                    0.375   IN"
 "
540 PRINT"                           CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTH;:PRINT "   NON-INSULATED"
541 PRINT"                           CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTHI;:PRINT "   INSULATED PIPE"
550 REM COMPUTE NET MATERIALS COSTS
552 INPUT"     ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N
)? ",I$:IF (I$="Y")+(I$="N")=0 THEN GOTO 552
```

```
554     FOR I=1 TO NOFROUT
555     LESHOR(I)=ROUTLEN(I,1)
562     NEXT I
564     FOR I=1 TO NOFROUT
566     LEDEEP(I)=NETLEN(I)-LESHOR(I)
567     NEXT I
570 REM COMPUTE MATERIALS COST FOR NEARSHORE LENGTH ASSUMING THIS SECTION IS INS
ULATED
571 REM MATERIALS UNIT COST DATA FROM LINES 1100-1109
572     FOR I=1 TO NOFROUT
574     PRINT:PRINT"        MATERIAL COST SUMMARY FOR OFFSHORE LEG ";I;" SCENARIO
 ";S$
576     PRINT"                     (ALL COSTS IN 1986 $ MILLIONS) "
577     PRINT"  ITEM               DEPTH<20 FT      DEPTH>20 FT      TOTAL"
579     TCOST=0
580     TEMP1=WPF*UCOST(1)*LESHOR(I)*5280:TEMP2=WPF*UCOST(1)*LEDEEP(I)*5280:LPCST
(I)=TEMP1+TEMP2
582 PRINT"LINE PIPE";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!;TEMP
2/1000000!;LPCST(I)/1000000!:TCOST=TCOST+LPCST(I)
584     TEMP1=WPFI*UCOST(1)*LESHOR(I)*5280:TEMP2=-WPFI*UCOST(1)*LEDEEP(I)*5280*(I
$="Y"):CPCST(I)=TEMP1+TEMP2
586 PRINT"CASING PIPE";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!;TE
MP2/1000000!;CPCST(I)/1000000!:TCOST=TCOST+CPCST(I)
588     TEMP1=(SFCLP+SCFCP)*UCOST(2)*LESHOR(I)*5280:TEMP2= (SFCLP-SFCCP*(I$="Y"))
*UCOST(2)*LEDEEP(I)*5280:CORCST(I)=TEMP1+TEMP2
590 PRINT"CORROSION COAT";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!
;TEMP2/1000000!;CORCST(I)/1000000!:TCOST=TCOST+CORCST(I)
592     TEMP1=(CONCRETI)*UCOST(3)*LESHOR(I)*5280:TEMP2= (CONCRET)*UCOST(3)*LEDEEP
(I)*5280:IF I$="Y" THEN TEMP2=TEMP2*(CONCRETI/CONCRET)
593 CONCST(I)=TEMP1+TEMP2
594 PRINT"CONCRETE COAT";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!;
TEMP2/1000000!;CONCST(I)/1000000!:TCOST=TCOST+CONCST(I)
596     TEMP1=(ANODEI)*UCOST(4)*LESHOR(I)*5280:TEMP2= (ANODE)*UCOST(4)*LEDEEP(I)*
5280:IF I$="Y" THEN TEMP2=TEMP2*(ANODEI/ANODE)
598 ANCST(I)=TEMP1+TEMP2
600 PRINT"ANODES     ";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!;TEM
P2/1000000!;ANCST(I)/1000000!:TCOST=TCOST+ANCST(I)
602     TEMP1=INSVOL*UCOST(5)*LESHOR(I)*5280:TEMP2= -INSVOL*UCOST(5)*LEDEEP(I)*52
80*(I$="Y"):INSCST(I)=TEMP1+TEMP2
604 PRINT"INSULATION   ";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!;
TEMP2/1000000!;INSCST(I)/1000000!:TCOST=TCOST+INSCST(I)
606 REM CALC COST FOR ANNULAR BULKHEADS AND SPACERS
607     TEMP1=((400+22.8*ODPIPE)/80)*LESHOR(I)*5280:TEMP2= 0:IF I$="Y" THEN TEMP2
=((400+22.8*ODPIPE)/80)*LEDEEP(I)*5280
608 BKDCST(I)=TEMP1+TEMP2
609 PRINT"BULKHEADS    ";TAB(20);:PRINT USING "###.#          ";TEMP1/1000000!;
TEMP2/1000000!;BKDCST(I)/1000000!:TCOST=TCOST+BKDCST(I)
620 PRINT TAB(15);:PRINT "SUBTOTAL - LEG ";I;:PRINT TAB(55);:PRINT USING"####.#
 ";TCOST/1000000!
621 TCOST(I)=TCOST
622 NEXT I
630 PRINT"   TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES              ";:PRINT US
ING"####.# ";(TCOST(1)+TCOST(2))/1000000!
660 REM COMPUTE NET LOGISTICS COST FOR OFFSHORE PIPELINE BASED ON $250/TON
662 TEMP=(LPCST(1)+LPCST(2))/UCOST(1)+(CPCST(1)+CPCST(2))/UCOST(1)
664 TEMP=TEMP+(CONCST(1)+CONCST(2))/UCOST(3)
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666 TEMP=TEMP+(ANCST(1)+ANCST(2))/UCOST(4)
668 NETWT=TEMP/2000:REM NET OFFSHORE MATERIALS WEIGHT (TONS)
669 LOGCST=250*NETWT:PRINT"LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/T
ON =    ";INT(LOGCST/1000000!)
670 INPUT"    REPEAT DESIGN AND COST SUMMARY (Y OR N)?",A$:IF A$="Y" THEN 418
680 PRINT"*************************************************************************
*********"
690 PRINT"BEGIN PIPELINE TRENCHING EVALUATION"
700 REM READING TRENCH DEPTHS FOR OFFSHORE LINES
705 PRINT"READING DEPTHS OF COVER                           LINES 1200-1240"
708 FOR I=1 TO 4
710 READ COVER(I) :NEXT I :REM DEPTH OF COVER BY WATER DEPTH RANGE
712 PRINT "READING COST, PRODUCT. FACTORS FOR TRENCHING (";LAT$;") LINES ";:IF L
AT$="NORTH" THEN PRINT"1300-1330" ELSE PRINT"1355-1380"
713 IF LAT$="SOUTH" THEN RESTORE 1364
715     FOR L=0 TO 8
716     READ C1A(L),C1B(L),C1C(L),C2(L),C3(L),V1(L),V2A(L),V2B(L),V2C(L),W(L),CLA
Y(L),SAND(L),WAVE(L),MECH(L),P1(L),P2(L):NEXT L
717 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN ";LAT$;"
TRENCHING FACTORS DATA SET. CHECK AND RE-RUN":IF LAT$="NORTH" THEN LIST 1300-133
0 ELSE LIST 1355-1380
718 IF TESTDAT<>999 THEN STOP
725 RESTORE 1420
730     FOR I= 1 TO NOFROUT
740 PRINT:PRINT"        TRENCHING REQUIREMENTS FOR OFFSHORE PIPELINE LEG ";I;"  S
CENARIO ";S$
750 PRINT"         WATER DEPTH RANGE (FT)        TRENCH DEPTH (FT)     PIPELINE LEN
GTH (MI)"
752 FOR J=1 TO 4
753 IF ROUTLEN(I,J)=0 THEN 790
754 TRENDEP(J)=COVER(J)+ODPIPE/12
756 IF COVER(J)=0 THEN TRENDEP(J)=0
758 IF J=1 THEN PRINT"                0-20 ";TAB(42);:PRINT USING"##.#";TRENDEP(J
);:PRINT TAB(64);ROUTLEN(I,J)
760 IF J=2 THEN PRINT"               20-165";TAB(42);:PRINT USING"##.#";TRENDEP(J
);:PRINT TAB(64);ROUTLEN(I,J)
762 IF J=3 THEN PRINT"              165-190";TAB(42);:PRINT USING"##.#";TRENDEP(J
);:PRINT TAB(64);ROUTLEN(I,J)
764 IF J=4 THEN PRINT"              190-300";TAB(42);:PRINT USING"##.#";TRENDEP(J
);:PRINT TAB(64);ROUTLEN(I,J)
790 NEXT J
800 REM
810 TR$(0)="THROUGH-ICE TRENCH/LAY"     :REM NOT VALID FOR BERING SEA
820 TR$(1)="CUTTER SUCTION DREDGE "
821 TR$(2)="CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES"
822 TR$(3)="LINEAR DREDGE"              :REM NOT VALID FOR BERING SEA
823 TR$(4)="TRAILING SUCTION HOPPER DREDGE"
824 TR$(5)="SINGLE PASS PLOW "
826 TR$(6)="MULTI-PASS PLOW "
827 TR$(7)="MECHANICAL TRENCHER"
828 TR$(8)="CONVENTIONAL HIGH PRESSURE JETTING"
829 TR$(9)="TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS O
NLY)"          :REM NOT VALID FOR BERING SEA
830 REM BEGIN INVESTIGATION INTO BEST TRENCHING METHOD
836   REM DEFINE MAXIMUM TRENCH DEPTH ALONG LEG I IN EACH WATER DEPTH ZONE
840 FOR K=1 TO 4
```

```
845 MAXTREN(I,K)=TRENDEP(K)
855 NEXT K
880 REM DEVELOP TRENCHER SELECTION
881 PRINT"*************   OFFSHORE PIPELINE LEG  ";I;" SCENARIO ";S$;" ****"
882   FOR W=1 TO 4
883   IF W>1 THEN 889        :REM 0 - 20 FT WATER DEPTHS
884   IF MAXTREN(I,1)=0 THEN 920
885 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 0-20 FT:"
886   IF MAXTREN(I,1)<=6 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"5-";TR$(5)
:PRINT"6-";TR$(6):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",T:TRENCHER(W)=T:IF
 (T=1)+(T=2)+(T=5)+(T=6)=0 THEN 886 ELSE 920
887   IF MAXTREN(I,1)<=10 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"6-";TR$(6
):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",T:TRENCHER(W)=T:IF (T=1)+(T=2)+(T=
6)=0 THEN 887 ELSE 920
888   PRINT"1-";TR$(1):PRINT"2-";TR$(2):INPUT"        ENTER YOUR CHOICE (BY NUMBER
)",TRENCHER(W):GOTO 920
889 IF W>2 THEN 901        :REM 20 - 165 FT WATER DEPTH
890   IF MAXTREN(I,2)=0 THEN 920
891 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 20-165 FT:"
892   IF MAXTREN(I,2)<=6 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"4-";TR$(4)
:PRINT "5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";TR$(8)
893 IF MAXTREN(I,2)<=6 THEN INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER
(W):GOTO 920
894   IF MAXTREN(I,2)<=10 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"4-";TR$(4
):PRINT "6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";TR$(8)
896 IF MAXTREN(I,2)<=10 THEN INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
897   IF MAXTREN(I,2)<=13 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"4-";TR$(4
):PRINT"7-";TR$(7):PRINT"8-";TR$(8)
899 IF MAXTREN(I,2)<=13 THEN INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
900   PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"4-";TR$(4):INPUT"        ENTER YOUR
 CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
901   IF W>3 THEN 909              :REM 165 - 190 FT WATER DEPTH
902   IF MAXTREN(I,3)=0 THEN 920
903 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH 165-190 FT:"
904   IF MAXTREN(I,3)<=6 THEN PRINT"4-";TR$(4):PRINT"5-";TR$(5):PRINT"6-";TR$(6)
:PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",T
RENCHER(W):GOTO 920
905   IF MAXTREN(I,3)<=10 THEN PRINT"4-";TR$(4):PRINT"6-";TR$(6):PRINT"7-";TR$(7
):PRINT"8-";TR$(8):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO
920
906   IF MAXTREN(I,3)<=13 THEN PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8
):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
907   PRINT"4-";TR$(4):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):I
F (TRENCHER(W)=4)=0 THEN 907 ELSE GOTO 920
909   IF MAXTREN(I,4)=0 THEN 920           :REM 190 - 300 FT WATER DEPTH
910 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH   >190 FT:"
911   IF MAXTREN(I,4)<=6 THEN PRINT"5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7)
:PRINT"8-";TR$(8):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 9
20
912 PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"        ENTER YOUR C
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HOICE (BY NUMBER)",TRENCHER(W):GOTO 920
920 NEXT W
980 REM GOTO TRENCHING COST SECTION -LINE 2000
982 GOTO 2000
1000 REM THIS IS DATA SECTION
1005 DATA SOUTH :REM OFFSHORE PIPELINES LOCATED NORTH OR SOUTH OF 60TH PARALLEL
1010 DATA 1:REM THIS IS NUMBER OF OFFSHORE LEGS IN SCENARIO
1020 REM THIS IS LENGTH DATA FOR 1ST OFFSHORE LEG IN STATUTE MILES
1024 DATA  1   :REM WATER DEPTH <20 FT
1026 DATA  142 :REM WATER DEPTH 20-165 FT
1027 DATA  0   :REM WATER DEPTH 165-190 FT
1028 DATA  0   :REM WATER DEPTH 190-300 FT
1030 REM THIS IS LENGTH DATA FOR 2ND OFFSHORE LEG IN STAT. MILES  (OPTIONAL)
1032 DATA  67  :REM <20 FT
1034 DATA  132 :REM 20-165 FT
1035 DATA  0   :REM 165-190 FT
1036 DATA  0   :REM 190-300 FT
1040 DATA 999:REM DATA CHECK
1050 DATA 1:REM THIS IS NUMBER OF ONSHORE LEGS IN SCENARIO
1060 DATA 309:REM LENGTH IN STATUTE MILES OF 1ST ONSHORE LEG
1070 DATA 000:REM LENGTH OF 2ND ONSHORE LEG (OPTIONAL)
1080 DATA 999:REM TEST DATA
1100 REM UNIT COST FOR MATERIALS
1102 DATA .38:REM X-65 PIPE $/LB
1104 DATA .60:REM FBE $/SQFT (APPLIED)
1106 DATA .15:REM CONCRETE WEIGHT COATING (APPLIED)
1108 DATA 1.6:REM ZINC ANODES $/LB
1109 DATA 2.0:REM POLYURETHANE FOAM INSULATION $/CUFT
1110 DATA 999
1119 REM PIPE DESIGN DATA
1120 DATA .89      :REM CRUDE OIL SPECIFIC GRAVITY
1130 DATA 7.3E-04 :REM KINEMATIC VISCOSITY (FT^2/SEC) AT MEAN FLOWING TEMP.
1140 DATA 60      :REM PIPE YIELD STRENGTH (KSI)
1150 DATA 999:REM TEST DATA
1200 REM ASSUMED PIPELINE DEPTHS OF COVER FOR BERING SEA. ACCOUNTING FOR ICE
     SCOUR, AND PIPE HYDRODYNAMIC STABILITY. (ORIGINAL SEABED TO TOP OF PIPE)
1210 DATA 5.0    :REM DEPTH OF COVER  0  -  20 FT WATER DEPTH (FEET)
1220 DATA 5.0    :REM DEPTH OF COVER  20 - 165 FT WATER DEPTH (FEET)
1230 DATA 3.0    :REM DEPTH OF COVER 165 - 190 FT WATER DEPTH (FEET)
1240 DATA 3.0    :REM DEPTH OF COVER 190 - 300 FT WATER DEPTH (FEET)
1300 REM COST AND PRODUCTION RATE FACTORS FOR TRENCHING EQUIPMENT
1305 REM      DATA FOR NORTH OF 60 DEG. N. LATITUDE
1310 REM  C1A  C1B C1C C2 C3 V1 V2A V2B  V2C  W  CLAY SAND WAVE MECH P1 P2
1314 DATA 6,6,6,0,17,1.5,0,0,0,0,1,1,.9,.95,1,0:REM THROUGH-ICE TRENCH/LAY
1315 DATA 15.6,17,24.2,4,15,.5,.8,1.8,6.8,3,.6,1,.61,.8,5.80,.7:REM S/C DREDGE
1316 DATA 15.6,17,24.2,4,20,.5,.8,1.8,6.8,3,.6,1,.61,.7,29,1.2:REM MOD SC DREDGE

1318 DATA 31.1,32.5,39.1,4,0,.8,.8,1.8,6.4,3,.6,1,.79,.8,20.5,.9:REM LINEAR DRDG

1320 DATA 14.7,16.8,23.7,4,5,.4,.5,1.9,6.8,3,.4,1,.97,.95,53,1.6:REM HOPPER
1322 DATA 1.2,3.7,9.3,2,12,0,.9,2.6,6.5,0,1,1,.97,.95,15,0:REM 1 PASS PLOW
1324 DATA .7,1.8,7.1,2,15,0,.5,1.2,5,2,1,1,.97,.95,118,1.2:REM MULTI-PASS PLOW
1326 DATA 10.7,11.8,19.7,4,2,.4,.5,1.2,6.5,3,1,.3,.8,.5,32,1:REM MECH TRENCHER
1328 DATA 21.1,22.5,29.7,4,0,.7,.8,1.8,6.5,3,.4,1,.8,.65,133,2:REM JETTING
1330 DATA 999:REM TESTDAT
1355 REM      DATA FOR SOUTH OF 60 DEG. N. LATITUDE
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1360 REM  C1A  C1B C1C C2 C3 V1 V2A V2B  V2C  W  CLAY SAND WAVE MECH P1 P2
1364 DATA 6,6,6,0,17,1.5,0,0,0,0,1,1,.9,.95,1,0:REM THROUGH-ICE TRENCH/LAY
1365 DATA 15.6,17,24.2,4,15,.5,.8,1.8,6.8,3,.6,1,.4,.8,5.80,.7:REM S/C DREDGE
1366 DATA 15.6,17,24.2,4,20,.5,.8,1.8,6.8,3,.6,1,.4,.7,29,1.2:REM MOD SC DREDGE
1368 DATA 31.1,32.5,39.1,4,0,.8,.8,1.8,6.4,3,.6,1,.6,.8,20.5,.9:REM LINEAR DRDG
1370 DATA 14.7,16.8,23.7,4,5,.4,.5,1.9,6.8,3,.4,1,.9,.95,53,1.6:REM HOPPER
1372 DATA 1.2,3.7,9.3,2,12,0,.9,2.6,6.5,0,1,1,.9,.95,15,0:REM 1 PASS PLOW
1374 DATA .7,1.8,7.1,2,15,0,.5,1.2,5,2,1,1,.9,.95,118,1.2:REM MULTI-PASS PLOW
1376 DATA 10.7,11.8,19.7,4,2,.4,.5,1.2,6.5,3,1,.3,.8,.5,32,1:REM MECH TRENCHER
1378 DATA 21.1,22.5,29.7,4,0,.7,.8,1.8,6.5,3,.4,1,.8,.65,133,2:REM JETTING
1380 DATA 999:REM TESTDAT
1400 REM COST AND PRODUCTION RATE FACTORS FOR INSTALLATION EQUIPMENT
1405 REM        DATA FOR NORTH OF 60 DEG. N. LATITUDE
1410 REM  LC1A  LC1B LC1C LC2 LC3 LV1 LV2A LV2B  LV2C  LW LWAVE LMECH LP1 LP2
1420 DATA 31.7,34.1,39.9,10,7,.8,1.2,3.1,6.9,5,.90,.8,57,.65:REM CONV. BARGE
1430 DATA 37,39.5,44.9,11,15,1.3,1.4,3.1,6.9,5,.95,.8,114,.65:REM 3RD GEN BRGE
1440 DATA 1.8,4.1,9.9,11,210,1.3,1.3,2.9,6.9,5,.90,.8,20.8,0:REM ARCT. LBG
1450 DATA 1.4,4.3,10.9,.6,15,.6,0.7,2.2,5.5,0,.97,.95,5.0,0:REM BOTTOM TOW
1460 DATA 3.3,6.1,12.3,.8,15,.9,1.0,2.5,6.0,.2,.94,.95,2.0,0:REM BOTTOM PULL
1470 DATA 999
1475 REM        DATA FOR SOUTH OF 60 DEG. N. LATITUDE
1476 REM  LC1A  LC1B LC1C LC2 LC3 LV1 LV2A LV2B  LV2C  LW LWAVE LMECH LP1 LP2
1478 DATA 31.7,34.1,39.9,10,7,.8,1.2,3.1,6.9,5,.75,.8,57,.65:REM CONV. BARGE
1480 DATA 37,39.5,44.9,11,15,1.3,1.4,3.1,6.9,5,.9,.8,114,.65:REM 3RD GEN BRGE
1482 DATA 1.8,4.1,9.9,11,210,1.3,1.3,2.9,6.9,5,.80,.8,20.8,0:REM ARCT. LBG
1484 DATA 1.4,4.3,10.9,.6,15,.6,0.7,2.2,5.5,0,.9,.95,5.0,0:REM BOTTOM TOW
1486 DATA 3.3,6.1,12.3,.8,15,.9,1.0,2.5,6.0,.2,.8,.95,2.0,0:REM BOTTOM PULL
1488 DATA 999
1500 REM UNIT COST DATA FOR PUMP STATIONS AND OFFSHORE PRODUCTION STRUCTURE
1510 DATA .0012: COST PER PUMP HORSEPOWER IN MILLIONS
1520 DATA 482:REM FIXED COST FOR OFFSHORE PRODUCTION STRUCTURE
1550 DATA 3.5,.06:REM ONSHORE PIPELINE FIXED COST PER MILE, COST/IN DIA-MI
2000 PRINT"CALCULATING TRENCHING TIMES FOR SPREAD SPECIFIED FOR LEG ";I;" (";LAT
$;" OF 60 DEG.)"
2001 FOR W=1 TO 4      :REM CHECK FOR INVALID TRENCHING EQPT.
2002 IF ((MAXTREN(I,W)<>0)*(TRENCHER(W)=0))=1 THEN 2004
2003 IF ((TRENCHER(W)=3)+(TRENCHER(W)=9))<>0 THEN 2004 ELSE 2005
2004 PRINT:PRINT"*************** WARNING INVALID TRENCHING EQUIPMENT USED.  ****
****************":INPUT"RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N)?  ",BADT$:
IF BADT$="N" THEN 2006 ELSE 880
2005 NEXT W
2006 INPUT"     INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C=CLAY S=SAND) ?  ",
PST$
2007 IF (PST$="S")+(PST$="C")=0 THEN 2006
2008 FOR W=1 TO 4:TTIME(W)=0:NEXT W
2010 REM CALC. COST FOR DEPTH RANGE 0-20 FT
2020 IF MAXTREN(I,1)=0 THEN 2100:REM NO TRENCHING IN THIS DEPTH
2025 PROD=P1(TRENCHER(1))/(MAXTREN(I,1)^P2(TRENCHER(1)))
2050 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(1))
2055 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(1))
2060 PROD(1)=PROD*WAVE(TRENCHER(1))*MECH(TRENCHER(1))
2070 TTIME(1)=ROUTLEN(I,1)/PROD(1)
2100 IF MAXTREN(I,2)=0 THEN 2200:REM NO TRENCHING IN DEPTH 20-165
2110 IF TRENCHER(2)<>9 THEN 2125
2112 PROD=P1(4)/(6^P2(4))
2114 PROD(2)=PROD*SAND(4)*WAVE(4)*MECH(4)
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2116 GOTO 2165
2125 PROD=P1(TRENCHER(2))/(MAXTREN(I,2)^P2(TRENCHER(2)))
2150 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(2))
2155 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(2))
2160 PROD(2)=PROD*WAVE(TRENCHER(2))*MECH(TRENCHER(2))
2165 REM
2170 TTIME(2)=ROUTLEN(I,2)/PROD(2)
2200 IF MAXTREN(I,3)=0 THEN 2300:REM NO TRENCHING IN DEPTH 165-190
2210 IF TRENCHER(3)<>9 THEN 2225
2212 PROD=P1(4)/(6^P2(4))
2214 PROD(3)=PROD*SAND(4)*WAVE(4)*MECH(4)
2216 GOTO 2265
2225 PROD=P1(TRENCHER(3))/(MAXTREN(I,3)^P2(TRENCHER(3)))
2250 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(3))
2255 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(3))
2260 PROD(3)=PROD*WAVE(TRENCHER(3))*MECH(TRENCHER(3))
2265 REM
2270 TTIME(3)=ROUTLEN(I,3)/PROD(3)
2300 IF MAXTREN(I,4)=0 THEN 2400:REM NO TRENCHING IN DEPTH  >190
2325 PROD=P1(TRENCHER(4))/(MAXTREN(I,4)^P2(TRENCHER(4)))
2350 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(4))
2355 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(4))
2360 PROD(4)=PROD*WAVE(TRENCHER(4))*MECH(TRENCHER(4))
2370 TTIME(4)=ROUTLEN(I,4)/PROD(4)
2400 REM COMPUTE NET WEEKS FOR EACH COMPONENT REQUIRED
2410 FOR L=0 TO 9:ETTIME(I,L)=0:NEXT L:REM RESET ALL TO 0
2420     FOR W= 1 TO 4
2425     IF TRENCHER(W)<>9 THEN 2430:REM IF PLOW/DREDGE COMBI. IS NOT USED GO ON
2426     ETTIME(I,4)=ETTIME(I,4)+TTIME(W)
2427     IF W=2 THEN ETTIME(I,6)=ETTIME(I,6)+(ROUTLEN(I,2)/((P1(6)/(6^P2(6)))*CLA
Y(6)*WAVE(6)*MECH(6)))
2428     IF W=3 THEN ETTIME(I,6)=ETTIME(I,6)+(ROUTLEN(I,3))/((P1(6)/(6^P2(6)))*CL
AY(6)*WAVE(6)*MECH(6))
2429 GOTO 2440
2430     ETTIME(I,TRENCHER(W))=ETTIME(I,TRENCHER(W))+TTIME(W)
2440     NEXT W
2445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
2450 FOR L=0 TO 8
2460 IF ETTIME(I,L)<>0 THEN PRINT TR$(L);"- ";TAB(65);:PRINT USING "###.#";ETTIM
E(I,L);:PRINT"WEEKS"
2470 NEXT L
2500 INPUT"     RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? ",A$
2510 IF A$="Y" THEN 880
2550 PRINT"**********************************************************************
**********":PRINT "COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG ";I;
2560   IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT PROCEDURE FOR LEG 2"
2600 NEXT I
2700 PRINT "CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED - ";LAT$

2701 REM         BERING SEA SUMMER CONSTRUCTION SEASON IS APPROX. JUNE THROUGH
                 SEPTEMBER (17 WEEKS) BASED ON SEA ICE AND WAVE CONDITIONS.
                 REF.: BROWER, ET AL.
2702 PRINT"      BERING SEA SUMMER CONSTRUCTION SEASON = APPROX. 17 WEEKS"
2703 SEASON=17
2705 PRINT"   INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG";:IN
PUT MSTC
```

```
2715    FOR I=1 TO NOFROUT
2717    PRINT:PRINT"********** TRENCHING COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
2800  LSEASON=SEASON:REM SAVE THIS VALUE FOR LATER USE IN INSTALLATION EVAL
2900  REM COMPUTE NUMBER OF SEASON FOR EACH TRENCHING EQUIPMENT
2905    TOTRENCST(I)=0
2910    FOR L=0 TO 8
2915    IF ETTIME(I,L)=0 THEN 2970
2920    TRENCHYRS(I,L)=ETTIME(I,L)/SEASON
2925 ICE$="A":REM BASE EQUIPMENT COSTS ON ICE CONDITION A (<3/10 CONCENTRATION)
2930    IF ICE$="A" THEN TEMP=V2A(L):TEMP2=C1A(L)
2932    IF ICE$="B" THEN TEMP=V2B(L):TEMP2=C1B(L)
2934    IF ICE$="C" THEN TEMP=V2C(L):TEMP2=C1C(L)
2935 TEMP3=INT(TRENCHYRS(I,L))+1
2936 PEAKNO=INT(TEMP3/MSTC)-((TEMP3/MSTC)>INT(TEMP3/MSTC)):REM DEFINE PEAK NO. I
N SPREAD
2940    TRENCOST(I,L)=(INT(TRENCHYRS(I,L))+1)*(TEMP2+W(L))+(C2(L)+C3(L))*PEAKNO
2950    TRENCOST(I,L)=TRENCOST(I,L)+ETTIME(I,L)*(V1(L)+TEMP)
2960    PRINT TR$(L);"(PROJECT PEAK=";PEAKNO;") ";INT(TRENCHYRS(I,L))+1;"EQPMNT-
SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";TRENCOST(I,L)
2965    TOTRENCST(I)=TOTRENCST(I)+TRENCOST(I,L)  :REM ADD ALL EQPT
2970    NEXT L
2975    PRINT"   TOTAL TRENCHING COST FOR LEG ";I;"= ";:PRINT TAB(73);:PRINT USI
NG "####.#";TOTRENCST(I):PRINT
2990 NEXT I
4000 REM BEGIN PIPE INSTALLATION SECTION
4001 PRINT"******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS
 *********":PRINT
4010 IN$(1)="CONVENTIONAL LAYBARGE "
4020 IN$(2)="3RD GENERATION LAYBARGE"
4030 IN$(3)="ARCTIC LAYBARGE"        :REM NOT VALID FOR BERING SEA
4040 IN$(4)="BOTTOM TOW"
4050 IN$(5)="BOTTOM PULL"
4100 REM READ INSTALLATION FACTORS FOR NORTH OR SOUTH OF 60 DEG. N. LATITUDE
4102 PRINT"READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION (";LAT$;")  LINES
 ";:IF LAT$="NORTH" THEN PRINT"1400-1470" ELSE PRINT"1475-1488"
4106 IF LAT$="SOUTH" THEN RESTORE 1478
4118   FOR L=1 TO 5
4120   READ LC1A(L),LC1B(L),LC1C(L),LC2(L),LC3(L),LV1(L),LV2A(L),LV2B(L),LV2C(L)
,LW(L),LWAVE(L),LMECH(L),LP1(L),LP2(L):NEXT L
4130 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NUMBER OF VALUES IN ";LAT
$;" INSTALLATION VESSEL DATA FILE, CHECK AND RE-RUN.":IF LAT="NORTH THEN LIST 14
00-1470 ELSE LIST 1475-1488
4132 IF TESTDAT<>999 THEN STOP
4134 RESTORE 1510
4140   FOR I =1 TO NOFROUT
4145   ANETLEN=NETLEN(I)
4150   REM DEVELOP INSTALLATION METHOD SELECTION
4155   IF (LESHOR(I)>0)*(TRENCHER(1)=0)=1 THEN ANETLEN=NETLEN(I)-LESHOR(I)
4160 PRINT:PRINT"FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF ";:PRINT USI
NG "###.#";ANETLEN
4165   IF ANETLEN=0 THEN GOTO 4445
4170  IF ANETLEN<=15 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"4-";IN$(4):PRI
NT"5-";IN$(5):INPUT"        ENTER YOUR CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200

4175  IF ANETLEN<=30 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"4-";IN$(4):INP
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UT"        ENTER YOUR CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200
4180  PRINT "1-";IN$(1):PRINT"2-";IN$(2):INPUT"       ENTER YOUR CHOICE (BY NUMB
ER)",INSTALLER(I):GOTO 4200
4200 REM INSTALLATION COST SECTION
4210 REM CALC. PRODUCTION RATE (MI/WEEK)
4220 LPROD=LP1(INSTALLER(I))/(ODPIPE^LP2(INSTALLER(I)))
4240 LPROD(I)=LPROD*LWAVE(INSTALLER(I))*LMECH(INSTALLER(I))
4400 REM COMPUTE WEEKS FOR EACH LEG
4430 LETTIME(I)=ANETLEN/LPROD(I):REM LAYING ELAPSED TIME FOR LEG I
4435 IF (INSTALLER(I)=4)+(INSTALLER(I)=5)<0 THEN 4445
4437 IF I$="Y" THEN LETTIME(I)=1.25*LETTIME(I):REM REDUCE PRODUCTION RATE BY 25%
 IF PIPE IS INSULATED.  THIS IS BASED ON USE OF PIPE IN PIPE WITH PREFABRICATED
END FORGINGS ALLOWING 1 CIRCUMFERENTIAL WELD ON BARGE
4440 LETTIME(I)=LETTIME(I)+1.43:REM 1.43 WKS FOR TIE-INS
4445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
4450    IF ANETLEN=0 THEN PRINT "***** ENTIRE LEG ";I;" IS INSTALLED DURING THROU
GH-ICE TRENCHING IN WINTER":GOTO 4590
4460 PRINT IN$(INSTALLER(I));"- ";TAB(65);:PRINT USING "###.#";LETTIME(I);:PRINT
"WEEKS"
4575     INPUT"      RE-RUN INSTALLATION EQUIPMENT SELECTION  ?(Y OR N)",A$
4580     IF A$="Y" THEN 4150
4590    PRINT"*****************************************************************
*************":PRINT "COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG ";I;
4592    IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT FOR LEG 2"
4600 NEXT I
4700 PRINT"CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED - ";LA
T$
4712 INPUT"   INPUT MAX. NO. OF SEASONS ALLOCATED TO INSTALLATION OF EACH LEG
",MSLC
4715   FOR I=1 TO NOFROUT
4717     PRINT:PRINT"********INSTALLATION COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
4747 REM RECALL AVERAGE INSTALLATION SEASON FROM TRENCHING EVALUATION
4750  IF ICE$="B" THEN LSEASON=LSEASON+4
4760  IF ICE$="C" THEN LSEASON=LSEASON+8
4765  PRINT"  MARINE CONSTRUCTION SEASON FOR THIS LEG = ";LSEASON;" WEEKS"
4770  REM COMPUTE NUMBER OF SEASON FOR INSTALLATION EQUIPMENT
4780    LAYRS(I)=LETTIME(I)/LSEASON
4790    IF ICE$="A" THEN TEMP=LV2A(INSTALLER(I)):TEMP2=LC1A(INSTALLER(I))
4792    IF ICE$="B" THEN TEMP=LV2B(INSTALLER(I)):TEMP2=LC1B(INSTALLER(I))
4794    IF ICE$="C" THEN TEMP=LV2C(INSTALLER(I)):TEMP2=LC1C(INSTALLER(I))
4796 TEMP3=INT(LAYRS(I))+1
4798 PEAKNO=INT(TEMP3/MSLC)-((TEMP3/MSLC)>INT(TEMP3/MSLC))
4800    LAYCOST(I)=(INT(LAYRS(I))+1)*(TEMP2+LW(INSTALLER(I)))+(LC2(INSTALLER(I))
+LC3(INSTALLER(I)))*PEAKNO
4810    LAYCOST(I)=LAYCOST(I)+LETTIME(I)*(LV1(INSTALLER(I))+TEMP)
4850    PRINT IN$(INSTALLER(I));"(PROJECT PEAK=";PEAKNO;") ";INT(LAYRS(I))+1;"EQ
PMNT-SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";LAYCOST(I)
4900 NEXT I
4950 REM INPUT"  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)",A$:IF A$="Y" THEN
GOTO 4700
5000 PRINT"READING PUMP AND PRODUCTION TERMINAL COSTS         1500-1520"
5005 READ PMPCST,PTERCST
5008 PRINT"CALCULATING PUMP STATION AND TERMINAL COSTS"
5020    PUMPPWR(1)=.022*PRODUCT*MAOP*(-(NOFROUT<>0))
5030    PUMPPWR(2)=PUMPPWR(1)*(NETLEN(2)/NETLEN(1))
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5040     PUMPCOST(1)=PMPCST*PUMPPWR(1)
5050     PUMPCOST(2)=PMPCST*PUMPPWR(2)
5060 IF NOFROUT=0 THEN PTERCOST=0:IF NO OFFSHORE LEG IS INCL. THEN NO PROD. STRU
CTURE
5100 PRINT "READING ONSHORE PIPELINE COST FACTORS                    1550"
5210 READ LNDPL1,LNDPL2
5220 LNDPLCST=LNDPL1+ODPIPE*LNDPL2
5240 IF NOFROUT=0 THEN 5300
5250 FOR I=1 TO NOFROUT
5270 NEXT I
5500 REM ACCUMULATE ALL PIPELINE COSTS AND DISPLAY RESULTS
5505 PRINT"****************** CAPITAL COST SUMMARY - SCENARIO ";S$;"  *******":
PRINT"                          (1986 MILLIONS OF $)":PRINT
5510 IF NOFROUT=0 THEN 5700
5520 IF NOFROUT>=1 THEN PRINT "OFFSHORE PIPELINE (BERING SEA ";LAT$;" OF 60TH PA
RALLEL)"
5530 IF NOFROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5531 PRINT"   MATERIALS";
5532 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";TCOST(1)/1000000!;
5535 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";TCOST(2)/1000000!;
5545 PRINT TAB(65);:PRINT USING "###.#";(TCOST(1)+TCOST(2))/1000000!
5547     TEMP=(TCOST(1)+TCOST(2))/1000000!
5550 PRINT"   MATERIALS LOGISTICS";TAB(65);:PRINT USING"###.#";LOGCST/1000000!
5552     TEMP=TEMP+LOGCST/1000000!
5555 PRINT "   TRENCHING";
5560 IF NOFROUT=2 THEN PRINT TAB(44);:PRINT USING"####.#";TOTRENCST(1);
5565 IF NOFROUT=2 THEN  PRINT TAB(56);:PRINT USING"####.#";TOTRENCST(2);
5570 PRINT TAB(64);:PRINT USING "####.#";TOTRENCST(1)+TOTRENCST(2)
5572     TEMP=TEMP+TOTRENCST(1)+TOTRENCST(2)
5575 PRINT "   INSTALLATION, TIE-INS/ SHORE CROSSINGS";
5580 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING "###.#";LAYCOST(1);
5585 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";LAYCOST(2);
5590 PRINT TAB(65);:PRINT USING "###.#";LAYCOST(1)+LAYCOST(2)
5592     TEMP=TEMP+LAYCOST(1)+LAYCOST(2)
5600 PRINT"   PUMP STATION(S)";
5610 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";PUMPCOST(1);
5620 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";PUMPCOST(2);
5625 PRINT TAB(65);:PRINT USING "###.#";PUMPCOST(1)+PUMPCOST(2):TEMP=TEMP+PUMPCO
ST(1)+PUMPCOST(2)
5640 PRINT"  PROJECT SERVICES (15%) :";TAB(65);:PRINT USING "###.#";.15*TEMP
5650    TEMP=1.15*TEMP
5660 PRINT"  CONTINGENCY (25%):";TAB(65);:PRINT USING "###.#";.25*TEMP
5670    TEMP=TEMP*1.25
5680 PRINT "     TOTAL OFFSHORE PIPELINE CAPITAL COSTS:";TAB(70);:PRINT USING "#
###.#";TEMP:OFCAPEX=TEMP
5700 IF NONROUT=0 THEN 5800
5705 PRINT
5710 IF NONROUT>=1 THEN PRINT "ONSHORE PIPELINE COSTS"
5730 IF NONROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5732 IF NONROUT=2 THEN PRINT TAB(45);:PRINT USING"####.#";LNDPLCST*ROUTLEN1(1);
5735 IF NONROUT=2 THEN PRINT TAB(57);:PRINT USING"###.#";LNDPLCST*ROUTLEN1(2);
5745 PRINT TAB(65);:PRINT USING "####.#";LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2)):ONCA
PEX=LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5800 PRINT"PRODUCTION STRUCTURE COSTS:";TAB(65);:PRINT USING"###.#";PTERCST
5802     TEMP=TEMP+PTERCST
5810 TEMP=TEMP+LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
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5815 PRINT
5820 PRINT"    TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE ";TAB(70
);:PRINT USING"####.#";TEMP
5850 REM
5855 INPUT"  RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? ",A$
5857 IF A$="Y" THEN 5500
5860 PRINT"CALCULATING OPERATING COSTS"
5900 REM OPERATING COSTS FOR OFFSHORE PIPELINE ARE TAKEN AS 2% OF CAPEX
5910 REM OPERATING COSTS FOR ONSHORE PIPELINE ARE TAKEN AS 3.5% OF CAPEX
5920 OFOPEX=.02*OFCAPEX
5930 ONOPEX=.035*ONCAPEX
5940 INPUT"   DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? ",A$
5945 TAPSTAR=0
5950 IF A$="Y" THEN TAPSTAR=3*365*PRODUCT/1000!
5960 INPUT"   LIFE OF PIPELINE SYSTEM (YEARS)? ",LIFE
5970 INPUT"   INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  ",CIF
5980 CIF=CIF/100
5985 PRINT
5990 PRINT"        PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYS
TEM "
5995 PRINT"                              YEAR (SCENARIO ";S$;" )"
6000 PRINT" ACCOUNT   ";:FOR J=1 TO LIFE STEP 2:PRINT TAB(9+3*J);:PRINT J;:NEXT
J:PRINT
6010 PRINT:TEMP1=0:TEMP2=0:TEMP3=0
6020 IF NOFROUT<=0 THEN 6030 ELSE PRINT"OFFSHORE PL";:FOR J=1 TO LIFE :TEMP1=TEM
P1 +OFOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";OFOPEX*(1/((1+CIF)^(J-1)));
6025 NEXT J:PRINT
6030 IF NONROUT<=0 THEN 6040 ELSE PRINT"ONSHORE PL ";:FOR J=1 TO LIFE:TEMP2=TEMP
2+ONOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT US
ING "###  ";ONOPEX*(1/((1+CIF)^(J-1)));
6035 NEXT J:PRINT
6040 IF TAPSTAR<=0 THEN 6050 ELSE PRINT"TAPS TARIFF";:FOR J=1 TO LIFE :TEMP3=TEM
P3+TAPSTAR*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";TAPSTAR*(1/((1+CIF)^(J-1)));
6045 NEXT J:PRINT
6050 PRINT:PRINT"  NET PRESENT VALUE OF OPERATING COSTS = ";:PRINT USING "#####.
#";(TEMP1+TEMP2+TEMP3)
6055 PRINT"  TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)= ";TEMP+TEMP1+
TEMP2+TEMP3;" MILLION $"
6060 INPUT"  RE-RUN OPERATING COST CALCULATION (Y OR N)  ";A$
6070 IF A$="Y" THEN 5970
6080 PRINT"*************  END OF INTEC ENGINEERING PROGRAM BERPIPE  ***********
**********"
8999 END
9000 REM
                 PIPELINE SIZING SUBROUTINE
     REM
9020 FRICT=.026  '    STARTING VALUE FOR FRICTION FACTOR
9023 PRINT "PIPELINE DESIGN OPTIONS INCLUDE:"
9024 PRINT "                  PIPE OD (IN)      APPROX. MAOP (PSIG)"
9030    IDVAL(1)=6!: ODVAL(1)=6.625
9040    IDVAL(2)=8!: ODVAL(2)=8.625
9050    IDVAL(3)=10!: ODVAL(3)=10.75
9060    IDVAL(4)=12!: ODVAL(4)=12.75
9070    IDVAL(5)=13!: ODVAL(5)=14!
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9080    FOR I=1 TO 25      'LIST PIPE DESIGN OPTIONS
9090    FLOWVEL=CUFOOT/(3.1416*((IDVAL(I)/12)^2)/4)
9100    IF FLOWVEL>20 GOTO 9160    'REJECT HIGH FLOW VELOCITY CASES, >20 FT/SEC
9110    IF (FLOWVEL<3)  AND (IDVAL(I)>13) GOTO 9160  ' REJECT LOW VELOCITIES
9115    IF FLOWVEL<1.5 GOTO 9160
9117    '      CALCULATE APPROX. PRESSURE DROP
9120    HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDVAL(I)/12)*2*32.2)
9130    DELTP=HF*62.4*CRUDESG/144
9140    IF DELTP>2500 GOTO 9160   '    REJECT HIGH PRESSURE DROP CASES
9150    PRINT TAB(20); ODVAL(I); TAB(40); USING"####."; (DELTP+50)
9160    IF I>=5 THEN ODVAL(I+1)=ODVAL(I)+2
9170    IF I>=5 THEN IDVAL(I+1)=ODVAL(I+1)-(2*ODVAL(I+1)/48)
9300    NEXT I
9400 KS=.00015   '     ROUGHNESS FOR STEEL PIPE (FT)
9430 WALL=.5            'STARTING VALUE
9435 INPUT"SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? ",ODPIPE
9437 DOT$="N"
9438     'ITERATE TO FIND WALL THICKNESS
9440    IDPIPE=ODPIPE-(2*WALL)
9450    FLOWVEL=CUFOOT/(3.1416*((IDPIPE/12)^2)/4)
9455    IF FLOWVEL>25 THEN PRINT"***** ARE YOU SURE? (Y OR N)";:INPUT F$:IF F$="
N" THEN 9430
9460    REYNOLDS=FLOWVEL*(IDPIPE/12)/VISCOS
9465       'ITERATE TO FIND FRICTION FACTOR
9470       TEMP=FRICT
9480       FRICT=(2.51/(REYNOLDS*(SQR(FRICT))))+(KS/(3.7*(IDPIPE/12)))
9490       FRICT=(-2*(.4342945*LOG(FRICT)))^(-2)
9500       IF (ABS(TEMP-FRICT)) >.0001 THEN GOTO 9470
9530    HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDPIPE/12)*2*32.2)
9540    DELTP=HF*62.4*CRUDESG/144
9550    MAOP=DELTP+50      'ADD 50 PSI FOR STATION LOSSES ETC.
9555    IF DOT$="Y" THEN GOTO 9600           'WT SET BY OD/WT RATIO
9560    TEMP=WALL
9570    WALL=.5*MAOP*ODPIPE/(.72*YIELD*1000)
9580    IF (ABS(TEMP-WALL))>.001 THEN GOTO 9440
9585 IF (ODPIPE/WALL)<=48 THEN GOTO 9600      'CHECK OD/WT RATIO
9586 WALL=(ODPIPE/48):DOT$="Y":GOTO 9440   'ASSUMED MAX. OD/WT RATIO FOR ARCTIC
9600 WALL=(INT((WALL-.0001)*32)+1)/32
9625 IF DOT$="Y" THEN PRINT"   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/
WT RATIO OF 48.  **********"
9627 PRINT
9650 RETURN
```

CHAPTER 4 - BERPIPE USER'S MANUAL

4.3 SAMPLE RUN

```
LOAD"BERPIPE
Ok
RUN
******************************************************************************
**              INTEC ENGINEERING PROGRAM BERPIPE - (REV. 0)                **
**                 BERING SEA PIPELINE COST EVALUATION                      **
**     This program allows rapid cost estimate preparation for crude oil    **
**     pipelines in the Bering Sea and the evaluation of total offshore     **
**     and onshore Alaskan pipeline transportation costs.  It is intended   **
**     to be used only by Participants in the Chukchi Sea Transportation    **
**     Feasibility and Cost Evaluation Joint industry Study - Phase 2.      **
**     Although the cost model used herein will allow rapid assessment of   **
**     the cost impact of various design, installation an trenching         **
**     options available, the user should inspect the results at the end    **
**     of each stage for validity.                                          **
******************************************************************************
   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?   BERPIPE SAMPLE

PIPELINE IS LOCATED --SOUTH-- OF THE 60TH PARALLEL           LINE     1005
READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO         LINE     1010
READING SEG. LENGTHS IN EACH DEPTH ZONE FOR ROUTE  1         ROUTLEN  1020-1040
READING NUMBER OF ONSHORE ROUTES IN SCENARIO                 ROUTLEN1  1050
READING ONSHORE ROUTE LENGTH FOR ROUTE  1                    ROUTLEN1 1050-1070
          PIPELINE LENGTH SUMMARY FOR SCENARIO BERPIPE SAMPLE   (MILES)
                LEG 1          LEG 2          TOTAL
 OFFSHORE       143            0               143    (SOUTH OF 60 DEG. N.)
 ONSHORE        309            0               309

TOTAL PIPELINE LENGTH ALL ROUTES                452
   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  N

READING UNIT COSTS FOR MATERIALS                LINES  1100-1109
   INPUT PRODUCTION RATE (MBPD) ?   400

CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT
PIPELINE DESIGN OPTIONS INCLUDE:
               PIPE OD (IN)      APPROX. MAOP (PSIG)
                   28                 2353
                   30                 1681
                   32                 1231
                   34                  922
                   36                  706
                   38                  550
                   40                  437
SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? 30
   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/WT RATIO OF 48.  *********

CALCULATING MATERIAL QUANTITIES
                 OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO BERPIPE SAMPLE
                   PIPE DIAMETER                 30.000   IN
                   PIPE WALL THICKNESS            0.625   IN
                   PIPE STEEL GRADE              60.0     KSI
                   PIPELINE MAOP               1704.3     PSIG
                   CASING DIA. (WHERE REQD)      36.000   IN
                   CASING WALL                    0.375   IN
                   CONCRETE THICKNESS             2.025   NON-INSULATED
```

```
                    CONCRETE THICKNESS          3.250   INSULATED PIPE
     ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N)? N

        MATERIAL COST SUMMARY FOR OFFSHORE LEG  1  SCENARIO BERPIPE SAMPLE
                 (ALL COSTS IN 1986 $ MILLIONS)
  ITEM             DEPTH<20 FT       DEPTH>20 FT       TOTAL
LINE PIPE             0.4              56.1            56.5
CASING PIPE           0.3               0.0             0.3
CORROSION COAT        0.0               3.5             3.6
CONCRETE COAT         0.2              30.2            30.4
ANODES                0.0               0.5             0.5
INSULATION            0.0               0.0             0.0
BULKHEADS             0.1               0.0             0.1
              SUBTOTAL - LEG  1                             91.3
   TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES                  91.3
LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/TON =        44
    REPEAT DESIGN AND COST SUMMARY (Y OR N)?N
**************************************************************************
BEGIN PIPELINE TRENCHING EVALUATION
READING DEPTHS OF COVER                          LINES 1200-1240
READING COST, PRODUCT. FACTORS FOR TRENCHING (SOUTH) LINES 1355-1380

       TRENCHING REQUIREMENTS FOR OFFSHORE PIPELINE LEG  1   SCENARIO
BERPIPE SAMPLE
        WATER DEPTH RANGE (FT)       TRENCH DEPTH (FT)    PIPELINE LENGTH (MI)
              0-20                         7.5                  1
             20-165                        7.5                142
**************   OFFSHORE PIPELINE LEG   1  SCENARIO BERPIPE SAMPLE ****

FEASIBLE EQPT FOR OBTAINING  7.5 FT TRENCH IN WATER DEPTH OF 0-20 FT:
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
6-MULTI-PASS PLOW
       ENTER YOUR CHOICE (BY NUMBER)1

FEASIBLE EQPT FOR OBTAINING  7.5 FT TRENCH IN WATER DEPTH OF 20-165 FT:
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
4-TRAILING SUCTION HOPPER DREDGE
6-MULTI-PASS PLOW
7-MECHANICAL TRENCHER
8-CONVENTIONAL HIGH PRESSURE JETTING
       ENTER YOUR CHOICE (BY NUMBER)6
CALCULATING TRENCHING TIMES FOR SPREAD SPECIFIED FOR LEG  1  (SOUTH OF 60 DEG.)
     INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C=CLAY S=SAND) ?  S
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO BERPIPE SAMPLE ****

CUTTER SUCTION DREDGE -                                          2.2WEEKS
MULTI-PASS PLOW -                                               15.8WEEKS
     RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? N
**************************************************************************
COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG  1
CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED - SOUTH
     BERING SEA SUMMER CONSTRUCTION SEASON = APPROX. 17 WEEKS
   INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG? 1
```

```
********** TRENCHING COST RESULTS FOR LEG  1  SCENARIO BERPIPE SAMPLE ****
CUTTER SUCTION DREDGE (PROJECT PEAK= 1 )  1 EQPMNT-SEASON(S)=              40.5
MULTI-PASS PLOW (PROJECT PEAK= 1 )  1 EQPMNT-SEASON(S)=                    27.6
   TOTAL TRENCHING COST FOR LEG  1 =                                        68.1

******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS  *********

READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION (SOUTH)  LINES 1475-1488

FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF 143.0
1-CONVENTIONAL LAYBARGE
2-3RD GENERATION LAYBARGE
       ENTER YOUR CHOICE (BY NUMBER)2
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO BERPIPE SAMPLE ****

3RD GENERATION LAYBARGE-                                        17.3WEEKS
     RE-RUN INSTALLATION EQUIPMENT SELECTION  ?(Y OR N)N
*******************************************************************************
COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG  1
CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED - SOUTH
   INPUT MAX. NO. OF SEASONS ALLOCATED TO INSTALLATION OF EACH LEG   2

********INSTALLATION COST RESULTS FOR LEG  1  SCENARIO BERPIPE SAMPLE ****
  MARINE CONSTRUCTION SEASON FOR THIS LEG =  17  WEEKS
3RD GENERATION LAYBARGE(PROJECT PEAK= 1 )  2 EQPMNT-SEASON(S)=          156.8
READING PUMP AND PRODUCTION TERMINAL COSTS         1500-1520
CALCULATING PUMP STATION AND TERMINAL COSTS
READING ONSHORE PIPELINE COST FACTORS              1550
******************* CAPITAL COST SUMMARY - SCENARIO BERPIPE SAMPLE  *******
                        (1986 MILLIONS OF $)

OFFSHORE PIPELINE (BERING SEA SOUTH OF 60TH PARALLEL)
   MATERIALS                                                    91.3
   MATERIALS LOGISTICS                                          44.1
   TRENCHING                                                    68.1
   INSTALLATION, TIE-INS/ SHORE CROSSINGS                      156.8
   PUMP STATION(S)                                              18.0
  PROJECT SERVICES (15%) :                                      56.7
  CONTINGENCY (25%):                                           108.7
     TOTAL OFFSHORE PIPELINE CAPITAL COSTS:                          543.7

ONSHORE PIPELINE COSTS
                                                               1637.7
PRODUCTION STRUCTURE COSTS:                                    482.0

    TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE        2663.4
  RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? N
CALCULATING OPERATING COSTS
   DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? Y
   LIFE OF PIPELINE SYSTEM (YEARS)? 20
   INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  10

       PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYSTEM
                            YEAR (SCENARIO BERPIPE SAMPLE )
 ACCOUNT    1     3     5     7     9    11    13    15    17    19
```

```
OFFSHORE PL 11      9     7     6     5     4     3     3     2     2
ONSHORE PL  57     47    39    32    27    22    18    15    12    10
TAPS TARIFF438    362   299   247   204   169   140   115    95    79

  NET PRESENT VALUE OF OPERATING COSTS =  4740.5
  TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)=  7403.903  MILLION $
  RE-RUN OPERATING COST CALCULATION (Y OR N)  ? N
*************  END OF INTEC ENGINEERING PROGRAM BERPIPE  ********************
Ok
```

CHAPTER 5 BEAUPIPE USER'S MANUAL

CHAPTER 5

BEAUPIPE USER'S MANUAL

5.1 PROGRAM INPUT/OUTPUT GUIDE

The computer program BEAUPIPE evaluates Beaufort Sea crude oil pipeline system costs. Program input and output are describe chronologically in the following paragraphs. Reference is made, where possible, to the CHUKPIPE Program Input/Output Guide (Chapter 3). The sample run described in this chapter has one offshore pipeline leg. Program trenching and installation sections repeat if there is a second offshore leg.

A printed record of all or part of the run can be made by using the "PRINT SCREEN" key while running the program. The program must be run with "Caps Lock" (Capitalization) on.

Load and Run Program

Same as for CHUKPIPE.

Scenario Designation

Same as for CHUKPIPE.

Pipeline Length

Same as for CHUKPIPE.

Production Rate

Same as for CHUKPIPE.

Pipeline Design

Same as for CHUKPIPE.

Pipeline Insulation

Same as for CHUKPIPE.

Materials Cost Summary

Same as for CHUKPIPE.

Trenching Requirements

Program reads pipeline depth of cover calculation parameters (lines 1200 to 1295) and trenching cost/productivity factors.

Program prompt: INPUT AVERAGE ICE KEEL-PIPELINE CONTACT RETURN PERIOD (YEARS)?

User inputs average ice keel-pipeline contact return period.

Program calculates trench depth requirements (original seabed to bottom of trench) and prints a summary. See Section 2.2 for a description of the trench depth calculation procedure.

Program prompt: RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)?

User inputs "Y" to repeat trench depth analysis.

Trenching Equipment Selection

Program prompt: FEASIBLE EQPT FOR OBTAINING XX.X FT TRENCH IN WATER DEPTH OF YY-YY FT:

0 - THROUGH-ICE TRENCH/LAY
1 - CUTTER SUCTION DREDGE
2 - CUTTER SUCTION DREDGE W/DOUBLE SWING WIRES
3 - LINEAR DREDGE
4 - TRAILING SUCTION HOPPER DREDGE
5 - SINGLE PASS PLOW
6 - MULTI-PASS PLOW
7 - MECHANICAL TRENCHER
8 - CONVENTIONAL HIGH PRESSURE JETTING
9 - TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS ONLY)

ENTER YOUR CHOICE (BY NUMBER)

Where:

XX.X = pipeline trench depth (original seabed to bottom of trench); and
YY-YY = water depth range.

Only equipment types feasible for the specified combination of trench depth and water depth are prompted.

User inputs "0" through "8" to select the corresponding equipment type and the program then prompts for the next water depth range. The user should confine the equipment selection to the options listed by the program. (Option

No. 9 is not considered feasible for the Beaufort Sea).

If pipeline trenching is required between 20 and 165 ft water depths, the program will prompt:

TRENCH DEPTH REQUIREMENTS IN 20 TO 165 FT WATER DEPTH ZONE RANGE FROM XX.X TO ZZ.Z FT. FEASIBLE EQUIPMENT INCLUDE: (ONE TYPE FOR ENTIRE ZONE).

Where:

XX.X = minimum required trench depth in that water depth zone; and
ZZ.Z = maximum required trench depth in that water depth zone.

User selects one type of trenching equipment for all trenching in the 20 to 165 ft water depth zone.

Soil Type

Program prompt: INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C = CLAY S = SAND)?

User inputs "C" if the soil is clay or "S" if the soil is sand. If neither is input, the question repeats.

Trenching Spread Times

Same as for CHUKPIPE.

Number of Trenching Seasons

Same as for CHUKPIPE.

Ice Condition

Same as for CHUKPIPE.

Construction Season Duration

The program calculates the average construction season duration along the pipeline route leg and prints results.

Program prompt: DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N)?

User inputs "N" to use the program's calculated season duration or "Y" to input the season duration based on site specific data. If this question is answered with Y, the program will prompt for the season duration input.

The program also checks to ensure that the calculated construction season duration is not equal to zero weeks at the pipeline route end points. If the program calculated durations equal zero, a warning is printed and the user must then specify a more severe Ice Condition or input the season duration to over-ride this data checking routine.

Trenching Cost Summary

Same as for CHUKPIPE.

Installation Equipment Selection

Same as for CHUKPIPE.

Installation Spread Time

Same as for CHUKPIPE.

Number of Installation Seasons

Same as for CHUKPIPE.

Construction Season Duration

Program calculates average installation construction season duration as described for pipeline trenching. If desired, user can input season duration.

Installation Cost Summary

Same as for CHUKPIPE.

Capital Cost Summary

Same as for CHUKPIPE.

TAPS Usage

Same as for CHUKPIPE.

Pipeline System Life

Same as for CHUKPIPE.

Interest Rate

Same as for CHUKPIPE.

Pipeline System Operating Costs

Same as for CHUKPIPE.

Total Pipeline System Present Worth Cost

Same as for CHUKPIPE.

CHAPTER 5 - BEAUPIPE USER'S MANUAL

5.2 PROGRAM LISTING

```
10 PRINT"*************************************************************************
********"
20 PRINT "**             INTEC ENGINEERING PROGRAM BEAUPIPE - (REV. 0)
      **"
30 PRINT "**                 BEAUFORT SEA PIPELINE COST EVALUATION
      **"
31 PRINT "**    This program allows rapid cost estimate preparation for crude oi
l       **"
32 PRINT "**    pipelines in the Beaufort Sea and the evaluation of total offsho
re      **"
33 PRINT "**    and onshore Alaskan pipeline transportation costs.  It is intend
ed      **"
34 PRINT "**    to be used only by Participants in the Chukchi Sea Transportatio
n       **"
35 PRINT "**    Feasibility and Cost Evaluation Joint Industry Study - Phase 2.
      **"
36 PRINT "**    Although the cost model used herein will allow rapid assessment
of      **"
37 PRINT "**    the cost impact of various design, installation and trenching
      **"
38 PRINT "**    options available, the user should inspect the results at the en
d       **"
39 PRINT "**    of each stage for validity.
      **"
40 PRINT "************************************************************************
*********"
41 '   REVISED OCTOBER 21, 1986
42 '   INTEC ENGINEERING, INC. 16801 GREENSPOINT PARK DRIVE, SUITE 105, HOUSTON,
       TEXAS 77060.
43 '   REMARKS 1) SEE PROGRAM DOCUMENTATION
               2) TAPS TARIFF =$3/BBL.
44 '           3) PIPELINE DESIGN BASED ON CRUDE PROPERTIES AND PRESSURE DROP ON
                  LONGEST OFFSHORE PIPELINE SEGMENT.
60 DIM ROUTLEN(2,8):REM LENGTH OF OFFSHORE PIPELINES (2 LEGS,8 DEPTHS)
65 DIM ETTIME(2,9):REM ELAPSED TIME FOR TRENCHING EQUIPMENT
67 DIM TRENCHYRS(2,8):REM NO. OF YEARS FOR EACH TYPE OF EQPT
68 DIM TRENCOST(2,8):REM NET COST FOR EACH TRENCHING EQUIPMENT
70 DIM MAXTREN(2,8):REM MAXIMUM TRENCH DEPTH (2 LEGS, 8 WATER DEPTHS)
80 INPUT"   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?    ",S$
105 PRINT
110 PRINT"READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO         LINE   1
010"
120 READ NOFROUT:REM NUMBER OF OFFSHORE LEGS IN ROUTE
130 IF NOFROUT>2 THEN PRINT"******** A MAXIMUM OF 2 OFFSHORE ROUTES PERMITTED, R
EDEFINE AND RE-RUN PROGRAM":STOP
135    FOR I =1 TO NOFROUT
140 PRINT"READING SEG. LENGTHS IN EACH DEPTH FOR ROUTE ";I;" ROUTLEN  1020-1040"

145    READ PLEND(I,1),PLEND(I,2) :REM READ DIST. OFFSHORE FOR PIPELINE END PTS
150       FOR J=1 TO 8:REM READ LENGTH IN EACH WATER DEPTH
160          READ ROUTLEN(I,J)
162          NETLEN(I)=NETLEN(I)+ROUTLEN(I,J):REM NET LENGTH OF EACH LEG
170       NEXT J
175    NEXT I
177 IF NOFROUT=1 THEN RESTORE 1040
180 REM READ TESTDATA TO CHECK DATA
```

```
185 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN OFFS
HORE ROUTE DATA, CHECK LINES 1020-1039 AND RE-RUN PROGRAM":LIST 1020-1039:STOP
200 PRINT "READING NUMBER OF ONSHORE ROUTES IN SCENARIO                  ROUTLEN1
  1050"
210 READ NONROUT:REM NUMBER OF ONSHORE ROUTE LEGS  IN SCENARIO
230 IF NONROUT>2 THEN PRINT"******** A MAXIMUM OF 2 ONSHORE ROUTES PERMITTED, RE
DEFINE AND RE-RUN PROGRAM":STOP
232 IF NONROUT=0 THEN RESTORE 1080:GOTO 280
235     FOR I =1 TO NONROUT
240 PRINT"READING ONSHORE ROUTE LENGTH FOR ROUTE ";I;"                    ROUTLEN
1 1050-1070"
250     READ ROUTLEN1(I):REM LENGTH OF ONSHORE ROUTE
275     NEXT I
277 IF NONROUT=1 THEN RESTORE 1080
280 REM READ TESTDAT TO CHECK DATA
290 READ TESTDAT
292 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN ONSHORE ROUTE DAT
A, CHECK AND RE-RUN PROGRAM":STOP
300 REM CALC. TOTAL LENGTH OF EACH OFFSHORE ROUTE AND TOTAL PIPELINE LENGTH
305     FOR I=1 TO NOFROUT
307     TOTLEN=TOTLEN+NETLEN(I)
309     NEXT I
310     FOR I=1 TO NONROUT
312     TOTLEN=TOTLEN+ROUTLEN1(I)
315     NEXT I
320 PRINT"           PIPELINE LENGTH SUMMARY FOR SCENARIO ";S$;"   (MILES)"
324 PRINT"                 LEG 1           LEG 2          TOTAL"
326 PRINT" OFFSHORE";TAB(17);NETLEN(1);TAB(32);NETLEN(2);TAB(49);NETLEN(1)+NETLE
N(2)
328 PRINT" ONSHORE";TAB(17);ROUTLEN1(1);TAB(32);ROUTLEN1(2);TAB(49);ROUTLEN1(1)+
ROUTLEN1(2)
330 PRINT:PRINT"TOTAL PIPELINE LENGTH ALL ROUTES ";TAB(49);TOTLEN
335 INPUT"   DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  ",A$
340 IF A$="Y" THEN PRINT"******* CORRECT ROUTE DATA SET (LINES 1010-1039) AND RE
-RUN PROGRAM":LIST 1010-1039:STOP
342 PRINT:PRINT"READING UNIT COSTS FOR MATERIALS                 LINES  1100-110
9
343   FOR I=1 TO 5:READ UCOST(I):NEXT I
344 READ TESTDAT
345 IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN UNIT COST DATA LINES 1
100-1108:LIST 1100-1108
350 REM COMPUTE LONGEST OFFSHORE SEGMENT FOR DIAMETER SIZING
355 LONGEST=NETLEN(1):IF NETLEN(2)>LONGEST THEN LONGEST = NETLEN(2)
360 INPUT "   INPUT PRODUCTION RATE (MBPD) ?   ",PRODUCT
375 IF (PRODUCT<25)+(PRODUCT>800) THEN PRINT"**** ARE YOUR SURE? (Y OR N)";:INPU
T A$:IF A$="N" THEN 360
380 CUFOOT=PRODUCT*1000*6.498E-05:REM CONVERT PRODUCTION TO CUBIC FT. PER SEC.
400 REM BEGIN PIPE SIZING
402 DIM IDVAL(26)     'POSSIBLE RANGE OF PIPE INSIDE DIAMETERS
403 DIM ODVAL(26)
404 REM READ PIPE DESIGN DATA
405 READ CRUDESG:REM READ CRUDE SPECIFIC GRAVITY
410 READ VISCOS:REM CRUDE VISCOSITY
415 READ YIELD:REM PIPE SPECIFIED MINIMUM YIELD STRESS
417 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF DATA POINTS IN PIPE
 DESIGN DATA, CHECK AND RE-RUN PROGRAM":LIST 1119-1150:STOP
```

```
418 PRINT:PRINT"CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT"
420 GOSUB 9000          'GO TO PIPELINE SIZING SUBROUTINE
480 PRINT "CALCULATING MATERIAL QUANTITIES"
482 REM CALCULATE LINE PIPE TONNAGE
484 WPF=2.68*(ODPIPE^2-(ODPIPE-2*WALL)^2)
486 REM IF PIPE IS INSULATED MATERIALS COSTS ARE BASED ON A PIPE IN A PIPE
487 REM CASING WALL THICKNESS OF .375 IN ASSUMED
488 WPFI=2.68*((ODPIPE+6)^2-(ODPIPE+6-2*.375)^2)
492 REM CALCULATE SURFACE AREA OF LINE PIPE
494 SFCLP=3.14*ODPIPE/12:REM SQ. FT. PER LINEAL FT.
496 SFCCP=3.14*(ODPIPE+6)/12:REM SURFACE AREA OF CASING PIPE
500 REM DETERMINE CONCRETE THICKNESS
502 REM CONCRETE TH. IS DETERMINED BASED ON A SPGR OF 1.15 EMPTY
504 TEMP=SQR((WPF+WPFI-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI
=(TEMP-(ODPIPE+6))/2
506 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
508 CONCRETI=.00545*190*((ODPIPE+6+2*CONCTHI)^2-(ODPIPE+6)^2):REM INSULATED PIPE
 CONCRETE WEIGHT PER FOOT
510 CONCRET=.00545*190*((ODPIPE+2*CONCTH)^2-(ODPIPE)^2):REM  PIPE CONCRETE WEIGH
T PER FOOT
512 REM CALC ZINC ANODE REQUIREMENTS BASED ON 350 AMP-HRS/LB, 10% HOLIDAY AND 6
MA/SQ FT FOR BURIED PIPELINES AND 20 YEAR LIFE
514 ANODEI=.05*SFCCP*.002*20*365*24/350:REM ANODE WEIGHT PER FOOT FOR INSULATED
515 TEMP=SQR((WPF-.00545*190*(ODPIPE+6)^2)/(1.15*.3491-.00545*190)):CONCTHI=(TEM
P-(ODPIPE+6))/2
516 ANODE=.05*SFCLP*.002*20*365*24/350:REM ANODE WT/FT FOR NON-INSULATED LINES
517 TEMP=SQR((WPF-.00545*190*(ODPIPE)^2)/(1.15*.3491-.00545*190)):CONCTH=(TEMP-(
ODPIPE))/2
518 REM CALC INSULATION VOLUME IF REQUIRED
520 INSVOL=.00545*((ODPIPE+6)^2-ODPIPE^2)
525 PRINT"                    OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO ";S$
526 PRINT"                       PIPE DIAMETER ";TAB(49);:PRINT USING "##.###";OD
PIPE;:PRINT"   IN"
527 PRINT"                       PIPE WALL THICKNESS ";TAB(49);:PRINT USING "##.#
##";WALL;:PRINT"   IN"
528 PRINT"                       PIPE STEEL GRADE ";TAB(49);:PRINT USING "##.#";Y
IELD;:PRINT"    KSI"
529 PRINT"                       PIPELINE MAOP ";TAB(47);:PRINT USING "####.#";MA
OP;:PRINT"     PSIG"
530 PRINT"                       CASING DIA. (WHERE REQD) ";TAB(49);:PRINT USING
"##.###";ODPIPE+6;:PRINT "   IN"
531 PRINT"                       CASING WALL                 0.375   IN"
 "
540 PRINT"                       CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTH;:PRINT "   NON-INSULATED"
541 PRINT"                       CONCRETE THICKNESS ";TAB(49);:PRINT USING "##.##
#";CONCTHI;:PRINT "   INSULATED PIPE"
550 REM COMPUTE NET MATERIALS COSTS
552 INPUT"     ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N
)? ",I$:IF (I$="Y")+(I$="N")=0 THEN GOTO 552
554     FOR I=1 TO NOFROUT
555     LESHOR(I)=ROUTLEN(I,1)
562     NEXT I
564     FOR I=1 TO NOFROUT
566     LEDEEP(I)=NETLEN(I)-LESHOR(I)
```

```
567    NEXT I
570 REM COMPUTE MATERIALS COST FOR NEARSHORE LENGTH ASSUMING THIS SECTION IS INS
ULATED
571 REM MATERIALS UNIT COST DATA FROM LINES 1100-1109
572    FOR I=1 TO NOFROUT
574    PRINT:PRINT"       MATERIAL COST SUMMARY FOR OFFSHORE LEG ";I;" SCENARIO
 ";S$
576    PRINT"                   (ALL COSTS IN 1986 $ MILLIONS) "
577    PRINT"  ITEM              DEPTH<20 FT      DEPTH>20 FT      TOTAL"
579    TCOST=0
580    TEMP1=WPF*UCOST(1)*LESHOR(I)*5280:TEMP2=WPF*UCOST(1)*LEDEEP(I)*5280:LPCST
(I)=TEMP1+TEMP2
582 PRINT"LINE PIPE";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!;TEMP
2/1000000!;LPCST(I)/1000000!:TCOST=TCOST+LPCST(I)
584    TEMP1=WPFI*UCOST(1)*LESHOR(I)*5280:TEMP2=-WPFI*UCOST(1)*LEDEEP(I)*5280*(I
$="Y"):CPCST(I)=TEMP1+TEMP2
586 PRINT"CASING PIPE";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!;TE
MP2/1000000!;CPCST(I)/1000000!:TCOST=TCOST+CPCST(I)
588    TEMP1=(SFCLP+SCFCP)*UCOST(2)*LESHOR(I)*5280:TEMP2= (SFCLP-SFCCP*(I$="Y"))
*UCOST(2)*LEDEEP(I)*5280:CORCST(I)=TEMP1+TEMP2
590 PRINT"CORROSION COAT";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!
;TEMP2/1000000!;CORCST(I)/1000000!:TCOST=TCOST+CORCST(I)
592    TEMP1=(CONCRETI)*UCOST(3)*LESHOR(I)*5280:TEMP2= (CONCRET)*UCOST(3)*LEDEEP
(I)*5280:IF I$="Y" THEN TEMP2=TEMP2*(CONCRETI/CONCRET)
593 CONCST(I)=TEMP1+TEMP2
594 PRINT"CONCRETE COAT";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!;
TEMP2/1000000!;CONCST(I)/1000000!:TCOST=TCOST+CONCST(I)
596    TEMP1=(ANODEI)*UCOST(4)*LESHOR(I)*5280:TEMP2= (ANODE)*UCOST(4)*LEDEEP(I)*
5280:IF I$="Y" THEN TEMP2=TEMP2*(ANODEI/ANODE)
598 ANCST(I)=TEMP1+TEMP2
600 PRINT"ANODES     ";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!;TEM
P2/1000000!;ANCST(I)/1000000!:TCOST=TCOST+ANCST(I)
602    TEMP1=INSVOL*UCOST(5)*LESHOR(I)*5280:TEMP2= -INSVOL*UCOST(5)*LEDEEP(I)*52
80*(I$="Y"):INSCST(I)=TEMP1+TEMP2
604 PRINT"INSULATION   ";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!;
TEMP2/1000000!;INSCST(I)/1000000!:TCOST=TCOST+INSCST(I)
606 REM CALC COST FOR ANNULAR BULKHEADS AND SPACERS
607    TEMP1=((400+22.8*ODPIPE)/80)*LESHOR(I)*5280:TEMP2= 0:IF I$="Y" THEN TEMP2
=((400+22.8*ODPIPE)/80)*LEDEEP(I)*5280
608 BKDCST(I)=TEMP1+TEMP2
609 PRINT"BULKHEADS    ";TAB(20);:PRINT USING "###.#           ";TEMP1/1000000!;
TEMP2/1000000!;BKDCST(I)/1000000!:TCOST=TCOST+BKDCST(I)
620 PRINT TAB(15);:PRINT "SUBTOTAL - LEG ";I;:PRINT TAB(55);:PRINT USING"####.#
 ";TCOST/1000000!
621 TCOST(I)=TCOST
622 NEXT I
630 PRINT"   TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES            ";:PRINT US
ING"####.# ";(TCOST(1)+TCOST(2))/1000000!
660 REM COMPUTE NET LOGISTICS COST FOR OFFSHORE PIPELINE BASED ON $250/TON
662 TEMP=(LPCST(1)+LPCST(2))/UCOST(1)+(CPCST(1)+CPCST(2))/UCOST(1)
664 TEMP=TEMP+(CONCST(1)+CONCST(2))/UCOST(3)
666 TEMP=TEMP+(ANCST(1)+ANCST(2))/UCOST(4)
668 NETWT=TEMP/2000:REM NET OFFSHORE MATERIALS WEIGHT (TONS)
669 LOGCST=250*NETWT:PRINT"LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/T
ON =   ";INT(LOGCST/1000000!)
670 INPUT"    REPEAT DESIGN AND COST SUMMARY (Y OR N)?",A$:IF A$="Y" THEN 418
```

```
680 PRINT"*********************************************************************************"
690 PRINT"BEGIN PIPELINE TRENCHING EVALUATION"
700 REM CALC. TRENCHING REQUIREMENTS FOR OFFSHORE LINES
705 PRINT"READING PIPELINE TRENCH DEPTH PARAMETERS                LINES 1200-1290"
706 FOR I=1 TO 8: READ TRENCHC(I),GBAR(I),LAMBDA(I),THETA(I),MINDEPTH(I)
707 NEXT I
708 READ TESTDAT :IF TESTDAT<>999 THEN PRINT "INCORRECT NO. OF VALUES IN TRENCHI
NG REQ. DATA SET-LINES 1200-1290. CHECK AND RE-RUN":LIST 1200-1290:STOP
714 PRINT"READING COST, PRODUCTIVITY FACTORS FOR TRENCHING     LINES 1300-1330"
715    FOR L=0 TO 8
716    READ C1A(L),C1B(L),C1C(L),C2(L),C3(L),V1(L),V2A(L),V2B(L),V2C(L),W(L),CLA
Y(L),SAND(L),WAVE(L),MECH(L),P1(L),P2(L):NEXT L
717 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NO. OF VALUES IN TRENCHING
 FACTORS DATA SET- LINES 1314-1330. CHECK AND RE-RUN":LIST 1310-1330:STOP
720 REM
725    FOR I= 1 TO NOFROUT
730 INPUT"     INPUT AVERAGE ICE KEEL-PIPELINE CONTACT RETURN PERIOD (YEARS) ?
",TIME
740    GOSUB 8000                   'GO TO BEAUFORT SEA TRENCH DEPTH SUBROUTINE
796 INPUT"RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)? ",A$:IF A$="Y" THEN 730
800 REM
810 TR$(0)="THROUGH-ICE TRENCH/LAY"
820 TR$(1)="CUTTER SUCTION DREDGE "
821 TR$(2)="CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES"
822 TR$(3)="LINEAR DREDGE"
823 TR$(4)="TRAILING SUCTION HOPPER DREDGE"
824 TR$(5)="SINGLE PASS PLOW "
826 TR$(6)="MULTI-PASS PLOW "
827 TR$(7)="MECHANICAL TRENCHER"
828 TR$(8)="CONVENTIONAL HIGH PRESSURE JETTING"
829 TR$(9)="TRAILING HOPPER DREDGE PLUS MULTI-PASS PLOW (LOOSE OVER HARD SOILS O
NLY)"                          :REM NOT VALID FOR BEAUFORT SEA
830 REM BEGIN INVESTIGATION INTO BEST TRENCHING METHOD
832 MAXTREN(I,1)=TRENDEP(I,1)       '0-20 FT WATER DEPTH ZONE
836   REM DEFINE MAXIMUM TRENCH DEPTH ALONG LEG I IN WATER DEPTH ZONE 20-165 FT
838 MAXTREN(I,2)=0
839 MINTREN(I,2)=100    'STARTING VALUE FOR SHALLOWEST TRENCH IN 20-165 FT ZONE
840   FOR W=2 TO 6
845   IF (TRENDEP(I,W)>MAXTREN(I,2))*(ROUTLEN(I,W)>0)=1 THEN MAXTREN(I,2)=TRENDE
P(I,W)
847   IF (TRENDEP(I,W)<MINTREN(I,2))*(ROUTLEN(I,W)>0)=1 THEN MINTREN(I,2)=TRENDE
P(I,W)
850   NEXT W
855 MAXTREN(I,3)=TRENDEP(I,7)        '165-190 FT WATER DEPTH ZONE
860 MAXTREN(I,4)=TRENDEP(I,8)        '190-300 FT WATER DEPTH ZONE
870 STRATA$="N"         'ASSUME HARD SOIL LAYER NOT PRESENT IN BEAUFORT SEA
880 REM DEVELOP TRENCHER SELECTION
881 PRINT"**************   OFFSHORE PIPELINE LEG  ";I;" SCENARIO ";S$;" ****"
882   FOR W=1 TO 4
883   IF W>1 THEN 889               :REM 0-20 FT WATER DEPTH ZONE
884   IF MAXTREN(I,1)=0 THEN 920
885 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH OF 0-20 FT:"
886   IF MAXTREN(I,1)<=6 THEN PRINT "0-";TR$(0):PRINT"1-";TR$(1):PRINT"2-";TR$(2
):PRINT"5-";TR$(5):PRINT"6-";TR$(6):INPUT"      ENTER YOUR CHOICE (BY NUMBER)",
```

```
T:TRENCHER(W)=T:IF (T=0)+(T=1)+(T=2)+(T=5)+(T=6)=0 THEN 886 ELSE 920
887   IF MAXTREN(I,1)<=10 THEN PRINT"0-";TR$(0):PRINT"1-";TR$(1):PRINT"2-";TR$(2
):PRINT"6-";TR$(6):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",T:TRENCHER(W)=T:I
F (T=0)+(T=1)+(T=2)+(T=6)=0 THEN 887 ELSE 920
888  PRINT"1-";TR$(1):PRINT"2-";TR$(2):INPUT"       ENTER YOUR CHOICE (BY NUMBER
)",TRENCHER(W):GOTO 920
889 IF W>2 THEN 901                                 :REM 20-165 FT WATER DEPTH ZONE
890   IF MAXTREN(I,2)=0 THEN 920
891 PRINT:PRINT"TRENCH DEPTH REQUIREMENTS IN 20 TO 165 FT WATER DEPTH ZONE RANGE
 FROM            ";USING "##.#";MINTREN(I,W);:PRINT " TO ";USING"##.#";MAXTREN(I
,W);:PRINT" FT. FEASIBLE EQUIPMENT INCLUDE: (ONE TYPE FOR ENTIRE ZONE.)"
892   IF MAXTREN(I,2)<=6 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"3-";TR$(3)
:PRINT"4-";TR$(4):PRINT "5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";
TR$(8)
893 IF MAXTREN(I,2)<=6 THEN INPUT"       ENTER YOUR CHOICE (BY NUMBER)",TRENCHER
(W):GOTO 920
894   IF (MAXTREN(I,2)<=10)*(STRATA$="N")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):PRINT "6-";TR$(6):PRINT"7-";TR$(7):PRINT"8
-";TR$(8)
895   IF (MAXTREN(I,2)<=10)*(STRATA$="Y")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"9-";TR$(9)
896 IF MAXTREN(I,2)<=10 THEN INPUT"       ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
897   IF (MAXTREN(I,2)<=13)*(STRATA$="N")=1 THEN PRINT"1-";TR$(1):PRINT"2-";TR$(
2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8)
898   IF (MAXTREN(I,2)<=13)*(STRATA$="Y")=1  THEN PRINT"1-";TR$(1):PRINT"2-";TR$
(2):PRINT"3-";TR$(3):PRINT"9-";TR$(9)
899 IF MAXTREN(I,2)<=13 THEN INPUT"       ENTER YOUR CHOICE (BY NUMBER)",TRENCHE
R(W):GOTO 920
900   PRINT"1-";TR$(1):PRINT"2-";TR$(2):PRINT"3-";TR$(3):PRINT"4-";TR$(4):INPUT"
       ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
901   IF W>3 THEN 909                               :REM 165-190 FT WATER DEPTH ZONE
902   IF MAXTREN(I,3)=0 THEN 920
903 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH 165-190 FT:"
904   IF MAXTREN(I,3)<=6 THEN PRINT"4-";TR$(4):PRINT"5-";TR$(5):PRINT"6-";TR$(6)
:PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",T
RENCHER(W):GOTO 920
905   IF (MAXTREN(I,3)<=10)*(STRATA$="N")=1 THEN PRINT"4-";TR$(4):PRINT"6-";TR$(
6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"       ENTER YOUR CHOICE (BY NUMBER)"
,TRENCHER(W):GOTO 920
906   IF MAXTREN(I,3)<=13 THEN PRINT"4-";TR$(4):PRINT"7-";TR$(7):PRINT"8-";TR$(8
):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 920
907   PRINT"4-";TR$(4):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):I
F (TRENCHER(W)=4)=0 THEN 907 ELSE GOTO 920
908 REM                       190-300 FT WATER DEPTH ZONE
909   IF MAXTREN(I,4)=0 THEN 920
910 PRINT:PRINT"FEASIBLE EQPT FOR OBTAINING ";:PRINT USING "##.#";MAXTREN(I,W);:
PRINT " FT TRENCH IN WATER DEPTH   >190 FT:"
911   IF MAXTREN(I,4)<=6 THEN PRINT"5-";TR$(5):PRINT"6-";TR$(6):PRINT"7-";TR$(7)
:PRINT"8-";TR$(8):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",TRENCHER(W):GOTO 9
20
912 PRINT"6-";TR$(6):PRINT"7-";TR$(7):PRINT"8-";TR$(8):INPUT"       ENTER YOUR C
HOICE (BY NUMBER)",TRENCHER(W):GOTO 920
920 NEXT W
980 REM GOTO TRENCHING COST SECTION -LINE 2000
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982 GOTO 2000
1000 REM THIS IS DATA SECTION
1010 DATA 1:REM THIS IS NUMBER OF OFFSHORE LEGS IN SCENARIO
1020 REM THIS IS LENGTH DATA FOR 1ST OFFSHORE LEG IN STATUTE MILES
1021 DATA 0.0,   45  :REM DIST. NORTH OF ALASKAN SHORELINE AT LEG 1 END POINTS
1022 DATA   4  :REM WATER DEPTH  0-20 FT
1023 DATA   8  :REM WATER DEPTH 20-60 FT
1024 DATA  12  :REM WATER DEPTH 60-90 FT
1025 DATA  16  :REM WATER DEPTH 90-120 FT
1026 DATA  12  :REM WATER DEPTH 120-150 FT
1027 DATA   8  :REM WATER DEPTH 150-165 FT
1028 DATA   5  :REM WATER DEPTH 165-190 FT
1029 DATA   1  :REM WATER DEPTH 190-300 FT
1030 REM THIS IS LENGTH DATA FOR 2ND OFFSHORE LEG IN STAT. MILES  (OPTIONAL)
1031 DATA 30 ,    20 :REM DIST. NORTH OF ALASKAN SHORELINE AT LEG 2 END POINTS
1032 DATA      :REM WATER DEPTH  0-20 FT
1033 DATA      :REM WATER DEPTH 20-60 FT
1034 DATA  10  :REM WATER DEPTH 60-90 FT
1035 DATA   5  :REM WATER DEPTH 90-120 FT
1036 DATA   5  :REM WATER DEPTH 120-150 FT
1037 DATA      :REM WATER DEPTH 150-165 FT
1038 DATA      :REM WATER DEPTH 165-190 FT
1039 DATA      :REM WATER DEPTH 190-300 FT
1040 DATA 999:REM DATA CHECK
1050 DATA 1:REM THIS IS NUMBER OF ONSHORE LEGS IN SCENARIO
1060 DATA 309:REM LENGTH IN STATUTE MILES OF 1ST ONSHORE LEG
1070 DATA 000:REM LENGTH OF 2ND ONSHORE LEG (OPTIONAL)
1080 DATA 999:REM TEST DATA
1100 REM UNIT COST FOR MATERIALS
1102 DATA .38:REM X-65 PIPE $/LB
1104 DATA .60:REM FBE $/SQFT (APPLIED)
1106 DATA .15:REM CONCRETE WEIGHT COATING (APPLIED)
1108 DATA 1.6:REM ZINC ANODES $/LB
1109 DATA 2.0:REM POLYURETHANE FOAM INSULATION $/CUFT
1110 DATA 999
1119 REM PIPE DESIGN DATA
1120 DATA .89      :REM CRUDE OIL SPECIFIC GRAVITY
1130 DATA 7.3E-04 :REM KINEMATIC VISCOSITY (FT^2/SEC) AT MEAN FLOWING TEMP.
1140 DATA 60      :REM PIPE YIELD STRENGTH (KSI)
1150 DATA 999:REM TEST DATA
1200 REM PIPELINE DEPTH OF COVER CALCULATION PARAMETERS
1210 REM C(METERS),GBAR(GOUGES/KM-YR),LAMBDA(1/METERS),THETA(DEGREES),MINDEPTH
(FEET)
1220 DATA 0.2, 5.2,   7.81, 90, 7  :REM  0-20 FT WATER DEPTH
1230 DATA 0.2, 5.2,   4.80, 90, 10 :REM 20-50 FT WATER DEPTH
1240 DATA 0.2, 5.2,   3.33, 90, 10 :REM 50-90 FT WATER DEPTH
1250 DATA 0.2, 5.2,   2.31, 90, 10 :REM 90-120 FT WATER DEPTH
1260 DATA 0.0, 0.013, 1.49, 90, 10 :REM 120-150 FT WATER DEPTH (CANADIAN DATA)
1270 DATA 0.0, 0.013, 2.24, 90, 10 :REM 150-165 FT WATER DEPTH (NOTE: LAMBDA
APPROXIMATED TO YIELD DEPTH =.67 * DEPTH AT 120-150 FT WATER DEPTH)
1280 DATA 0.0, 0.013, 4.47, 90, 5  :REM 165-190 FT WATER DEPTH (NOTE: LAMBDA
APPROXIMATED TO YIELD DEPTH =.33 * DEPTH AT 120-150 FT WATER DEPTH)
1290 DATA 0.0, 0.013, 1E10, 90, 0  :REM 190-300 FT WATER DEPTH (NOTE: LAMBDA
APPROXIMATED TO YIELD DEPTH OF COVER = APPROX. 0.0 FT)
1295 DATA 999 :REM TEST DATA
1300 REM COST AND PRODUCTION RATE FACTORS FOR TRENCHING EQUIPMENT
```

```
1310 REM  C1A  C1B C1C C2 C3 V1 V2A V2B  V2C  W  CLAY SAND WAVE MECH P1 P2
1314 DATA 6,6,6,0,17,1.5,0,0,0,0,1,1,.9,.95,1,0:REM THROUGH-ICE TRENCH/LAY
1315 DATA 15.6,17,24.2,4,15,.5,.8,1.8,6.8,3,.6,1,.61,.8,5.80,.7:REM S/C DREDGE
1316 DATA 15.6,17,24.2,4,20,.5,.8,1.8,6.8,3,.6,1,.61,.7,29,1.2:REM MOD SC DREDGE

1318 DATA 31.1,32.5,39.1,4,0,.8,.8,1.8,6.4,3,.6,1,.79,.8,20.5,.9:REM LINEAR DRDG

1320 DATA 14.7,16.8,23.7,4,5,.4,.5,1.9,6.8,3,.4,1,.97,.95,53,1.6:REM HOPPER
1322 DATA 1.2,3.7,9.3,2,12,0,.9,2.6,6.5,0,1,1,.97,.95,15,0:REM 1 PASS PLOW
1324 DATA .7,1.8,7.1,2,15,0,.5,1.2,5,2,1,1,.97,.95,118,1.2:REM MULTI-PASS PLOW
1326 DATA 10.7,11.8,19.7,4,2,.4,.5,1.2,6.5,3,1,.3,.8,.5,32,1:REM MECH TRENCHER
1328 DATA 21.1,22.5,29.7,4,0,.7,.8,1.8,6.5,3,.4,1,.8,.65,133,2:REM JETTING
1330 DATA 999:REM TESTDAT
1400 REM COST AND PRODUCTION RATE FACTORS FOR INSTALLATION EQUIPMENT
1410 REM  LC1A  LC1B LC1C LC2 LC3 LV1 LV2A LV2B  LV2C  LW LWAVE LMECH LP1 LP2
1420 DATA 31.7,34.1,39.9,10,7,.8,1.2,3.1,6.9,5,.90,.8,57,.65:REM CONV. BARGE
1430 DATA 37,39.5,44.9,11,15,1.3,1.4,3.1,6.9,5,.95,.8,114,.65:REM 3RD GEN BRGE
1440 DATA 1.8,4.1,9.9,11,210,1.3,1.3,2.9,6.9,5,.90,.8,20.8,0:REM ARCT. LBG
1450 DATA 1.4,4.3,10.9,.6,15,.6,0.7,2.2,5.5,0,.97,.95,5.0,0:REM BOTTOM TOW
1460 DATA 3.3,6.1,12.3,.8,15,.9,1.0,2.5,6.0,.2,.94,.95,2.0,0:REM BOTTOM PULL
1470 DATA 999
1500 REM UNIT COST DATA FOR PUMP STATIONS AND OFFSHORE PRODUCTION STRUCTURE
1510 DATA .0012: COST PER PUMP HORSEPOWER IN MILLIONS
1520 DATA 482:REM FIXED COST FOR OFFSHORE PRODUCTION STRUCTURE
1550 DATA 3.5,.06:REM ONSHORE PIPELINE FIXED COST PER MILE, COST/IN DIA-MI
2000 PRINT"CALCULATING TRENCHING TIMES FOR SPREAD SPECIFIED FOR LEG ";I
2001 FOR W= 1 TO 4 :REM CHECK FOR INVALID TRENCHING EQUIPMENT
2002 IF TRENCHER(W)=9 THEN 2004 ELSE 2005
2004 PRINT:PRINT"**** WARNING TRAILING SUCT. HOPPER W/ PLOW ASSUMED NOT VALID FO
R BEAUFORT SEA ":INPUT"       RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? ",B
ADT$:IF BADT$="N" THEN 2006 ELSE 880
2005 NEXT W
2006 INPUT"      INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C=CLAY S=SAND)  ? ",
PST$
2007 IF (PST$="S")+(PST$="C")=0 THEN 2006
2008 FOR W=1 TO 4:TTIME(W)=0:NEXT W
2010 REM CALC. COST FOR DEPTH RANGE 0-20 FT
2020 IF MAXTREN(I,1)=0 THEN 2100:REM NO PIPE IN THIS DEPTH
2025 PROD=P1(TRENCHER(1))/(MAXTREN(I,1)^P2(TRENCHER(1)))
2050 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(1))
2055 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(1))
2060 PROD(1)=PROD*WAVE(TRENCHER(1))*MECH(TRENCHER(1))
2070 TTIME(1)=LESHOR(I)/PROD(1)
2100 IF MAXTREN(I,2)=0 THEN 2200:REM NO PIPE IN DEPTH 20-165
2110 IF TRENCHER(2)<>9 THEN 2118
2112 PROD=P1(4)/(6^P2(4))
2114 PROD(2)=PROD*SAND(4)*WAVE(4)*MECH(4)
2115 TTIME(2)=(ROUTLEN(I,2)+ROUTLEN(I,3)+ROUTLEN(I,4)+ROUTLEN(I,5)+ROUTLEN(I,6))
/PROD(2)
2116 GOTO 2200
2118 REM     20 TO 165 FT WATER DEPTH ZONE IS MADE UP OF 5 SUB-ZONES. CALCULATE
TRENCHING TIME FOR EACH AND TOTAL.
2120 TTIME(2)=0
2125      FOR WD = 2 TO 6
2130      IF TRENDEP(I,WD)=0 THEN 2175
2145      PROD=P1(TRENCHER(2))/(TRENDEP(I,WD)^P2(TRENCHER(2)))
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2150      IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(2))
2155      IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(2))
2160      PROD2=PROD*WAVE(TRENCHER(2))*MECH(TRENCHER(2))
2165      TTIME2=ROUTLEN(I,WD)/PROD2
2170      TTIME(2)=TTIME(2)+TTIME2
2175      NEXT WD
2200 IF MAXTREN(I,3)=0 THEN 2300:REM NO PIPE IN DEPTH 165-190
2210 IF TRENCHER(3)<>9 THEN 2225
2212 PROD=P1(4)/(6^P2(4))
2214 PROD(3)=PROD*SAND(4)*WAVE(4)*MECH(4)
2216 GOTO 2265
2225 PROD=P1(TRENCHER(3))/(MAXTREN(I,3)^P2(TRENCHER(3)))
2250 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(3))
2255 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(3))
2260 PROD(3)=PROD*WAVE(TRENCHER(3))*MECH(TRENCHER(3))
2265 REM
2270 TTIME(3)=ROUTLEN(I,7)/PROD(3)
2300 IF MAXTREN(I,4)=0 THEN 2400:REM NO PIPE IN DEPTH  >190
2325 PROD=P1(TRENCHER(4))/(MAXTREN(I,4)^P2(TRENCHER(4)))
2350 IF PST$="C" THEN PROD=PROD*CLAY(TRENCHER(4))
2355 IF PST$="S" THEN PROD=PROD*SAND(TRENCHER(4))
2360 PROD(4)=PROD*WAVE(TRENCHER(4))*MECH(TRENCHER(4))
2370 TTIME(4)=ROUTLEN(I,8)/PROD(4)
2400 REM COMPUTE NET WEEKS FOR EACH COMPONENT REQUIRED
2410 FOR L=0 TO 9:ETTIME(I,L)=0:NEXT L:REM RESET ALL TO 0
2420     FOR W= 1 TO 4
2425     IF TRENCHER(W)<>9 THEN 2430:REM IF PLOW/DREDGE COMBI. IS NOT USED GO ON
2426     ETTIME(I,4)=ETTIME(I,4)+TTIME(W)
2427     IF W=2 THEN ETTIME(I,6)=ETTIME(I,6)+(ROUTLEN(I,2)+ROUTLEN(I,3)+ROUTLEN(I
,4)+ROUTLEN(I,5)+ROUTLEN(I,6))/((P1(6)/(6^P2(6)))*CLAY(6)*WAVE(6)*MECH(6))
2428     IF W=3 THEN ETTIME(I,6)=ETTIME(I,6)+(ROUTLEN(I,7))/((P1(6)/(6^P2(6)))*CL
AY(6)*WAVE(6)*MECH(6))
2429 GOTO 2440
2430     ETTIME(I,TRENCHER(W))=ETTIME(I,TRENCHER(W))+TTIME(W)
2440     NEXT W
2445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
2450 FOR L=0 TO 8
2460 IF ETTIME(I,L)<>0 THEN PRINT TR$(L);"- ";TAB(65);:PRINT USING "###.#";ETTIM
E(I,L);:PRINT"WEEKS"
2470 NEXT L
2500 INPUT"    RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? ",A$
2510 IF A$="Y" THEN 880
2550 PRINT"**********************************************************************
**********":PRINT "COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG ";I;
2560   IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT PROCEDURE FOR LEG 2"
2600 NEXT I
2700 PRINT "CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED"
2705 PRINT"   INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG";:IN
PUT MSTC
2710 INPUT"   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C
=10/10)",ICE$:IF (ICE$="A")+(ICE$="B")+(ICE$="C")=0 THEN 2710
2715    FOR I=1 TO NOFROUT
2720    REM COMPUTE AVERAGE SEASON LENGTH FOR ICE COVERAGE SPECIFIED
2730       FOR J=1 TO 2
2740       SEASON(I,J)=12-((INT(PLEND(I,J)/10)+1)*2)
2744       IF ICE$="B" THEN SEASON(I,J)=SEASON(I,J)+4
```

```
2746        IF ICE$="C" THEN SEASON(I,J)=SEASON(I,J)+6
2750        IF SEASON(I,J)<0 THEN SEASON(I,J)=0
2765        NEXT J
2770 SEASON=(SEASON(I,1)+SEASON(I,2))/2
2825  PRINT:PRINT"COMPUTED AVERAGE MARINE CONST. SEASON LENGTH ALONG ROUTE LEG "
;I;" = ";SEASON;" WEEKS"
2840 INPUT"   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  ",SEASON$
2845 IF ((SEASON(I,1)=0)*(SEASON$<>"Y"))=1 THEN 2848
2847 IF ((SEASON(I,2)=0)*(SEASON$<>"Y"))=1 THEN 2848 ELSE 2850
2848 PRINT:PRINT"******** WARNING: COMPUTED MEDIAN YEAR MARINE CONST. SEASON EQU
ALS 0 WEEKS ************* FOR A PORTION OF LEG ";I;"******** CHOOSE DIFERENT ICE
 COND. OR INPUT SEASON LENGTH TO OVER-RIDE.":PRINT:GOTO 2710
2850 IF SEASON$="Y" THEN INPUT"   INPUT MARINE CONSTRUCTION SEASON DURATION (WEE
KS) ? ",SEASON
2860 IF (SEASON$="Y")*(SEASON<=1)=1 THEN INPUT"     ARE YOU SURE (Y OR N) ?  ",S
CHECK$ : IF SCHECK$="N" THEN 2840
2870 IF TRENCHER(1)=0 THEN PRINT"WINTER CONSTRUCTION SEASON FOR DEPTHS <20 FT =
15 WEEKS"
2890     PRINT:PRINT"********** TRENCHING COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
2900  REM COMPUTE NUMBER OF SEASON FOR EACH TRENCHING EQUIPMENT
2905     TOTRENCST(I)=0
2910     FOR L=0 TO 8
2915     IF ETTIME(I,L)=0 THEN 2970
2920     TRENCHYRS(I,L)=ETTIME(I,L)/SEASON
2925 IF L=0 THEN TRENCHYRS(I,L)=ETTIME(I,L)/15:REM ASSUME 15 WKS/YR FOR WINTER
2930     IF ICE$="A" THEN TEMP=V2A(L):TEMP2=C1A(L)
2932     IF ICE$="B" THEN TEMP=V2B(L):TEMP2=C1B(L)
2934     IF ICE$="C" THEN TEMP=V2C(L):TEMP2=C1C(L)
2935 TEMP3=INT(TRENCHYRS(I,L))+1
2936 PEAKNO=INT(TEMP3/MSTC)-((TEMP3/MSTC)>INT(TEMP3/MSTC)):REM DEFINE PEAK NO. I
N SPREAD
2940     TRENCOST(I,L)=(INT(TRENCHYRS(I,L))+1)*(TEMP2+W(L))+(C2(L)+C3(L))*PEAKNO
2950     TRENCOST(I,L)=TRENCOST(I,L)+ETTIME(I,L)*(V1(L)+TEMP)
2954 REM  ADD 1 WINTERING COST PER EQUIPMENT SPREAD FOR NOT CLEARING PT. BARROW
2955     TRENCOST(I,L)=TRENCOST(I,L)+(PEAKNO*W(L))
2960     PRINT TR$(L);"(PROJECT PEAK=";PEAKNO;")  ";INT(TRENCHYRS(I,L))+1;"EQPMNT-
SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";TRENCOST(I,L)
2965     TOTRENCST(I)=TOTRENCST(I)+TRENCOST(I,L)  :REM ADD ALL EQPT
2970     NEXT L
2975     PRINT"   TOTAL TRENCHING COST FOR LEG ";I;"= ";:PRINT TAB(73);:PRINT USI
NG "####.#";TOTRENCST(I):PRINT
2990 NEXT I
3000 INPUT"   RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS? (Y OR N)",A$
3010 IF A$="Y" THEN 2700
4000 REM BEGIN PIPE INSTALLATION SECTION
4001 PRINT"******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS
 *********":PRINT
4010 IN$(1)="CONVENTIONAL LAYBARGE "
4020 IN$(2)="3RD GENERATION LAYBARGE"
4030 IN$(3)="ARCTIC LAYBARGE"
4040 IN$(4)="BOTTOM TOW"
4050 IN$(5)="BOTTOM PULL"
4100 PRINT"READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION
0"
4110   FOR L=1 TO 5
```

```
4120   READ LC1A(L),LC1B(L),LC1C(L),LC2(L),LC3(L),LV1(L),LV2A(L),LV2B(L),LV2C(L)
,LW(L),LWAVE(L),LMECH(L),LP1(L),LP2(L):NEXT L
4130 READ TESTDAT:IF TESTDAT<>999 THEN PRINT"INCORRECT NUMBER OF VALUES IN INSTA
LLATION VESSEL DATA FILE, CHECK AND RE-RUN":STOP
4140   FOR I =1 TO NOFROUT
4145   ANETLEN=NETLEN(I)
4150   REM DEVELOP INSTALLATION METHOD SELECTION
4155   IF (LESHOR(I)>0)*(TRENCHER(1)=0)=1 THEN ANETLEN=NETLEN(I)-LESHOR(I)
4160 PRINT:PRINT"FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF ";:PRINT USI
NG "###.#";ANETLEN
4165   IF ANETLEN=0 THEN GOTO 4445
4170  IF ANETLEN<=15 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):PRI
NT"4-";IN$(4):PRINT"5-";IN$(5):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",INSTA
LLER(I):GOTO 4200
4175  IF ANETLEN<=30 THEN PRINT"1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):PRI
NT"4-";IN$(4):INPUT"       ENTER YOUR CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200

4180  PRINT "1-";IN$(1):PRINT"2-";IN$(2):PRINT"3-";IN$(3):INPUT"       ENTER YOU
R CHOICE (BY NUMBER)",INSTALLER(I):GOTO 4200
4200 REM INSTALLATION COST SECTION
4210 REM CALC. PRODUCTION RATE (MI/WEEK)
4220 LPROD=LP1(INSTALLER(I))/(ODPIPE^LP2(INSTALLER(I)))
4240 LPROD(I)=LPROD*LWAVE(INSTALLER(I))*LMECH(INSTALLER(I))
4400 REM COMPUTE WEEKS FOR EACH LEG
4430 LETTIME(I)=ANETLEN/LPROD(I):REM LAYING ELAPSED TIME FOR LEG I
4435 IF (INSTALLER(I)=4)+(INSTALLER(I)=5)<0 THEN 4445
4437 IF I$="Y" THEN LETTIME(I)=1.25*LETTIME(I):REM REDUCE PRODUCTION RATE BY 25%
 IF PIPE IS INSULATED.  THIS IS BASED ON USE OF PIPE IN PIPE WITH PREFABRICATED
END FORGINGS ALLOWING 1 CIRCUMFERENTIAL WELD ON BARGE
4440 LETTIME(I)=LETTIME(I)+1.43:REM 1.43 WKS FOR TIE-INS
4445 PRINT"**********   EQUIPMENT SUMMARY LEG ";I;" SCENARIO ";S$;" ****":PRINT
4450   IF ANETLEN=0 THEN PRINT "***** ENTIRE LEG ";I;" IS INSTALLED DURING THROU
GH-ICE TRENCHING IN WINTER":GOTO 4590
4460 PRINT IN$(INSTALLER(I));"- ";TAB(65);:PRINT USING "###.#";LETTIME(I);:PRINT
"WEEKS"
4575    INPUT"    RE-RUN INSTALLATION EQUIPMENT SELECTION ?(Y OR N) ",A$
4580    IF A$="Y" THEN 4150
4590    PRINT"*************************************************************
*************":PRINT "COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG ";I;
4592    IF (NOFROUT=2)*(I=1)=1 THEN PRINT"REPEAT FOR LEG 2"
4600 NEXT I
4700 PRINT"CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED"
4712 INPUT"   INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG ",MSL
C
4713 INPUT"   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C
=10/10)",ICE$:IF (ICE$="A")+(ICE$="B")+(ICE$="C")=0 THEN 4713
4715   FOR I=1 TO NOFROUT
4720    REM COMPUTE AVERAGE SEASON LENGTH FOR ICE COVERAGE SPECIFIED
4722       FOR J=1 TO 2
4724       SEASON(I,J)=12-((INT(PLEND(I,J)/10)+1)*2)
4726       IF ICE$="B" THEN SEASON(I,J)=SEASON(I,J)+4
4728       IF ICE$="C" THEN SEASON(I,J)=SEASON(I,J)+6
4730       IF SEASON(I,J)<0 THEN SEASON(I,J)=0
4732       NEXT J
4734 SEASON=(SEASON(I,1)+SEASON(I,2))/2
4736  PRINT:PRINT"COMPUTED AVERAGE MARINE CONST. SEASON LENGTH ALONG ROUTE LEG "
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```
;I;" = ";SEASON;" WEEKS"
4738 INPUT"   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  ",SEASON$
4740 IF ((SEASON(I,1)=0)*(SEASON$<>"Y"))=1 THEN 4744
4742 IF ((SEASON(I,2)=0)*(SEASON$<>"Y"))=1 THEN 4744 ELSE 4746
4744 PRINT:PRINT"******** WARNING: COMPUTED MEDIAN YEAR MARINE CONST. SEASON EQU
ALS 0 WEEKS ************* FOR A PORTION OF LEG ";I;"******** CHOOSE DIFERENT ICE
 COND. OR INPUT SEASON LENGTH TO OVER-RIDE.":PRINT:GOTO 4713
4746 IF SEASON$="Y" THEN INPUT"   INPUT MARINE CONSTRUCTION SEASON DURATION (WEE
KS) ? ",SEASON
4748 IF (SEASON$="Y")*(SEASON<=1)=1 THEN INPUT"     ARE YOU SURE (Y OR N) ?  ",S
CHECK$ : IF SCHECK$="N" THEN 4738
4750 LSEASON=SEASON
4765    PRINT:PRINT"********INSTALLATION COST RESULTS FOR LEG ";I;" SCENARIO ";S
$;" ****"
4770  REM COMPUTE NUMBER OF SEASON FOR INSTALLATION EQUIPMENT
4780    LAYRS(I)=LETTIME(I)/LSEASON
4790    IF ICE$="A" THEN TEMP=LV2A(INSTALLER(I)):TEMP2=LC1A(INSTALLER(I))
4792    IF ICE$="B" THEN TEMP=LV2B(INSTALLER(I)):TEMP2=LC1B(INSTALLER(I))
4794    IF ICE$="C" THEN TEMP=LV2C(INSTALLER(I)):TEMP2=LC1C(INSTALLER(I))
4796 TEMP3=INT(LAYRS(I))+1
4798 PEAKNO=INT(TEMP3/MSLC)-((TEMP3/MSLC)>INT(TEMP3/MSLC))
4800    LAYCOST(I)=(INT(LAYRS(I))+1)*(TEMP2+LW(INSTALLER(I)))+(LC2(INSTALLER(I))
+LC3(INSTALLER(I)))*PEAKNO
4810    LAYCOST(I)=LAYCOST(I)+LETTIME(I)*(LV1(INSTALLER(I))+TEMP)
4815 REM  ADD 1 WINTERING COST PER EQUIPMENT SPREAD FOR NOT CLEARING PT. BARROW
4820    LAYCOST(I)=LAYCOST(I)+(PEAKNO*LW(INSTALLER(I)))
4850    PRINT IN$(INSTALLER(I));"(PROJECT PEAK=";PEAKNO;") ";INT(LAYRS(I))+1;"EQ
PMNT-SEASON(S)= ";:PRINT TAB(72);:PRINT USING "####.#";LAYCOST(I)
4900 NEXT I
4950 INPUT"  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)",A$:IF A$="Y" THEN GOTO
 4700
5000 PRINT"READING PUMP AND PRODUCTION TERMINAL COSTS          1500-1520"
5005 READ PMPCST,PTERCST
5008 PRINT"CALCULATING PUMP STATION AND TERMINAL COSTS"
5020    PUMPPWR(1)=.022*PRODUCT*MAOP*(-(NOFROUT<>0))
5030    PUMPPWR(2)=PUMPPWR(1)*(NETLEN(2)/NETLEN(1))
5040    PUMPCOST(1)=PMPCST*PUMPPWR(1)
5050    PUMPCOST(2)=PMPCST*PUMPPWR(2)
5060 IF NOFROUT=0 THEN PTERCOST=0:IF NO OFFSHORE LEG IS INCL. THEN NO PROD. STRU
CTURE
5100 PRINT "READING ONSHORE PIPELINE COST FACTORS              1550"
5210 READ LNDPL1,LNDPL2
5220 LNDPLCST=LNDPL1+ODPIPE*LNDPL2
5240 IF NOFROUT=0 THEN 5300
5250 FOR I=1 TO NOFROUT
5270 NEXT I
5500 REM ACCUMULATE ALL PIPELINE COSTS AND DISPLAY RESULTS
5505 PRINT"****************** CAPITAL COST SUMMARY - SCENARIO ";S$;"  *******":
PRINT"                          (1986 MILLIONS OF $)":PRINT
5510 IF NOFROUT=0 THEN 5700
5520 IF NOFROUT>=1 THEN PRINT "OFFSHORE PIPELINE (BEAUFORT SEA)"
5530 IF NOFROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5531 PRINT"   MATERIALS";
5532 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";TCOST(1)/1000000!;
5535 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";TCOST(2)/1000000!;
5545 PRINT TAB(65);:PRINT USING "###.#";(TCOST(1)+TCOST(2))/1000000!
```

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5547      TEMP=(TCOST(1)+TCOST(2))/1000000!
5550 PRINT"   MATERIALS LOGISTICS";TAB(65);:PRINT USING"###.#";LOGCST/1000000!
5552      TEMP=TEMP+LOGCST/1000000!
5555 PRINT "   TRENCHING";
5560 IF NOFROUT=2 THEN PRINT TAB(44);:PRINT USING"####.#";TOTRENCST(1);
5565 IF NOFROUT=2 THEN  PRINT TAB(56);:PRINT USING"####.#";TOTRENCST(2);
5570 PRINT TAB(64);:PRINT USING "####.#";TOTRENCST(1)+TOTRENCST(2)
5572      TEMP=TEMP+TOTRENCST(1)+TOTRENCST(2)
5575 PRINT "   INSTALLATION, TIE-INS/ SHORE CROSSINGS";
5580 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING "###.#";LAYCOST(1);
5585 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";LAYCOST(2);
5590 PRINT TAB(65);:PRINT USING "###.#";LAYCOST(1)+LAYCOST(2)
5592      TEMP=TEMP+LAYCOST(1)+LAYCOST(2)
5600 PRINT"   PUMP STATION(S)";
5610 IF NOFROUT=2 THEN PRINT TAB(45);:PRINT USING"###.#";PUMPCOST(1);
5620 IF NOFROUT=2 THEN  PRINT TAB(57);:PRINT USING"###.#";PUMPCOST(2);
5625 PRINT TAB(65);:PRINT USING "###.#";PUMPCOST(1)+PUMPCOST(2):TEMP=TEMP+PUMPCO
ST(1)+PUMPCOST(2)
5640 PRINT"  PROJECT SERVICES (15%) :";TAB(65);:PRINT USING "###.#";.15*TEMP
5650     TEMP=1.15*TEMP
5660 PRINT"  CONTINGENCY (25%):";TAB(65);:PRINT USING "###.#";.25*TEMP
5670     TEMP=TEMP*1.25
5680 PRINT "      TOTAL OFFSHORE PIPELINE CAPITAL COSTS:";TAB(70);:PRINT USING "#
###.#";TEMP:OFCAPEX=TEMP
5700 IF NONROUT=0 THEN 5800
5705 PRINT
5710 IF NONROUT>=1 THEN PRINT "ONSHORE PIPELINE COSTS"
5730 IF NONROUT=2 THEN PRINT TAB(45);"LEG 1       LEG 2    TOTAL"
5732 IF NONROUT=2 THEN PRINT TAB(45);:PRINT USING"####.#";LNDPLCST*ROUTLEN1(1);
5735 IF NONROUT=2 THEN PRINT TAB(57);:PRINT USING"###.#";LNDPLCST*ROUTLEN1(2);
5745 PRINT TAB(65);:PRINT USING "####.#";LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2)):ONCA
PEX=LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5800 PRINT"PRODUCTION STRUCTURE COSTS:";TAB(65);:PRINT USING"###.#";PTERCST
5802      TEMP=TEMP+PTERCST
5810 TEMP=TEMP+LNDPLCST*(ROUTLEN1(1)+ROUTLEN1(2))
5815 PRINT
5820 PRINT"    TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE ";TAB(70
);:PRINT USING"####.#";TEMP
5850 REM
5855 INPUT"  RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? ",A$
5857 IF A$="Y" THEN 5500
5860 PRINT"CALCULATING OPERATING COSTS"
5900 REM OPERATING COSTS FOR OFFSHORE PIPELINE ARE TAKEN AS 2% OF CAPEX
5910 REM OPERATING COSTS FOR ONSHORE PIPELINE ARE TAKEN AS 3.5% OF CAPEX
5920 OFOPEX=.02*OFCAPEX
5930 ONOPEX=.035*ONCAPEX
5940 INPUT"   DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? ",A$
5945 TAPSTAR=0
5950 IF A$="Y" THEN TAPSTAR=3*365*PRODUCT/1000!
5960 INPUT"   LIFE OF PIPELINE SYSTEM (YEARS)? ",LIFE
5970 INPUT"   INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  ",CIF
5980 CIF=CIF/100
5985 PRINT
5990 PRINT"       PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYS
TEM "
5995 PRINT"                              YEAR (SCENARIO ";S$;" )"
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6000 PRINT" ACCOUNT   ";:FOR J=1 TO LIFE STEP 2:PRINT TAB(9+3*J);:PRINT J;:NEXT
J:PRINT
6010 PRINT:TEMP1=0:TEMP2=0:TEMP3=0
6020 IF NOFROUT<=0 THEN 6030 ELSE PRINT"OFFSHORE PL";:FOR J=1 TO LIFE :TEMP1=TEM
P1 +OFOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";OFOPEX*(1/((1+CIF)^(J-1)));
6025 NEXT J:PRINT
6030 IF NONROUT<=0 THEN 6040 ELSE PRINT"ONSHORE PL ";:FOR J=1 TO LIFE:TEMP2=TEMP
2+ONOPEX*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT US
ING "###  ";ONOPEX*(1/((1+CIF)^(J-1)));
6035 NEXT J:PRINT
6040 IF TAPSTAR<=0 THEN 6050 ELSE PRINT"TAPS TARIFF";:FOR J=1 TO LIFE :TEMP3=TEM
P3+TAPSTAR*(1/((1+CIF)^(J-1))):IF (INT(J/2)-J/2)<0 THEN PRINT TAB(9+3*J);:PRINT
USING "###  ";TAPSTAR*(1/((1+CIF)^(J-1)));
6045 NEXT J:PRINT
6050 PRINT:PRINT"  NET PRESENT VALUE OF OPERATING COSTS = ";:PRINT USING "#####.
#";(TEMP1+TEMP2+TEMP3)
6055 PRINT"  TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)= ";TEMP+TEMP1+
TEMP2+TEMP3;" MILLION $"
6060 INPUT"  RE-RUN OPERATING COST CALCULATION (Y OR N)  ";A$
6070 IF A$="Y" THEN 5970
6080 PRINT"**************  END OF INTEC ENGINEERING PROGRAM BEAUPIPE  **********
**********"
7090 END
8000 REM
                              BEAUFORT SEA TRENCH DEPTH SUBROUTINE
     REM
8020 REM CALCULATE PIPELINE TRENCHING REQ. BASED ON U.S. ICE GOUGE DATA
     REF.: WEEKS, ET AL.,1983
8025 NETLENKM(I)=NETLEN(I)*1.6093                     'CONVERT LENGTH TO KILOMETERS
8027 PRINT"TRENCHING REQUIREMENT SUMMARY FOR PIPELINE LEG ";I;" SCENARIO ";S$
8029 PRINT:PRINT"         WATER DEPTH              TRENCH DEPTH (FT)          PIPE
LINE LENGTH"
8030 PRINT"           (FT)          (SEABED TO BOTTOM OF TRENCH)             (MI)
"
8035 FOR W=1 TO 8
8038 IF ROUTLEN(I,W)=0 THEN 8200
8040 COVER=GBAR(W)*TIME*NETLENKM(I)*SIN(THETA(W)*3.141593/180)
8050 COVER=TRENCHC(W)+(LOG(COVER)/LAMBDA(W))
8060 COVER=COVER*3.2808
8070 IF COVER<MINDEPTH(W) THEN COVER=MINDEPTH(W)       'CONVERT FROM METERS TO FEET
8080 TRENDEP(I,W)=COVER+(ODPIPE/12)                          'ADD PIPE DIAMETER
8085 IF COVER<.01 THEN TRENDEP(I,W)=0              'DO NOT TRENCH IF COVER = 0.0
8090 IF W=1 THEN PRINT"            0 - 20";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8100 IF W=2 THEN PRINT"           20 - 60";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8110 IF W=3 THEN PRINT"           60 - 90";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8120 IF W=4 THEN PRINT"           90 -120";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8130 IF W=5 THEN PRINT"          120 -150";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8140 IF W=6 THEN PRINT"          150 -165";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8150 IF W=7 THEN PRINT"          165 -190";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
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T TAB(65);USING"###.#";ROUTLEN(I,W):GOTO 8200
8160 IF W=8 THEN PRINT"          190 -300";TAB(38);USING"##.#";TRENDEP(I,W);:PRIN
T TAB(65);USING"###.#";ROUTLEN(I,W)
8200 NEXT W
8210 RETURN
9000 REM
                    PIPELINE SIZING SUBROUTINE
     REM
9020 FRICT=.026  '    STARTING VALUE FOR FRICTION FACTOR & APPROX. MAOP
9023 PRINT "PIPELINE DESIGN OPTIONS INCLUDE:"
9024 PRINT "                    PIPE OD (IN)      APPROX. MAOP (PSIG)"
9030    IDVAL(1)=6!: ODVAL(1)=6.625
9040    IDVAL(2)=8!: ODVAL(2)=8.625
9050    IDVAL(3)=10!: ODVAL(3)=10.75
9060    IDVAL(4)=12!: ODVAL(4)=12.75
9070    IDVAL(5)=13!: ODVAL(5)=14!
9080    FOR I=1 TO 25     'LIST PIPE DESIGN OPTIONS
9090    FLOWVEL=CUFOOT/(3.1416*((IDVAL(I)/12)^2)/4)
9100    IF FLOWVEL>20 GOTO 9160    'REJECT HIGH FLOW VELOCITY CASES, >20 FT/SEC
9110    IF (FLOWVEL<3)  AND (IDVAL(I)>13) GOTO 9160  ' REJECT LOW VELOCITIES
9115    IF FLOWVEL<1.5 GOTO 9160
9117    '     CALCULATE APPROX. PRESSURE DROP
9120    HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDVAL(I)/12)*2*32.2)
9130    DELTP=HF*62.4*CRUDESG/144
9140    IF DELTP>2500 GOTO 9160   '    REJECT HIGH PRESSURE DROP CASES
9150    PRINT TAB(20); ODVAL(I); TAB(40); USING"####."; (DELTP+50)
9160    IF I>=5 THEN ODVAL(I+1)=ODVAL(I)+2
9170    IF I>=5 THEN IDVAL(I+1)=ODVAL(I+1)-(2*ODVAL(I+1)/48)
9300    NEXT I
9400 KS=.00015   '      ROUGHNESS FOR STEEL PIPE (FT)
9430 WALL=.5             'STARTING VALUE
9435 INPUT"SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? ",ODPIPE
9437 DOT$="N"
9438     'ITERATE TO FIND WALL THICKNESS
9440    IDPIPE=ODPIPE-(2*WALL)
9450    FLOWVEL=CUFOOT/(3.1416*((IDPIPE/12)^2)/4)
9455    IF FLOWVEL>25 THEN PRINT"***** ARE YOU SURE? (Y OR N)";:INPUT F$:IF F$="
N" THEN 9430
9460    REYNOLDS=FLOWVEL*(IDPIPE/12)/VISCOS
9465       'ITERATE TO FIND FRICTION FACTOR
9470       TEMP=FRICT
9480       FRICT=(2.51/(REYNOLDS*(SQR(FRICT))))+(KS/(3.7*(IDPIPE/12)))
9490       FRICT=(-2*(.4342945*LOG(FRICT)))^(-2)
9500       IF (ABS(TEMP-FRICT)) >.0001 THEN GOTO 9470
9530    HF=(FRICT*LONGEST*5280*(FLOWVEL^2))/((IDPIPE/12)*2*32.2)
9540    DELTP=HF*62.4*CRUDESG/144
9550    MAOP=DELTP+50      'ADD 50 PSI FOR STATION LOSSES ETC.
9555    IF DOT$="Y" THEN GOTO 9600          'WT SET BY OD/WT RATIO
9560    TEMP=WALL
9570    WALL=.5*MAOP*ODPIPE/(.72*YIELD*1000)
9580    IF (ABS(TEMP-WALL))>.001 THEN GOTO 9440
9585 IF (ODPIPE/WALL)<=48 THEN GOTO 9600      'CHECK OD/WT RATIO
9586 WALL=(ODPIPE/48):DOT$="Y":GOTO 9440   'ASSUMED MAX. OD/WT RATIO FOR ARCTIC

9600 WALL=(INT((WALL-.0001)*32)+1)/32
9625 IF DOT$="Y" THEN PRINT"   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/
```

```
WT RATIO OF 48.  **********"
9627 PRINT
9650 RETURN
```

CHAPTER 5 - BEAUPIPE USER'S MANUAL

5.3 SAMPLE RUN

```
LOAD"BEAUPIPE
Ok
RUN
*******************************************************************************
**          INTEC ENGINEERING PROGRAM BEAUPIPE - (REV. 0)                    **
**              BEAUFORT SEA PIPELINE COST EVALUATION                        **
**    This program allows rapid cost estimate preparation for crude oil      **
**    pipelines in the Beaufort Sea and the evaluation of total offshore     **
**    and onshore Alaskan pipeline transportation costs.  It is intended     **
**    to be used only by Participants in the Chukchi Sea Transportation      **
**    Feasibility and Cost Evaluation Joint Industry Study - Phase 2.        **
**    Although the cost model used herein will allow rapid assessment of     **
**    the cost impact of various design, installation and trenching          **
**    options available, the user should inspect the results at the end      **
**    of each stage for validity.                                            **
*******************************************************************************
   INPUT ALPHANUMERIC SCENARIO DESIGNATION ?   BEAUPIPE SAMPLE

 READING NUMBER OF OFFSHORE PIPELINE LEGS IN SCENARIO          LINE   1010
 READING SEG. LENGTHS IN EACH DEPTH FOR ROUTE  1  ROUTLEN  1020-1040
 READING NUMBER OF ONSHORE ROUTES IN SCENARIO                ROUTLEN1  1050
 READING ONSHORE ROUTE LENGTH FOR ROUTE  1                   ROUTLEN1 1050-1070
           PIPELINE LENGTH SUMMARY FOR SCENARIO BEAUPIPE SAMPLE   (MILES)
                 LEG 1            LEG 2           TOTAL
 OFFSHORE        66               0               66
 ONSHORE         309              0               309

 TOTAL PIPELINE LENGTH ALL ROUTES                     375
    DOES LENGTH DATA SET REQUIRE MODIFICATION (Y OR N) ?  N

 READING UNIT COSTS FOR MATERIALS                     LINES  1100-1109
    INPUT PRODUCTION RATE (MBPD) ?   400

 CALCULATING PIPE DIAMETER AND WALL THICKNESS REQUIREMENT
 PIPELINE DESIGN OPTIONS INCLUDE:
                PIPE OD (IN)      APPROX. MAOP (PSIG)
                   24                  2347
                   26                  1590
                   28                  1113
                   30                   803
                   32                   595
                   34                   453
                   36                   353
                   38                   281
                   40                   229
 SELECT DESIRED PIPE DESIGN OPTION BY OUTSIDE DIAMETER (IN)? 26
   ********* NOTE: WALL THICKNESS SET BY MAXIMUM OD/WT RATIO OF 48.  *********

 CALCULATING MATERIAL QUANTITIES
                 OFFSHORE PIPELINE DESIGN SUMMARY SCENARIO BEAUPIPE SAMPLE
                   PIPE DIAMETER                 26.000    IN
                   PIPE WALL THICKNESS            0.563    IN
                   PIPE STEEL GRADE              60.0      KSI
                   PIPELINE MAOP               1559.8      PSIG
                   CASING DIA. (WHERE REQD)     32.000    IN
```

CASING WALL	0.375	IN
CONCRETE THICKNESS	1.681	NON-INSULATED
CONCRETE THICKNESS	2.911	INSULATED PIPE

ARE OFFSHORE PIPELINES TO BE INSULATED OVER ENTIRE LENGTH (Y OR N)? N

MATERIAL COST SUMMARY FOR OFFSHORE LEG 1 SCENARIO BEAUPIPE SAMPLE
(ALL COSTS IN 1986 $ MILLIONS)

ITEM	DEPTH<20 FT	DEPTH>20 FT	TOTAL
LINE PIPE	1.2	19.1	20.3
CASING PIPE	1.0	0.0	1.0
CORROSION COAT	0.1	1.3	1.4
CONCRETE COAT	0.7	9.5	10.1
ANODES	0.0	0.2	0.2
INSULATION	0.1	0.0	0.1
BULKHEADS	0.3	0.0	0.3
SUBTOTAL - LEG 1			33.4

TOTAL MATERIALS COSTS FOR OFFSHORE PIPELINES 33.4
LOGISTICS COST FOR OFFSHORE MATERIALS BASED ON $250/TON = 15
REPEAT DESIGN AND COST SUMMARY (Y OR N)?N
****
BEGIN PIPELINE TRENCHING EVALUATION
READING PIPELINE TRENCH DEPTH PARAMETERS LINES 1200-1290
READING COST, PRODUCTIVITY FACTORS FOR TRENCHING LINES 1300-1330
INPUT AVERAGE ICE KEEL-PIPELINE CONTACT RETURN PERIOD (YEARS) ? 1000
TRENCHING REQUIREMENT SUMMARY FOR PIPELINE LEG 1 SCENARIO BEAUPIPE SAMPLE

WATER DEPTH (FT)	TRENCH DEPTH (FT) (SEABED TO BOTTOM OF TRENCH)	PIPELINE LENGTH (MI)
0 - 20	9.2	4.0
20 - 60	12.2	8.0
60 - 90	15.8	12.0
90 -120	21.6	16.0
120 -150	18.1	12.0
150 -165	12.8	8.0
165 -190	7.5	5.0
190 -300	0.0	1.0

RE-RUN TRENCH DEPTH ANALYSIS (Y OR N)? N
************** OFFSHORE PIPELINE LEG 1 SCENARIO BEAUPIPE SAMPLE ****

FEASIBLE EQPT FOR OBTAINING 9.2 FT TRENCH IN WATER DEPTH OF 0-20 FT:
0-THROUGH-ICE TRENCH/LAY
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
6-MULTI-PASS PLOW
ENTER YOUR CHOICE (BY NUMBER)0

TRENCH DEPTH REQUIREMENTS IN 20 TO 165 FT WATER DEPTH ZONE RANGE FROM
12.2 TO 21.6 FT. FEASIBLE EQUIPMENT INCLUDE: (ONE TYPE FOR ENTIRE ZONE.)
1-CUTTER SUCTION DREDGE
2-CUTTER SUCTION DREDGE W/ DOUBLE SWING WIRES
3-LINEAR DREDGE
4-TRAILING SUCTION HOPPER DREDGE
ENTER YOUR CHOICE (BY NUMBER)3

FEASIBLE EQPT FOR OBTAINING 7.5 FT TRENCH IN WATER DEPTH 165-190 FT:
4-TRAILING SUCTION HOPPER DREDGE

```
6-MULTI-PASS PLOW
7-MECHANICAL TRENCHER
8-CONVENTIONAL HIGH PRESSURE JETTING
      ENTER YOUR CHOICE (BY NUMBER)6
CALCULATING TRENCHING TIMES FOR SPREAD SPECIFIED FOR LEG  1
    INPUT PREDOMINANT SOIL TYPE ALONG THIS LEG (C=CLAY S=SAND)  ? S
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO BEAUPIPE SAMPLE ****

THROUGH-ICE TRENCH/LAY-                                          4.7WEEKS
LINEAR DREDGE-                                                  55.3WEEKS
MULTI-PASS PLOW -                                                0.5WEEKS
    RE-RUN TRENCHING EQUIPMENT SELECTION (Y OR N) ? N
********************************************************************************
COMPLETED TRENCHING EQUIPMENT SELECTION FOR LEG  1
CALCULATING TRENCHING COSTS FOR SPREADS AND TIMES SPECIFIED
   INPUT MAX. NO. OF SEASONS ALLOCATED TO TRENCHING FOR EACH LEG? 3
   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)B

COMPUTED AVERAGE MARINE CONST. SEASON LENGTH ALONG ROUTE LEG  1  =  10  WEEKS
   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  N
WINTER CONSTRUCTION SEASON FOR DEPTHS <20 FT = 15 WEEKS

********** TRENCHING COST RESULTS FOR LEG  1  SCENARIO BEAUPIPE SAMPLE ****
THROUGH-ICE TRENCH/LAY(PROJECT PEAK= 1 )  1 EQPMNT-SEASON(S)=          30.0
LINEAR DREDGE(PROJECT PEAK= 2 )  6 EQPMNT-SEASON(S)=                  370.7
MULTI-PASS PLOW (PROJECT PEAK= 1 )  1 EQPMNT-SEASON(S)=                23.4
   TOTAL TRENCHING COST FOR LEG  1 =                                  424.1

   RE-RUN ICE COVERAGE DEFINITION AND COST RESULTS? (Y OR N)N
******* COMPLETED TRENCHING ANALYSIS, STARTING INSTALLATION ANALYSIS  *********

READING COST, PRODUCTIVITY FACTORS FOR INSTALLATION          1400-1470

FEASIBLE INSTALLATION EQPT. FOR PIPELINE LENGTH OF  62.0
1-CONVENTIONAL LAYBARGE
2-3RD GENERATION LAYBARGE
3-ARCTIC LAYBARGE
      ENTER YOUR CHOICE (BY NUMBER)2
**********   EQUIPMENT SUMMARY LEG  1  SCENARIO BEAUPIPE SAMPLE ****

3RD GENERATION LAYBARGE-                                         7.4WEEKS
    RE-RUN INSTALLATION EQUIPMENT SELECTION ?(Y OR N) N
********************************************************************************
COMPLETED INSTALLATION EQUIPMENT SELECTION FOR LEG  1
CALCULATING INSTALLATION COSTS FOR TIMES AND SPREADS SPECIFIED
   INPUT MAX. NO. SEASONS ALLOCATED TO INSTALLATION OF EACH LEG 2
   INPUT MAX ICE COVERAGE TOLERATED BY MARINE SPREAD (A=3/10 B=8/10 C=10/10)A

COMPUTED AVERAGE MARINE CONST. SEASON LENGTH ALONG ROUTE LEG  1  =  6  WEEKS
   DO YOU WANT TO INPUT CONST. SEASON DURATION (Y OR N) ?  N

********INSTALLATION COST RESULTS FOR LEG  1  SCENARIO BEAUPIPE SAMPLE ****
3RD GENERATION LAYBARGE(PROJECT PEAK= 1 )  2 EQPMNT-SEASON(S)=        134.9
  RE-RUN INSTALLATION VESSEL RESULTS (Y OR N)N
READING PUMP AND PRODUCTION TERMINAL COSTS        1500-1520
CALCULATING PUMP STATION AND TERMINAL COSTS
```

```
READING ONSHORE PIPELINE COST FACTORS                   1550
****************** CAPITAL COST SUMMARY - SCENARIO BEAUPIPE SAMPLE  *******
                        (1986 MILLIONS OF $)

OFFSHORE PIPELINE (BEAUFORT SEA)
  MATERIALS
  MATERIALS LOGISTICS                                           33.4
  TRENCHING                                                     15.5
  INSTALLATION, TIE-INS/ SHORE CROSSINGS                       424.1
  PUMP STATION(S)                                              134.9
 PROJECT SERVICES (15%) :                                       16.5
 CONTINGENCY (25%):                                             93.7
   TOTAL OFFSHORE PIPELINE CAPITAL COSTS:                      179.5
                                                                     897.6
ONSHORE PIPELINE COSTS

PRODUCTION STRUCTURE COSTS:                                   1563.5
                                                               482.0

   TOTAL OFFSHORE + ONSHORE PIPELINE + PRODUCTION STRUCTURE          2943.1
 RE-RUN CAPITAL COST SUMMARY TABLE (Y OR N) ? N
CALCULATING OPERATING COSTS
  DOES SCENARIO USE TAPS AS PART OF SYSTEM (Y OR N) ? Y
  LIFE OF PIPELINE SYSTEM (YEARS)? 20
  INTEREST RATE (%) FOR PRESENT WORTH CALCULATIONS ?  10
```

PRESENT WORTH OPERATING COST PROFILE OVER LIFE OF PIPELINE SYSTEM

YEAR (SCENARIO BEAUPIPE SAMPLE)

ACCOUNT	1	3	5	7	9	11	13	15	17	19
OFFSHORE PL	18	15	12	10	8	7	6	5	4	3
ONSHORE PL	55	45	37	31	26	21	17	14	12	10
TAPS TARIFF	438	362	299	247	204	169	140	115	95	79

```
 NET PRESENT VALUE OF OPERATING COSTS =  4782.4
 TOTAL COSTS INCLUSIVE OF CAPEX AND OPEX (PR WORTHED)=  7725.546  MILLION $
 RE-RUN OPERATING COST CALCULATION (Y OR N)  ? N
**************  END OF INTEC ENGINEERING PROGRAM BEAUPIPE  *******************
Ok
```