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Optimization of Storm Sewer Construction Costs Using a Microcomputer Program

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OPTIMIZATION OF STORM SEWER CONSTRUCTION COSTS
USING A MICROCOMPUTER PROGRAM

BY

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THESIS

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ABSTRACT

When designing a storm sewer system there is a material and labor cost trade-off between changing pipe diameter for a specific flowrate while keeping physical pipe slope constant, and changing physical pipe slope for the same flowrate while keeping the pipe diameter constant. To calculate costs associated with every possible combination of pipe diameters and excavation depth to find the optimum design for a storm sewer network without the use of a computer would be a very cumbersome task indeed. In fact, a minimum cost solution may never be found. This paper presents a microcomputer program which assists the engineer in designing the storm sewer system for the minimum cost. The Rational Method is employed to calculate flowrates for each sub basin, Manning's Equation is used to calculate pipe flow for each pipe link in the system, and complete enumeration methodology is used to determine material and labor costs for each network possibility. Material and labor costs are maintained by the engineer in a cost table file.

The work described herein represents the opinions and conclusions of the author and does not necessarily represent the views and opinions of the reviewers or the University of Central Florida.

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CHAPTER I - INTRODUCTION

Most storm sewer systems in the Central Florida area are gravity dependent piping networks which transport stormwater from an array of sub basins to a retention/detention pond for treatment before discharge into a surface water body. When larger pipes are chosen to carry a certain flowrate, the associated hydraulic grade line slope decreases, which means a less steep physical pipe slope can be used. On the other hand, when a smaller pipe is selected to carry the same flowrate, the hydraulic grade line slope is greater, which means a steeper physical pipe slope is used, resulting in lower pipe costs, but greater excavation costs.

When the storm sewer system contains many pipe links, with numerous choices to be made concerning pipe diameter and physical pipe slopes, an extensive set of calculations is mandatory if the optimal system cost is to be determined. The microcomputer program presented in this paper models complete enumeration, and provides interaction with the engineer to give greater flexibility in design decisions.

This computer model is limited to gravity sewer systems. Pipe costs and excavation costs are considered. However, manhole costs are assumed to be equal for any system configuration and are therefore not considered.

CHAPTER II - LITERATURE REVIEW

Several articles have been reviewed to gain background knowledge of other research in the area of computer programming to obtain an optimal or sub-optimal stormwater system design with regard to construction costs.

In the technical paper "Designing Sanitary Sewers with Microcomputers," by Drew P. Desher and Patrick K. Davis [1], a computer program was discussed which utilizes heuristic programming methodologies to find the least costly gravity sewer design. The program, Sanitary Sewer Design (SSD), is written in the BASIC language for the Apple II microcomputer, and was developed as part of a research project at the University of North Carolina. Before running the program, the engineer first calculates the flowrate at each manhole. The input into the program includes the flowrate, pipe lengths and diameters, velocity and cover constraints, ground elevations, network geographical configurations, and cost data. The program keeps the diameters constant and varies the physical pipe slope. If the engineer wants to obtain an optimal design, the program would be re-run with different diameters and then results of the different runs compared. The SSD program was used by the Orange Water & Sewer Authority in North Carolina for a sewer upgrade project.

In the paper by R. K. Price, "Design of Storm Sewers for Minimum Construction Costs" [2], the major topic of interest is a methodology which closely models the Discrete Differential Dynamic Programming (DDDP) Method, as described by Mays and Yen. The DDDP methodology calculates the flowrate at each manhole by using the Rational formula, and cover constraints are checked at both ends of each pipe section between manholes. A confined corridor is defined for allowable pipe depths. This corridor is iteratively reduced by varying pipe slope until the relative changes in construction cost with each iteration become less than some predefined tolerance level. Price also discusses in his paper a Non-Linear Programming (NLP) methodology as given by Murray. In this model pipe diameters are treated as continuous variables, and the construction cost is minimized by constraining pipe cover and flow velocity. The disadvantage to the NLP methodology is that the pipe diameters have to be adjusted, after the model has been run, to commercially available pipe sizes. Both the DDDP and NLP methodologies were applied to the same sewer redesign project in Derby, England. After analyzing the results from this practical application, it was concluded that the DDDP methodology was preferable for sewer design since more consistent results were obtained with DDDP than NLP.

In the paper "Storm Sewer Optimum Design" by Dong Hoang [3], a computer program is discussed which finds the sewer network configuration with the least cost. In this program, the physical pipe slope is iteratively modified. With each iteration the pipe diameter

is calculated by the Manning's Equation for the particular slope, then two commercially available pipe sizes, one immediately smaller and one immediately larger than the calculated diameter, are chosen and the cost of the pipe computed.

Dr. G. A. Walters' paper entitled "Designing New Sewer Networks to a Minimum Cost by the Use of Dynamic Programming" [4] discusses the use of dynamic programming for finding optimal costs of sewer systems. The dynamic programming approach predefines allowable depths of manholes into discrete levels. Calculations are started at the minimum allowable depth, after which in most cases only one more iteration is needed. The author also mentions that more research needs to be done, and is being done by Walters and Templeman, since the pipe diameter also needs to be a constraint (upstream diameter should be equal to or smaller than downstream).

In the article "Introduction of Fictitious Discharges and Use of a Reduced Network for the Optimal Design of Urban Storm Sewers" by Pierre Guisset and Yves Zech of Belgium [5], a Nonlinear programming technique is discussed. The authors considered using Dynamic Programming techniques, but found it was most suited to simplistic modeling and not fully developed. A "paradoxal" conclusion comes from the research into the use of fictitious discharges, and is that by increasing the flow in certain pipes, the total construction cost of the network can be reduced. The authors concede that further improvement of their methodology is possible.

The research described herein is a natural progression of the methodologies examined above. The designer can vary pipe slopes and diameters within the same computer run, as well as have the design checked for design constraints, and have the optimal solution determined. In a few of the above models, multiple computer runs had to be executed to obtain a solution, which was not necessarily optimal. This research contains some of the same attributes as the above models; however, it does not contain any of their apparent drawbacks.

CHAPTER III - MODEL

The computer program used to determine the optimum storm sewer
construction cost is comprised of four separate programs: (1) A Main
Menu, (2) The Rational Method, (3) A Construction Cost Editor, and (4)
The Optimization Model, which uses the complete enumeration
methodology. A complete source code listing of all programs is
included as Appendix A. The model is limited by a maximum of 20 pipe
stages and 500 possible network configurations.

Rational Method Program

The Rational Method is used to calculate the peak flowrate through
each pipe link prior to initializing the complete enumeration
methodology. The Rational Method uses the equation

$$Q_p = C \, I \, A$$

where Q_p = flowrate, cfs

C = Runoff Coefficient, unitless

I = Rainfall Intensity, inches/hour

A = Contributing Area, acres

The designer first enters information concerning each sub basin and
network configuration. The runoff coefficients to be used can either
be input once for all sub basins (the runoff coefficient will be the

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same in every case), or individually for each sub basin.   Additionally,
the designer has the choice of using composite runoff coefficients to
include weighting for pervious and impervious acres of land cover, or
separate runoff coefficients for pervious and impervious acres.   A
rainfall intensity curve is chosen by the designer.   Rainfall intensity
for the Orlando area, Florida Department of Transportation (FDOT) Zone
7, is available for selection, as well as the other 10 zones.   The 25
year frequency storm is the set of curves used for each of the FDOT
zones.   The rainfall intensity to be used in the Rational Method is
determined from the curves using the time of concentration.   The time
of concentration for each pipe link (i.e., the pipe between two
successive inlet structures) can either be entered or calculated using
the South Florida Water Management District Equation,

$$T_c = (2 \ A)^{1/2}$$

where T_c = Time of Concentration, hours

A = Contributing Area, acres.

This time of concentration takes into account the entire
contributing area, and therefore has some flowrate attenuating
consequences.   The Rational Method is used to calculate the flowrate
into each inlet, as well as the cumulative flowrate through each pipe
link, using the contributing sub basin area, contributing sub basin
runoff coefficient and rainfall intensity.

Cost Editor

The optimization program uses pipe cost data as deemed appropriate by the designer in order to calculate construction costs for the piping network. The differences in costs for manholes and other appurtenances for different piping network configurations are assumed negligible. The costs for material and labor can be updated by the designer as necessary by use of the cost editor program. The costs for pipe are listed according to depth of excavation ($ per Vertical linear foot) for each pipe diameter kept in the data base. The pipe cost data currently being used for examples contained herein are from "The Bid Reporter," February 1985. Some of the data needed for completeness that were not found explicitly from this source were interpolated from the available information (i.e., some pipe diameters or depths were missing since the Bid Reporter is for actual projects that did not encompass all diameters and depths). An example set of cost data for an 18" pipe is shown in Table 1.

TABLE 1

EXAMPLE COST DATA

EXISTING COSTS FOR PIPE SIZE 18 INCHES

FROM DEPTH, FT	TO DEPTH, FT	COST, $/LF
Ø	6	5Ø
6	8	55
8	1Ø	62

COST PER ADDITIONAL VERTICAL LINEAR FOOT = $7/LF

As seen by this example cost data, the cost for pipe increases with depth. This is due to increased requirements for the amount and intensity of labor and supporting equipment as excavation depth increases, and trenching and dewatering efforts become more extensive.

Complete Enumeration

Complete enumeration involves the trial of every possible mathematical configuration. When complete enumeration is used with the piping network problem, the construction cost for each potential combination of pipe diameters and physical pipe slopes is calculated. This methodology can be illustrated by the use of a decision tree, with each candidate pipe size for each stage being a separate branch on the tree. This graphical method of representing the piping network problem by the complete enumeration methodology is shown in Figure 1. As shown in this illustration, the number of possible combinations is calculated by multiplying together the number of candidate pipe sizes at each stage. Complete enumeration involves calculating the construction cost for each of these possible piping network configurations. The optimum construction cost configuration is found by comparing each of the piping network configuration construction costs and selecting the one with the minimum cost.

The Optimization Program

The optimization program uses Manning's equation to determine physical pipe slope given flowrate (as calculated in the Rational Method module) and diameter (entered by the designer in an interactive

General Equation:

Number of possibilities =
$$\prod_{i=1}^{n} (\text{number of choices})_{\text{stage } i} \; ;$$
where n = number of stages
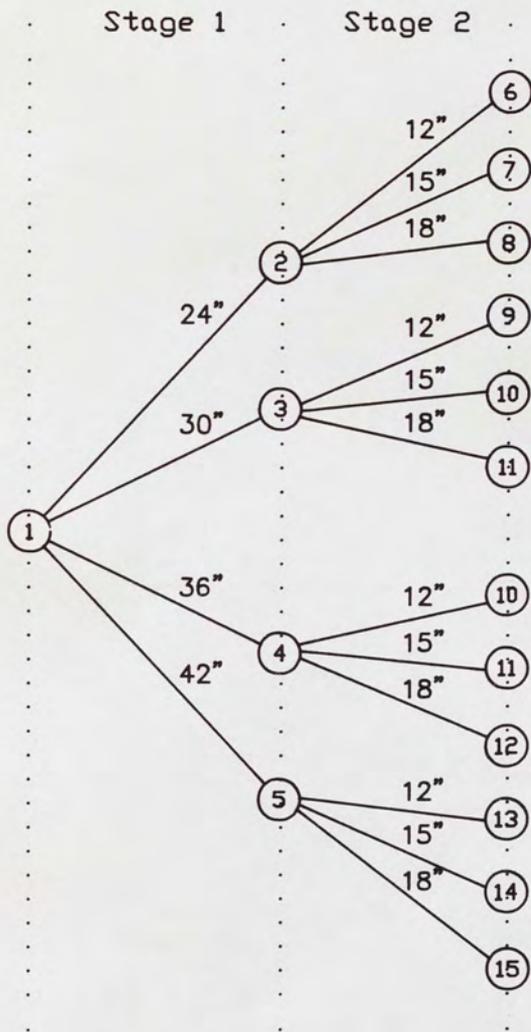
Stage 1 · Stage 2 ·

For this example:
Number of possibilities =
4 x 3 = 12

POSSIBILITIES:

1.	Stage 1 – 24"	Stage 2 – 12"
2.	Stage 1 – 24"	Stage 2 – 15"
3.	Stage 1 – 24"	Stage 2 – 18"
4.	Stage 1 – 30"	Stage 2 – 12"
5.	Stage 1 – 30"	Stage 2 – 15"
6.	Stage 1 – 30"	Stage 2 – 18"
7.	Stage 1 – 36"	Stage 2 – 12"
8.	Stage 1 – 36"	Stage 2 – 15"
9.	Stage 1 – 36"	Stage 2 – 18"
10.	Stage 1 – 42"	Stage 2 – 12"
11.	Stage 1 – 42"	Stage 2 – 15"
12.	Stage 1 – 42"	Stage 2 – 18"

Figure 1.   Tree Diagram Illustrating Complete Enumeration

decision session). Manning's formula can be written for English units
as:

$$Q = (1.49/n) \ A \ R^{2/3} \ S_o^{1/2}$$

where Q = flowrate, cfs

A = cross sectional area of pipe, ft^2

R = hydraulic radius, ft

S_o = hydraulic slope, ft/ft

n = Manning's roughness coefficient

The optimization program assumes that the flowrate through each
pipe length is not under pressure; therefore, the hydraulic slope is
equivalent to the physical pipe slope.

The optimization program steps through the entire piping network
one pipe link at a time, in order to receive information from the
designer interactively. At the beginning of the screen for each pipe
link, the flowrate as calculated by the Rational Method is shown to the
designer. The length of each pipe link is entered by the designer.
Also entered are the Manning's roughness coefficient; minimum and
average ground elevations; ground elevations at extreme pipe ends; and
the pipe invert at the outfall or most downstream point of the piping
network. Then, once the pipe length, Manning's roughness coefficient,
fitting loss coefficient and ground elevations are entered, the
designer can try different pipe diameters for the pipe link. As soon
as the designer types in a pipe diameter to try for the pipe link, the
continuity equation is applied for the diameter entered. The
continuity equation is:

$$Q = V \ A$$

where Q = flowrate, cfs

V = velocity, ft/sec

A = cross sectional area of pipe, ft^2

The physical pipe slope and velocity that correspond to the diameter are immediately shown on the bottom of the computer screen for consideration by the designer. If the physical pipe slope and velocity are within the range acceptable to the designer, the pipe diameter can be selected for consideration in the optimal design. The designer can then continue with the same pipe link, trying and selecting additional pipe diameters for consideration.

With calculated invert elevations based on physical pipe slope for each piping network configuration, the depth from the ground surface to the crown of the pipe is checked at the point along the pipe length where the minimum ground elevation has been entered. If the pipe depth is less than three feet, a warning is given to the designer. The particular pipe configuration can then be eliminated from further consideration by the designer.

The optimization program utilizes ASCII data files to store data about each potential piping network configuration. This allows larger networks to be computed since there are no arrays defined in the BASIC program. The size of the network that can be run is limited only by available disk storage space.

CHAPTER IV - EXAMPLE DESIGN APPLICATION

An example problem solution using the set of computer programs is included as Appendix B. The sub-basin layout, inlet locations and supporting information for the design of the stormwater management system is presented as Figure 2. As seen from the drawing, there are three stormwater inlets. The system discharges to a retention/detention pond, with an invert elevation set for the outfall pipe of 68 feet mean sea level (MSL). The objective of the design problem to be solved by the computer programs is to recommend a configuration of pipe diameters and inverts for the three pipes to carry the stormwater from the inlets to the pond, and to ensure that this recommended piping configuration has minimum construction costs when compared to the other options the designer selects.

The first program to be run is the main menu program which in turn makes the appropriate transfers for the designer into the other programs. The selection is made by the designer to perform watershed data input and editing. This selection from the main menu causes the Rational Method program to be run, where peak flowrates through each of the three pipes is determined. The time of concentration for the rainfall intensity curve is selected be calculated by using the South Florida Water Management District Equation. The rainfall intensity data for FDOT Zone 7 (Orlando area) is selected as the curve to be used

Area = 5.24 acres
lawns, 2.74 acres
pavement & roofs, 2.50 acres

Stage 3
200 ft

Area = 3.92 acres
lawns, 1.92 acres
pavement & roofs, 2.00 acres

Stage 2
200 ft

Area = 3.56 acres
lawns, 1.56 acres
pavement & roofs, 2.00 acres

Stage 1
250 ft

Outfall invert
(pond)
EL 68' MSL

Legend:
— — Sub-basin divide
○ Stormwater Inlet
Stormwater Path
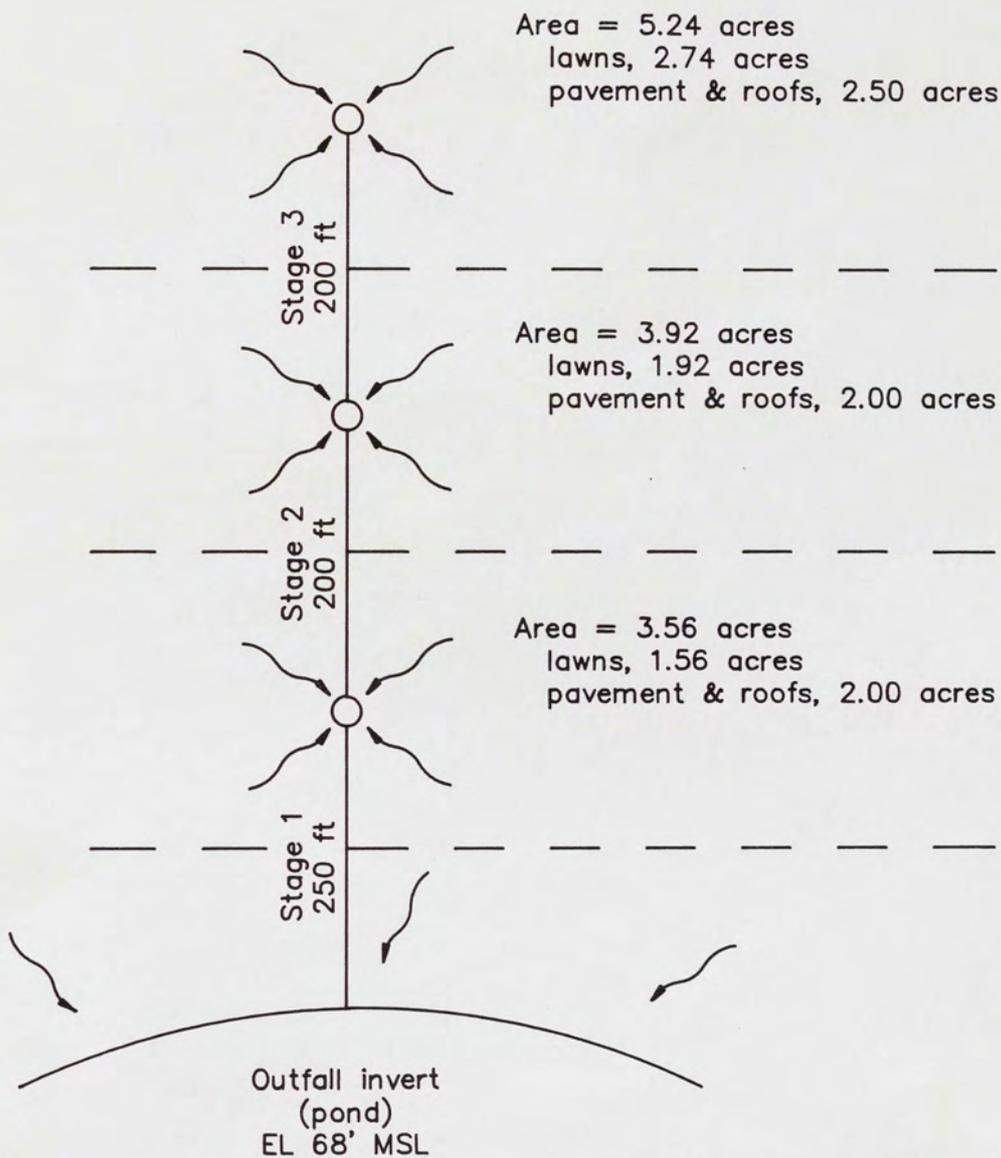
Runoff coefficients
for all sub-basins
lawns, C=0.2
pavement & roofs, C=0.9
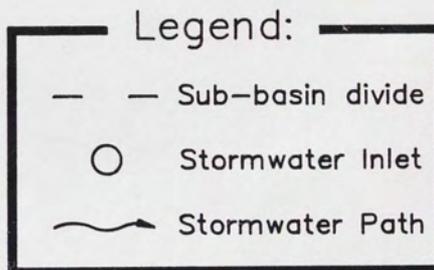
Figure 2.   Example Problem
Sub-basin Information

to determine intensity corresponding to the calculated time of concentration. The Rational Method is then used to find peak flowrates for each pipe link. Next, the main menu program is once again called automatically, where the designer selects the choice for pipe data input, editing and optimization. This choice activates the optimization program where the designer is prompted for information on all three pipes. For each pipe the designer chose two different pipe diameters to try, each being within an acceptable design velocity range. The program works with the cost data available in the cost files, compares the alternatives, and recommends a piping network configuration. The cost information used for this example is included with the computer run in Appendix B. There are eight alternatives for the case of two pipe diameters to be tried with each of the three pipes. The profiles of each of these eight alternative piping configurations are shown in Figures 3 through 1Ø. In this example, the minimum cost was $52,85Ø and is shown in Table 2 along with a few other potential design configurations and their costs.

TABLE 2

RANGE OF COST RESULTS

NETWORK CONFIGURATION			COST,$	COMMENT
PIPE 1	PIPE 2	PIPE 3		
24"	3Ø"	36"	52,85Ø	minimum cost
27"	36"	42"	58,9ØØ	exceeds min. by 11%
36"	36"	36"	6Ø,45Ø	exceeds min. by 14%
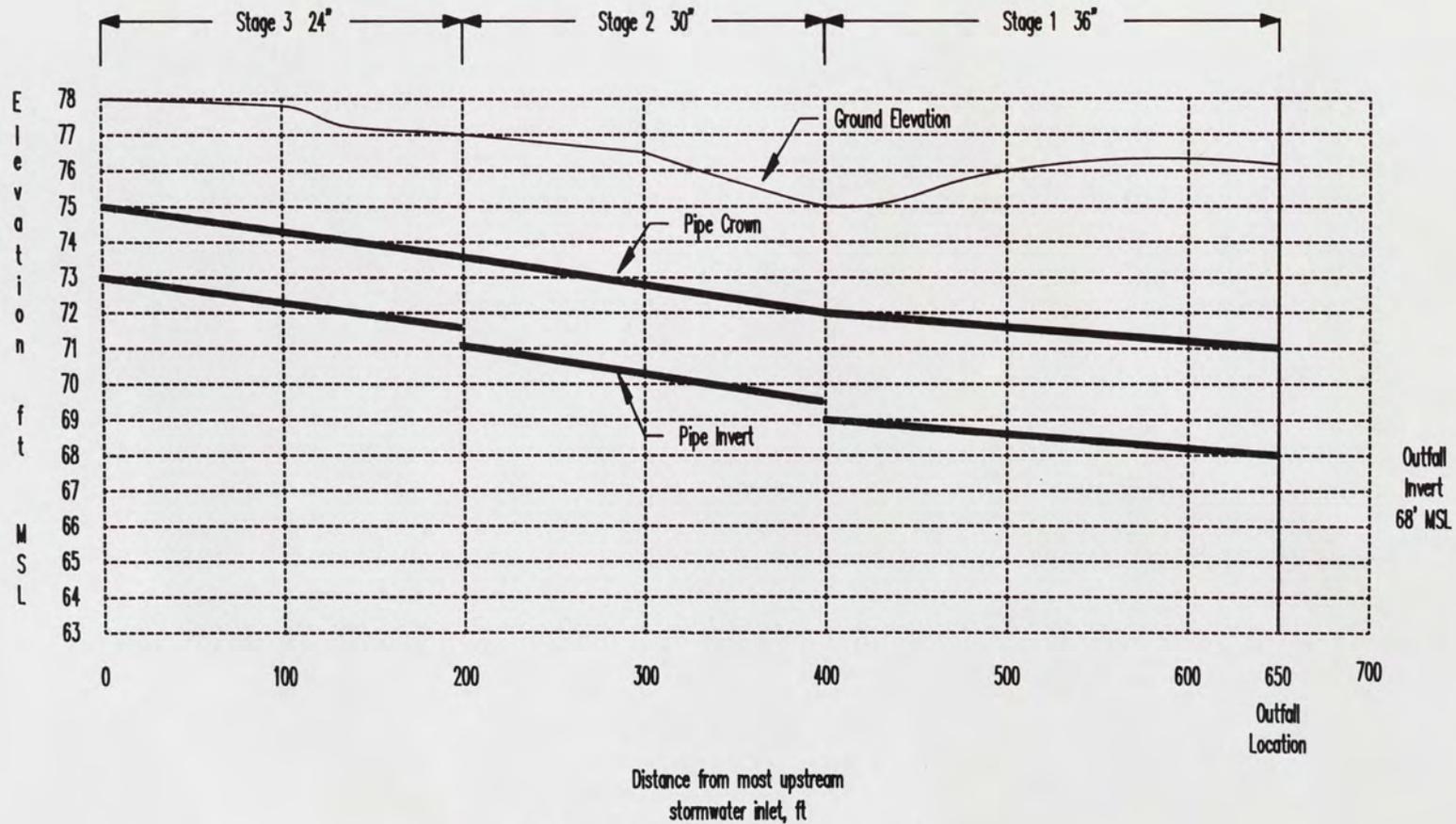
Figure 3.   Alternative Number 1
Pipe Combination 24" 30" 36"

Stage 3 27"   Stage 2 30"   Stage 1 36"

Ground Elevation

Pipe Crown

Pipe Invert

Outfall
Invert
68' MSL

Outfall
Location

Distance from most upstream
stormwater inlet, ft
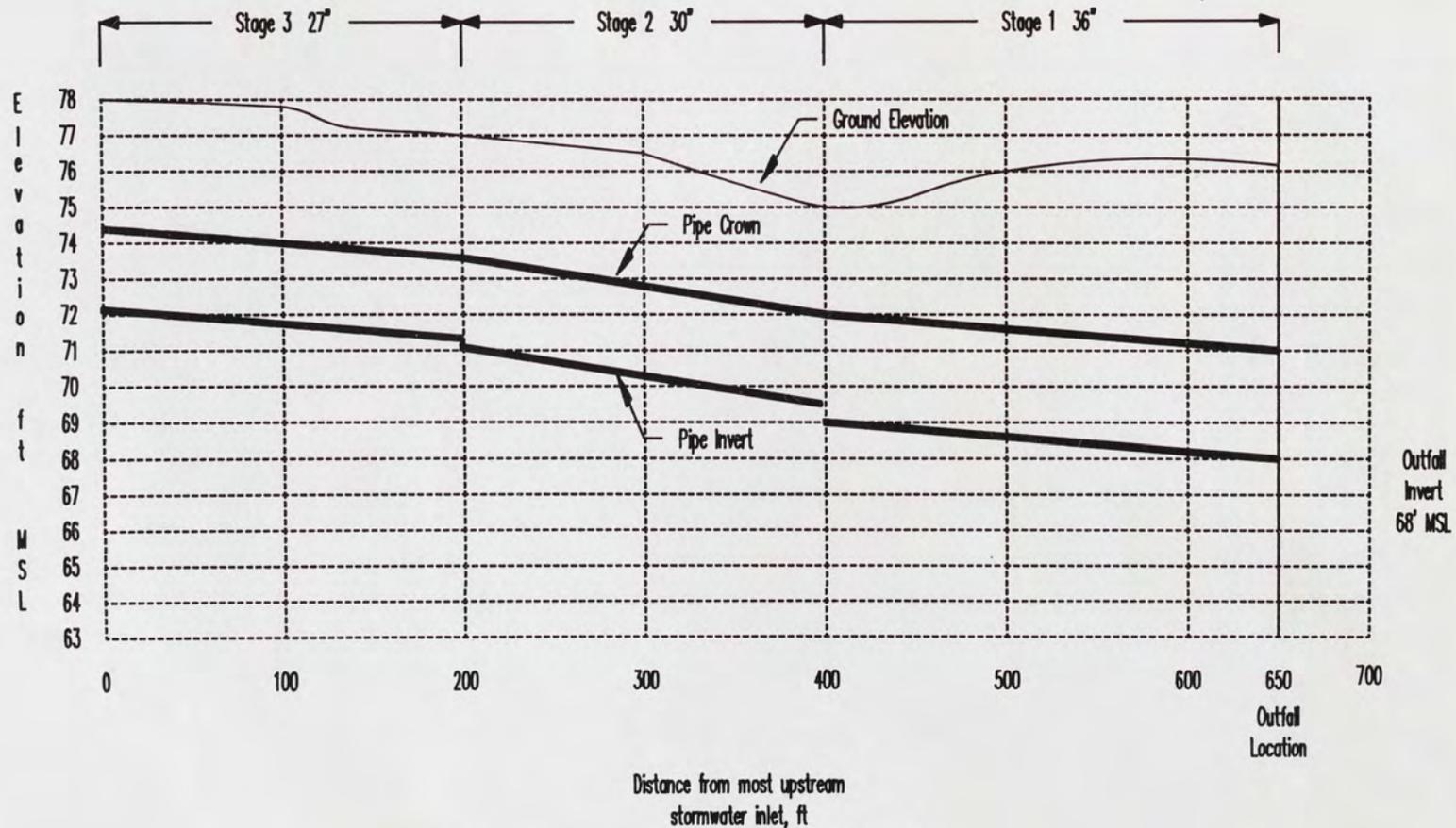
Figure 4.   Alternative Number 2
Pipe Combination 27" 30" 36"

17
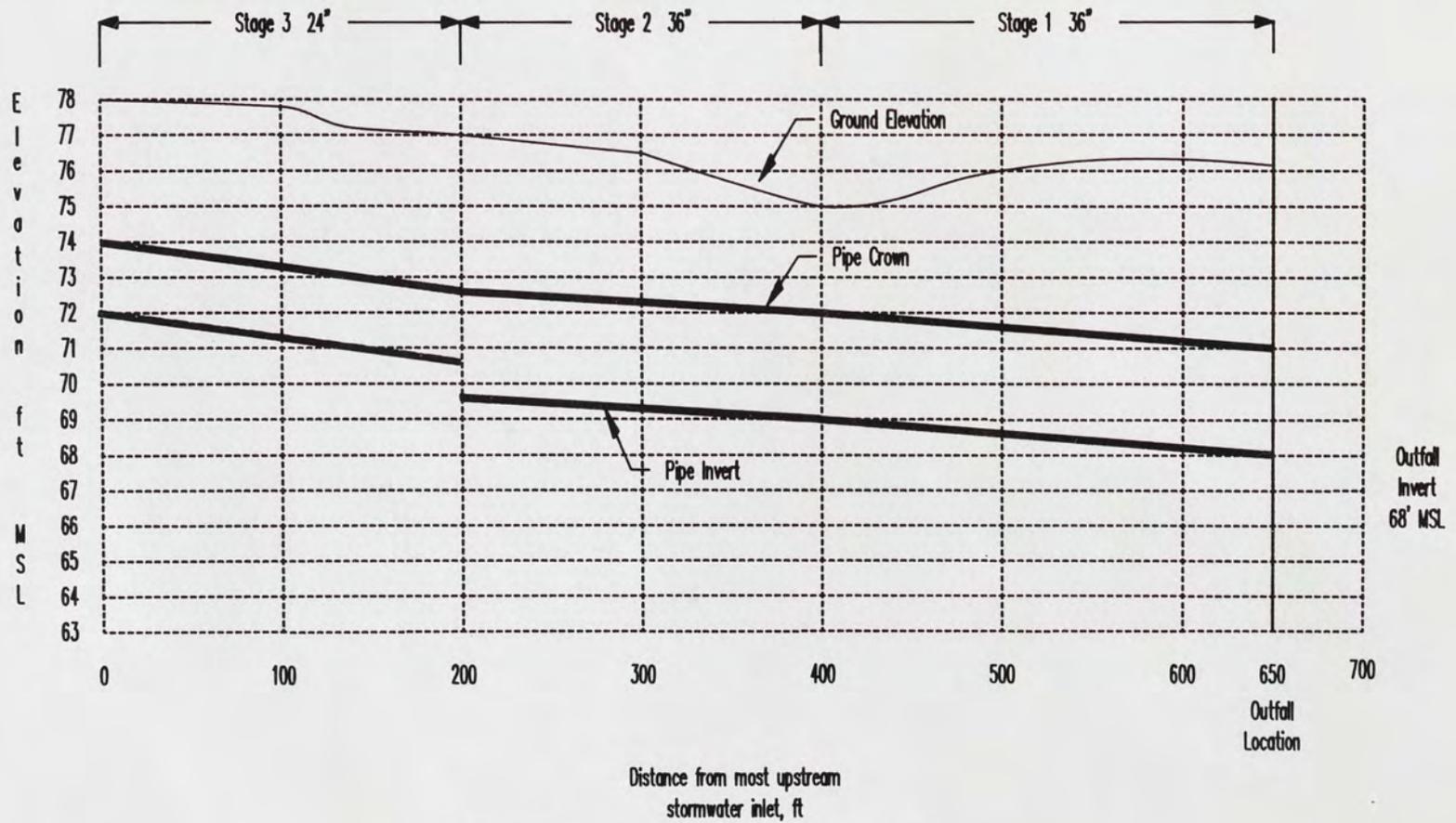
Figure 5.   Alternative Number 3
Pipe Combination 24" 36" 36"
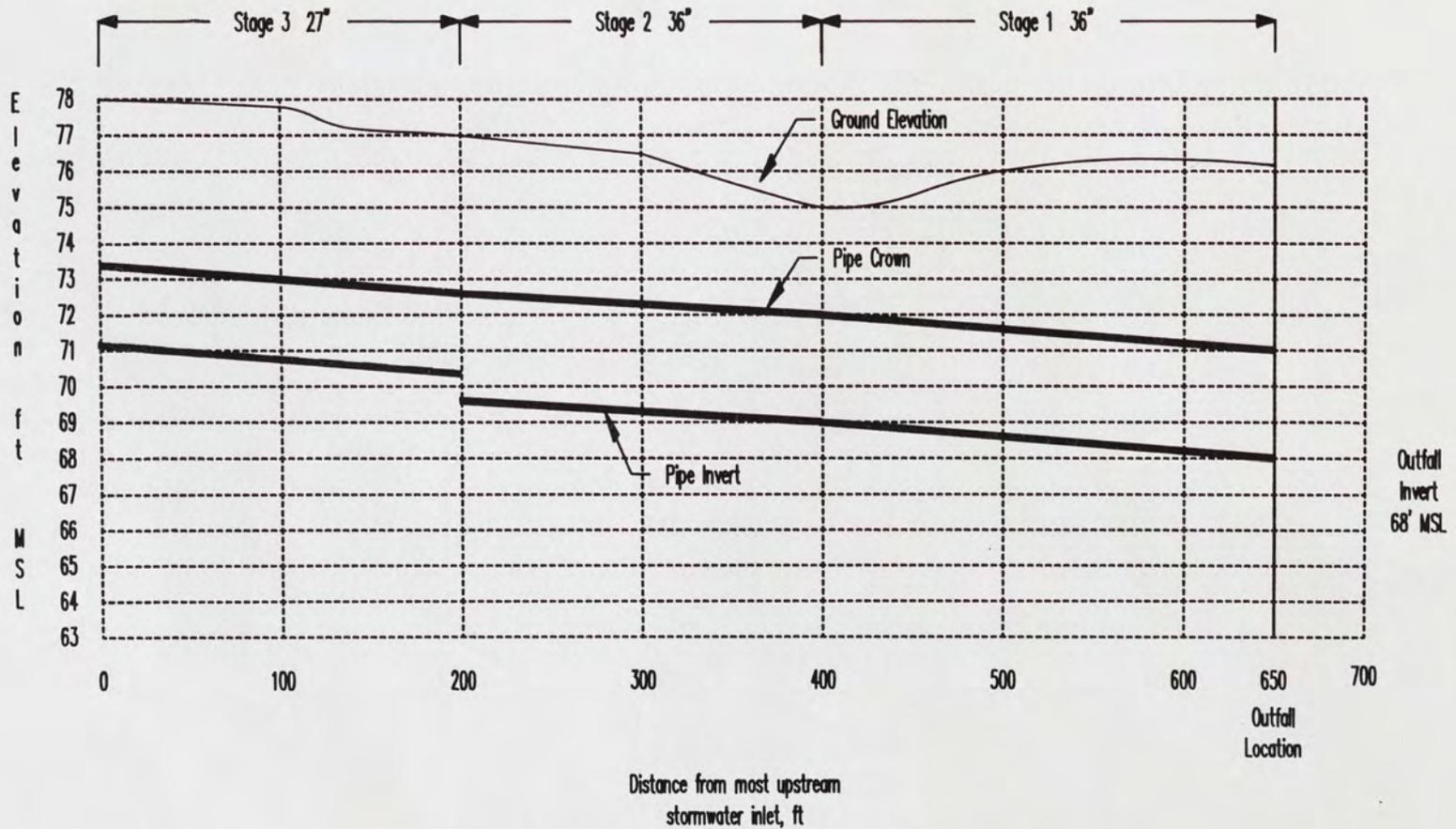
Figure 6.   Alternative Number 4
            Pipe Combination 27" 36" 36"
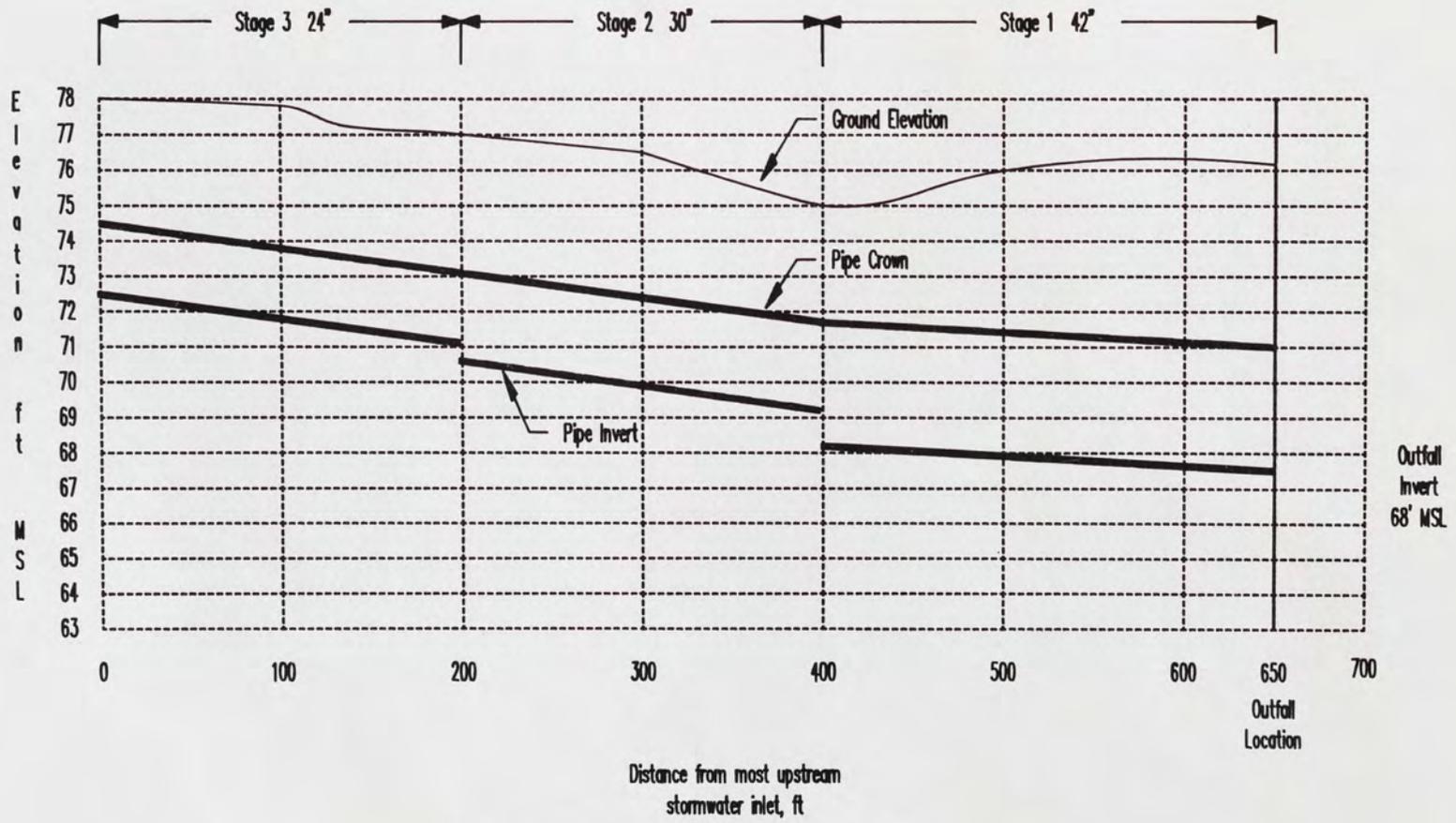
Figure 7. Alternative Number 5
Pipe Combination 24" 30" 42"

Stage 3 27"   Stage 2 30"   Stage 1 42"

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Ground Elevation

Pipe Crown

Pipe Invert

Outfall
Invert
68' MSL

0   100   200   300   400   500   600   650   700

Outfall
Location

Distance from most upstream
stormwater inlet, ft
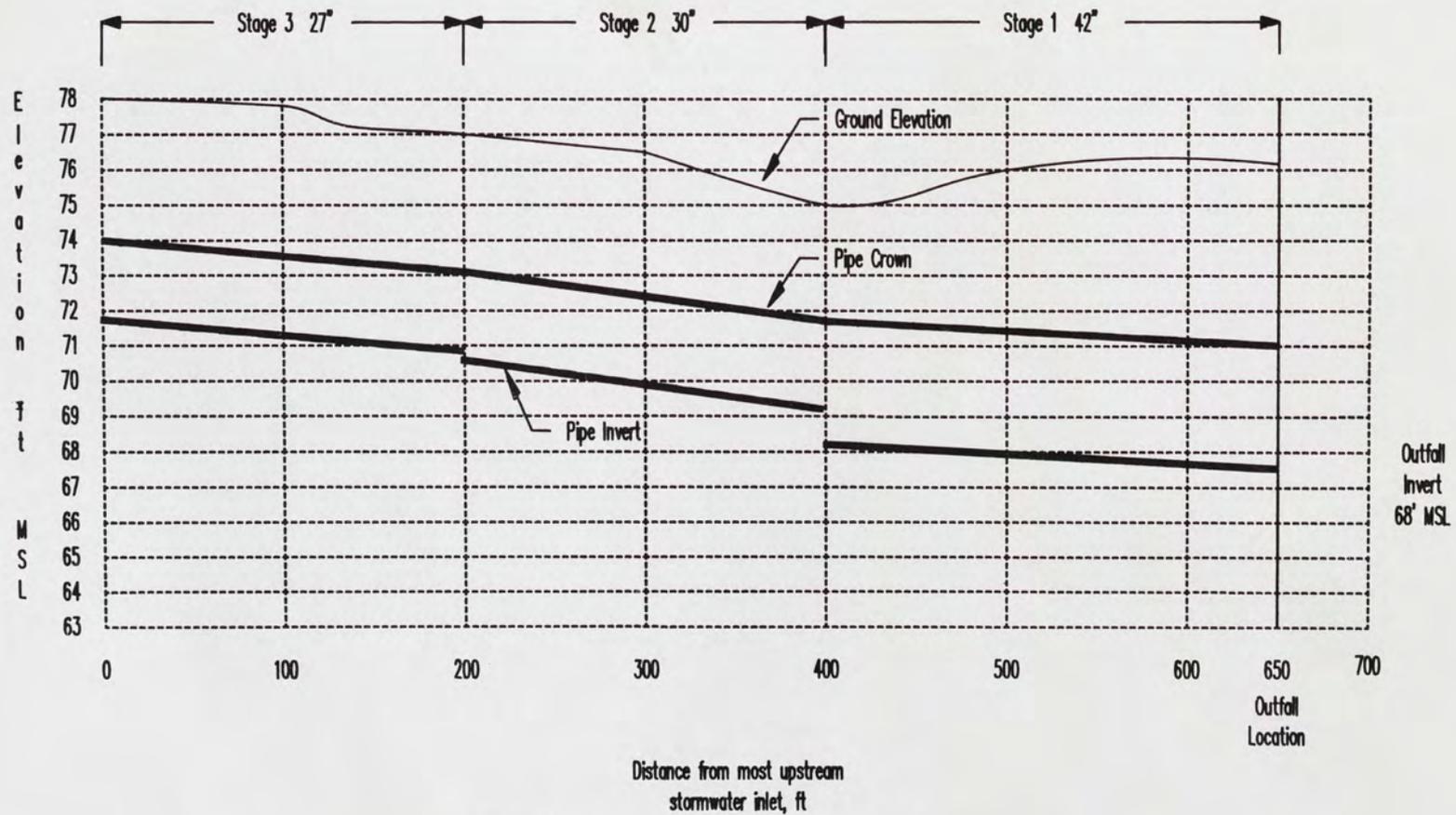
Figure 8.   Alternative Number 6
Pipe Combination 27" 3Ø" 42"
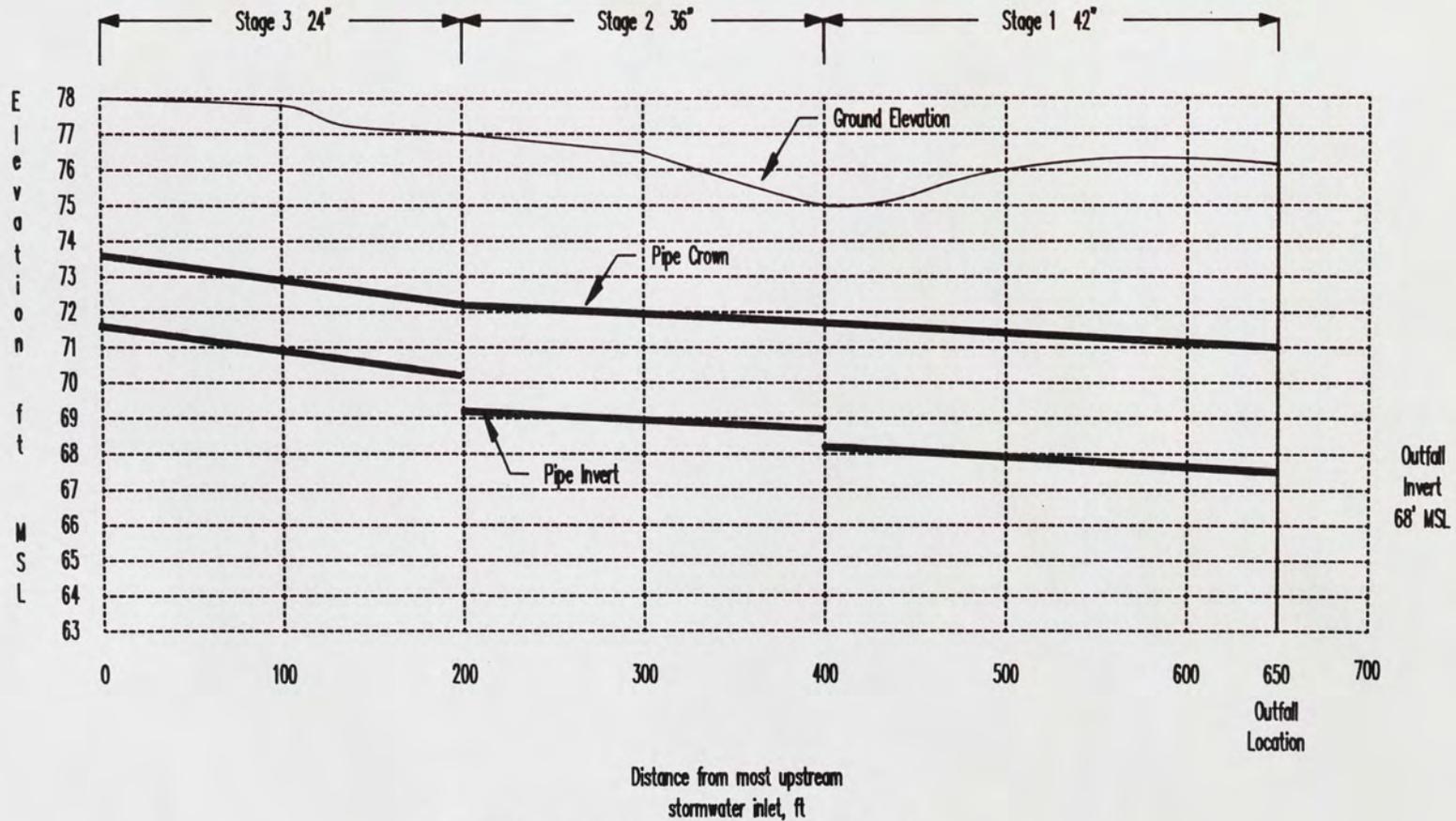
Figure 9. Alternative Number 7
Pipe Combination 24" 36" 42"

Stage 3 27"   Stage 2 36"   Stage 1 42"

Ground Elevation

Pipe Crown

Pipe Invert

Outfall
Invert
68' MSL

Outfall
Location

Distance from most upstream
stormwater inlet, ft
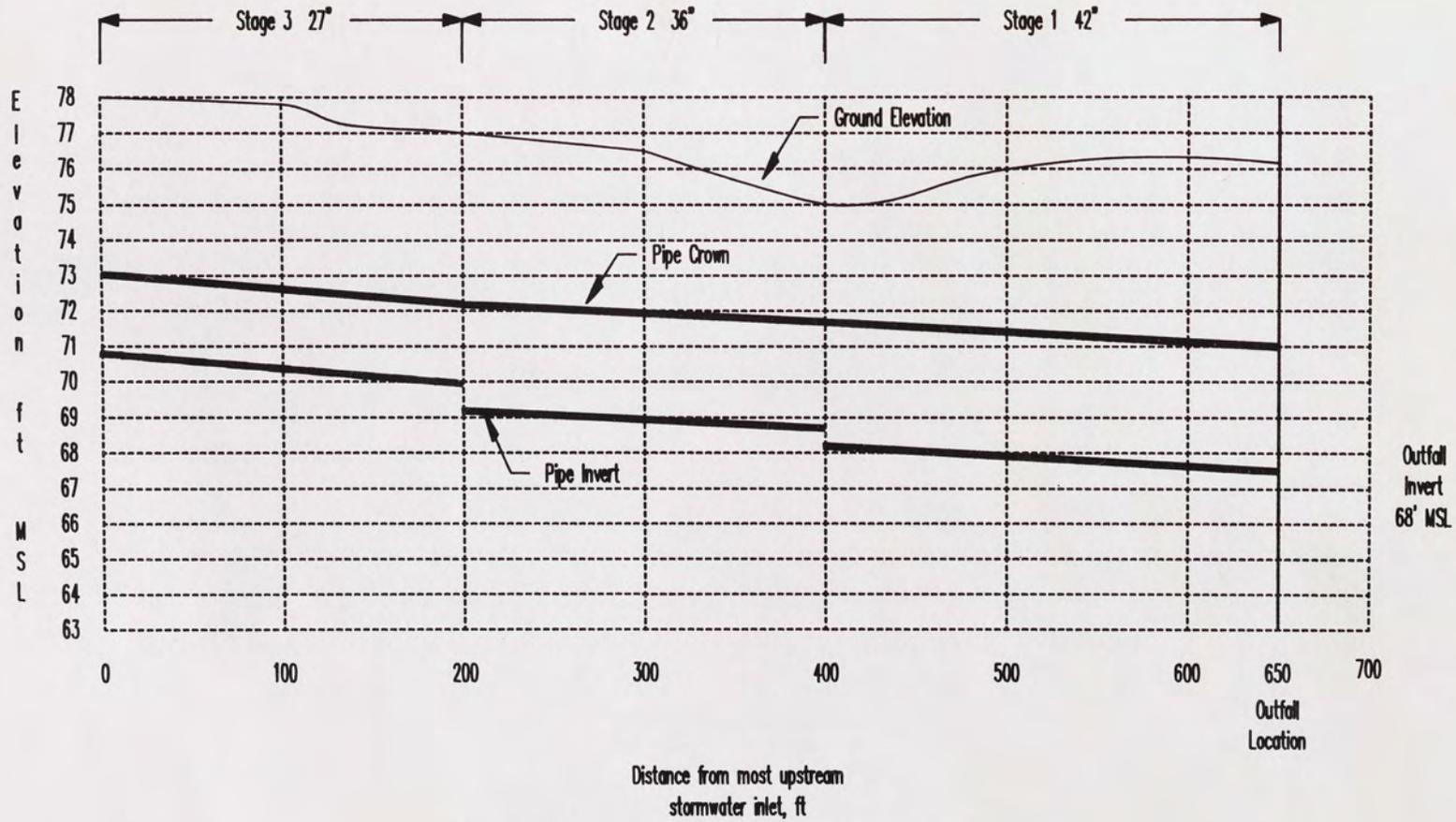
Figure 1Ø.   Alternative Number 8
Pipe Combination 27" 36" 42"

CHAPTER V - CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The use of this set of programs can save construction costs by assisting the engineer in designing the minimum cost piping network configuration for a gravity stormwater collection system. There is a cost tradeoff between pipe diameter and physical pipe slope: the cost of increasing pipe diameter varies inversely with increasing physical pipe slope. The design of a piping network for minimum construction cost can involve the trial of a magnitude of different pipe diameter and depth of excavation combinations. When done by hand, the designer will not usually design for minimum cost, since it is so time consuming to consider all available piping network configurations. The programs use the Rational Method for peak hydrograph computations; Manning's Equation and the Continuity Equation for pipe sizing information; and the Complete Enumeration methodology for optimization of the piping network system. The designer enters information such as sub-basin areas, runoff coefficients, pipe diameters to try for each pipe link, and ground elevations. Costs for piping material and labor are maintained by the designer through the use of cost files and an interactive cost data editor. The optimum piping network configuration is determined by the computer model based on minimum cost.

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Recommendations

As currently written, the engineer must input pipe lengths and topographical information which would usually be read off a set of drawings for each pipe link. Since the writing of this program, however, microcomputer applications have advanced to the point where graphical information from a database is commonly used for design calculation purposes. Therefore, the program could be executed in a more efficient manner by using AutoCAD for interactive graphic input from the designer that could automatically be used again for engineering drawings. This efficiency gained by reusing design data for drafting purposes would certainly be worth further research. The AutoLISP programming language that interfaces directly with AutoCAD could be used to control the graphics environment, while the C programming language could be used for more efficient program code for the mathematical portions of the model. The drainage sub-basins and piping layout could be drawn over a topographic base sheet, and the runoff coefficients automatically generated based on soils information and percent impervious surfaces from the drawing. Then flowrates could be generated for each pipe link using the Rational Method program outside the AutoCAD environment. The optimization program could extract ground elevation and lengths of pipes directly from the AutoCAD drawing file, and the designer could interactively input the pipe sizes to try as is currently done. Then once the optimum piping network configuration is determined, the pipe size and invert information could be automatically updated in the AutoCAD drawing for a complete engineering stormwater plan and profile set.

APPENDIX A

COMPUTER PROGRAM SOURCE CODE

```
100 CLS:COLOR 6,,8:KEY OFF
200 'FILENAME : MENU.BAS
300 'DATE :  DECEMBER 8, 1985
400 PRINT "                    ***********************************************"
500 PRINT "                    *                                             *"
600 PRINT "                    *       M A I N   M E N U                     *"
700 PRINT "                    *                                             *"
800 PRINT "                    *       PIPE SYSTEM OPTIMIZATION FOR           *"
900 PRINT "                    *                                             *"
1000 PRINT "                    *       MINIMUM CONSTRUCTION COSTS            *"
1100 PRINT "                    *                                             *"
1200 PRINT "                    ***********************************************"
1300 PRINT:PRINT
1400 PRINT "           C     Cost data editing"
1500 PRINT:PRINT
1600 PRINT "           W     Watershed data input / editing"
1700 PRINT:PRINT
1800 PRINT "           P     Pipe data input / editing  and  Optimization"
1900 PRINT:PRINT
2000 PRINT "           X     eXit to system"
2100 PRINT:PRINT
2200 COLOR 7:INPUT DECIDE$:COLOR 3
2300 IF (DECIDE$="C") OR (DECIDE$="c") THEN GOTO 3100
2400 IF (DECIDE$="W") OR (DECIDE$="w") THEN GOTO 3200
2500 IF (DECIDE$="P") OR (DECIDE$="p") THEN GOTO 3300
2600 IF (DECIDE$="X") OR (DECIDE$="x") THEN GOTO 3400
2700 PRINT "  You must type in one of the SINGLE LETTERs from the above menu"
2800 PRINT " try again . . ."
2900 FOR I=1 TO 10000:NEXT I
3000 GOTO 100
3100  RUN "EDITCOST.BAS"
3200 RUN "RATIONAL.BAS"
3300 RUN "OPTIMIZE.BAS"
3400 SYSTEM
```

```
50 CLS:COLOR 6,,8
100 'RATIONAL METHOD
150 'WRITTEN BY DAWN E. FETTER
200 'FILENAME : RATIONAL.BAS
250 'DATE  :  JANUARY 6, 1985   UPDATED TO MAKE LABELS AN ARRAY
300 '
350 '            NOTE : LINE NUMBERING CANNOT GO PAST 65500
400 KEY OFF
450 DIM CF(50),MF(50)
455 DIM LABEL$(50)
500 DIM OLDCF(50)
550 DIM INFLOW(50)
600 DIM INTEN(50),TC(50),DUR(50),ONE(50),CFACTOR(50),AREA(50)
650 DIM FLOW(50)
700 DIM CIMP(50),CPERV(50),SAREA(50),IMPAREA(50)
750 DIM RFROM(50,50),FROM(50,50),PIPE#(50),THIS(50)
800 PRINT "       ************************************************************
***"
850 PRINT "       *                    RATIONAL METHOD
  *
900 PRINT "       *              UNIVERSITY OF CENTRAL FLORIDA
  *"
950 PRINT "       ************************************************************
***"
1000 PRINT:COLOR 3:PRINT "Enter a project name or description ";:COLOR 7
1050 INPUT PROJ$
1100 PRINT:COLOR 3
1150 PRINT "Do you want a hardcopy of your input data and results (Y/N) ";
1200 COLOR 7:INPUT HARD$
1250 NSTRUC=1
1300 CHANGE$="N"
1350 UNITS=1
1400 PRINT:PRINT:COLOR 3
1450 PRINT "Place your data disk in drive & press return when ready ";:COLOR 7
1500 INPUT RTURN
1550 PRINT
1600 PRINT:COLOR 3
1650 PRINT "Which of the following do you want to do?"
1700 PRINT "   1) Use an existing data file"
1750 PRINT "   2) Create a new data file"
1800 COLOR 7:INPUT WHERE
1850 PRINT:COLOR 3
1900 PRINT "Do you need to see a directory of your data disk ? (Y/N)":COLOR 7
1950 INPUT TORY$
2000 PRINT:COLOR 3
2050 IF (TORY$="N") OR (TORY$="n")  GOTO 2150
2100 FILES "*.*"
2150 IF WHERE=1 THEN GOTO 10200
2200 PRINT "Enter the name of the data file you'll be creating ( 8 char max )"
2250 PRINT "( B:FILENAME.EXT )"
```

```
2300 COLOR 7:INPUT D$:COLOR 3
2350 PRINT:PRINT "Enter the number of nodes in your stormwater collection system
     ";:COLOR 7
2400 INPUT NNODES
2450 NUMPIPES=NNODES-1
2500 CLS:COLOR 6,,8
2550 PRINT "-------------------"
2600 PRINT "RUNOFF COEFFICIENT"
2650 PRINT "-------------------"
2700 PRINT
2750 PRINT "  Which option would you like to use:"
2800 PRINT
2850 PRINT "  1) input 1 set of C factors to use for all structures"
2900 PRINT "  2) input a different set of C factors for each structure"
2950 PRINT "  3) input 1 composite C factor to use for all structures "
3000 PRINT "  4) input a different composite C factor for each structure "
3050 COLOR 7:INPUT CCHOICE
3100 IF (CCHOICE)=1) OR (CCHOICE(=4) THEN GOTO 3250
3150 COLOR 3:PRINT "Not a valid choice . . . try again"
3200 GOTO 2550
3250 IF ((CCHOICE=2) OR (CCHOICE=4)) THEN GOTO 4850
3300 IF KIND=3 GOTO 4100
3350 IF CCHOICE=1 THEN GOTO 3800
3400 PRINT:PRINT:COLOR 3:PRINT "Enter the composite C factor ";:COLOR 7
3450 INPUT CFACTOR
3500 FOR I=1 TO NNODES
3550     CFACTOR(I)=CFACTOR
3600     OLDCF(I)=CFACTOR(I)
3650 NEXT I
3700 IF KIND=6 THEN GOTO 18200
3750 GOTO 4350
3800 PRINT:PRINT:COLOR 3:PRINT "Enter the C factor of the impervious area ";
3850 COLOR 7:INPUT CIMP
3900 FOR I=1 TO NNODES
3950   CIMP(I)=CIMP
4000 NEXT I
4050 IF KIND=4 GOTO 4500
4100 PRINT:COLOR 3:PRINT "Enter the C factor of the pervious area ";:COLOR 7
4150 INPUT CPERV
4200 FOR I=1 TO NNODES
4250   CPERV(I)=CPERV
4300 NEXT I
4350 IF KIND=3 GOTO 4500
4400 GOTO 4850
4450 PRINT:PRINT:PRINT
4500 FOR K=1 TO NNODES
4550     CFACTOR(K)=(CIMP(K)*IMPAREA(K))+(CPERV(K)*(SAREA(K)-IMPAREA(K)))
4600 IF SAREA(K)=0 THEN GOTO 4750
4650     CFACTOR(K)=CFACTOR(K)/SAREA(K)
4700     CFACTOR(K)=INT(CFACTOR(K)*100)/100
4750 NEXT K
```

```
4800 GOTO 18200
4850 '
4900 '
4950 '
5000 OPEN D$ FOR OUTPUT AS #1
5050 PRINT #1,CCHOICE
5100 PRINT #1,NNODES
5150 FOR I=1 TO 2000:NEXT I
5250 FOR P = 1 TO NNODES
5300    CLS:COLOR 6,,8
5350    PRINT "---------------------------"
5400    PRINT " NODE # : ";P
5450    PRINT "---------------------------"
5500    PRINT:PRINT:PRINT:COLOR 3
5550    PRINT "Enter the node LABEL you have assigned to this node ";:COLOR 7
5600 PIPE#(P)=P
5650 INPUT LABEL$(P)
5750    COLOR 3:PRINT "How many nodes flow into this node ";:COLOR 7
5800    INPUT THIS(P)
5850    FOR I=1 TO THIS(P)
5900    COLOR 3:PRINT "node   :";:COLOR 7
5950    INPUT RFROM(P,I)
6000 FROM(P,I)=RFROM(P,I)
6200    NEXT I
6250    COLOR 3:PRINT "Enter the sub area (acres) that contributes to this node
";:COLOR 7
6300    INPUT SAREA(P)
6350    AREA(P)=SAREA(P)
6400 IF ((CCHOICE=3) OR (CCHOICE=4)) THEN GOTO 7250
6450    COLOR 3:PRINT "Enter the impervious area (acres)  ";:COLOR 7
6500    INPUT IMPAREA(P)
6550    IF IMPAREA(P)(=AREA(P) GOTO 6700
6600    COLOR 3:PRINT "* the impervious area must be less than or equal to the t
otal area *"
6650    GOTO 6450
6700 IF KIND=2 GOTO 8400
6750 IF CCHOICE=1 THEN GOTO 7450
6800 IF KIND=3 GOTO 7000
6850    COLOR 3:PRINT "Enter the C factor for the impervious area ";:COLOR 7
6900    INPUT CIMP(P)
6950 IF KIND=4 GOTO 7150
7000    COLOR 3:PRINT "Enter the C factor for the pervious area ";:COLOR 7
7050    INPUT CPERV(P)
7100 IF KIND=3 GOTO 7150
7150 IF (KIND=3) OR (KIND=4) GOTO 8400
7200 GOTO 7500
7250 IF CCHOICE=3 THEN GOTO 7500
7300 COLOR 3:PRINT "Enter the composite C factor ";:COLOR 7
7350 INPUT CFACTOR(P)
7400 OLDCF(P)=CFACTOR(P)
7450    PRINT:PRINT
```

```
7500 PRINT:PRINT:COLOR 3
7550    PRINT:PRINT "Is this correct (Y/N) ";:COLOR 7
7600    INPUT PERHAPS$
7650    IF (PERHAPS$="N") OR (PERHAPS$="n") GOTO 5300
7700 PRINT #1,LABEL$(P)
7750 PRINT #1,THIS(P)
7800 FOR L=1 TO THIS(P)
7850    PRINT #1,FROM(P,L)
7900    PRINT #1,RFROM(P,L)
7950 NEXT L
8000 PRINT #1,AREA(P)
8050 PRINT #1,IMPAREA(P)
8100 IF CCHOICE=2 GOTO 8250
8150 CIMP(P)=CIMP
8200 CPERV(P)=CPERV
8250 PRINT #1,CIMP(P)
8300 PRINT #1,CPERV(P)
8350 IF ((CCHOICE=3) OR (CCHOICE=4)) THEN GOTO 8650
8400    CFACTOR(P)=(CIMP(P)*IMPAREA(P))+(CPERV(P)*(SAREA(P)-IMPAREA(P)))
8450 IF SAREA(P)=0 THEN GOTO 8700
8500    CFACTOR(P)=CFACTOR(P)/SAREA(P)
8550 OLDCF(P)=CFACTOR(P)
8600 OLDCF(P)=INT(OLDCF(P)*100)/100
8650 CFACTOR(P)=INT(CFACTOR(P)*100)/100
8700 IF KIND=4 GOTO 18200
8750 IF KIND=3 GOTO 18200
8800 IF KIND=1 GOTO 9150
8850 IF KIND=2 GOTO 18050
8900 PRINT #1,CFACTOR(P)
8950 PRINT #1,OLDCF(P)
9000 NEXT P
9050 IF (CHANGE$="Y") OR (CHANGE$="y") THEN GOTO 18200
9100 CLS
9150 FOR P=1 TO NNODES
9200 AREA(P)=SAREA(P)
9250    FOR A=1 TO THIS(P)
9300     AREA(P)=AREA(P)+AREA(RFROM(P,A))
9350    NEXT A
9400 IF ((KIND=1) OR (KIND=6)) THEN GOTO 9500
9450 PRINT #1,AREA(P)
9500 NEXT P
9600 FOR P=1 TO NNODES
9650 CF(P)=(OLDCF(P)*SAREA(P))/AREA(P)
9700 MF(P)=OLDCF(P)*SAREA(P)
9750    FOR A=1 TO THIS(P)
9800 MF(P)=MF(P)+MF(RFROM(P,A))
9850    CF(P)=MF(P)/AREA(P)
9900    NEXT A
9950 CFACTOR(P)=CF(P)
10000 NEXT P
10050 IF KIND=1 GOTO 13200
```

```
10100 IF KIND=6 GOTO 18200
10150 GOTO 11750
10200 COLOR 3:PRINT "Enter the name of the data file you'll be using";
10250 PRINT "( B:FILENAME.EXT )":COLOR 7
10300 INPUT D$
10350 OPEN D$ FOR INPUT AS #1
10400 INPUT #1,CCHOICE
10450 INPUT #1,NNODES
10500 FOR I=1 TO NNODES
10550   INPUT #1,LABEL$(I)
10600   INPUT #1,THIS(I)
10650   FOR J=1 TO THIS(I)
10700     INPUT #1,FROM(I,J)
10750     INPUT #1,RFROM(I,J)
10800   NEXT J
10850   INPUT #1,AREA(I)
10900 SAREA(I)=AREA(I)
10950   INPUT #1,IMPAREA(I)
11000   INPUT #1,CIMP(I)
11050   INPUT #1,CPERV(I)
11100   INPUT #1,CFACTOR(I)
11150 INPUT #1,OLDCF(I)
11200 NEXT I
11250 FOR I=1 TO NNODES
11300   INPUT #1,AREA(I)
11350 NEXT I
11400 FOR I=1 TO NNODES
11450   INPUT #1,TC(I)
11500 NEXT I
11550 CLOSE #1
11600 GOTO 14100
11650 CLS
11700 PRINT:PRINT
11750 CLS
11800 PRINT:PRINT
11850 COLOR 6,,8:PRINT "----------------------"
11900 PRINT "TIME OF CONCENTRATION"
11950 PRINT "----------------------"
12000 PRINT
12050 PRINT " Which option would you like to use:"
12100 PRINT
12150 PRINT " 1)  input your own time of concentration"
12200 PRINT " 2)  use the SFWMD equation to calculate time of concentration"
12250 COLOR 7:INPUT CHOICE
12300 IF (CHOICE=1) OR (CHOICE=2) THEN GOTO 12450
12350 COLOR 3:PRINT "Not a valid choice . . . try again"
12400 GOTO 11850
12450 PRINT
12500 IF CHOICE=2 THEN GOTO 13200
12550 PRINT
12600 IF (CCHOICE=2) AND (CHOICE=1) THEN GOTO 12650
```

```
12650 PRINT:PRINT:COLOR 3:PRINT "Enter the time of concentration for each struct
ure"
12700 FOR I=1 TO NNODES
12750    COLOR 3:PRINT "Node # ";I;" :";:COLOR 7
12800    INPUT TC(I)
12850 PRINT #1,TC(I)
12900 NEXT I
12950 COLOR 3:PRINT "Has the above data been entered correctly (Y/N) ";:COLOR 7
13000 INPUT CORRTC$
13050 IF ((CORRTC$="n") OR (CORRTC$="N")) THEN GOTO 12650
13100 CLOSE #1
13150 GOTO 14050
13200 FOR I=1 TO NNODES
13250 IF UNITS=1 THEN AREA(I)=AREA(I)*.001562
13300    TC(I)=2*(AREA(I)^(1/2))*60
13350 IF (CHANGE$="Y") OR (CHANGE$="y") GOTO 13450
13400 PRINT #1,TC(I)
13450 NEXT I
13500 CLOSE #1
13550 UNITS=2
13600 IF (CHANGE$="Y") OR (CHANGE$="y") THEN GOTO 18200
13650 COLOR 6,,8:PRINT "Structure     Time of Concentration (minutes)"
13700 PRINT "---------     -------------------------------":COLOR 7
13750 FOR I=1 TO NNODES
13800 T1=INT(TC(I)*100)/100
13850 PRINT TAB(3);I;TAB(20);T1
13900 NEXT I
13950 COLOR 3:PRINT "press return when ready to continue . . .";
14000 INPUT CCCC
14050 '
14100 CLS:COLOR 6,,8
14150 PRINT "-----------------------------------------------------------------
-------------"
14200 PRINT:PRINT "                    INPUT DATA FOR FILE ";D$
14250 PRINT
14300 IF((CCHOICE=3) OR (CCHOICE=4)) THEN GOTO 15000
14350 PRINT " NODE   USER    SUB     IMPERVIOUS   C FACTOR    C FACTOR
  TIME OF "
14400 PRINT "  #    LABEL   AREA      AREA       PERVIOUS   IMPERVIOUS    C
ONCENTRATION"
14450 PRINT "               (ACRES)   (ACRES)
  (MINUTES)"
14500 PRINT "------ ------  --------  ----------  ---------  ----------   -
-------------"
14550 PRINT:COLOR 7
14650 FOR I=1 TO NNODES
14700 TC(I)=INT(TC(I)*100+.5)/100
14800 PRINT TAB(2);I;TAB(9);LABEL$(I);TAB(16);SAREA(I);TAB(29);IMPAREA(I);TAB(42
);CPERV(I);TAB(55);CIMP(I);TAB(70);TC(I)
14850 NEXT I
14950 GOTO 15650
```

```
15000 COLOR 6,,8:PRINT "           NODE    USER    SUB       COMPOSITE    WEIGHTED
      TIME OF "
15050 PRINT "          #     LABEL    AREA     C FACTOR    COMPOSITE      CONCEN
TRATION"
15100 PRINT "                        (ACRES)              C FACTOR       (MINU
TES)"
15150 PRINT "           ------- ------  --------  -----------  ----------   -------
-------"
15200 PRINT:COLOR 7
15300 FOR I=1 TO NNODES
15400 TC(I)=INT(TC(I)*100+.5)/100
15450 CFACTOR(I)=INT(CFACTOR(I)*100+.5)/100
15500 PRINT TAB(11);I;TAB(18);LABEL$(I);TAB(25);SAREA(I);TAB(38);OLDCF(I);TAB(51
);CFACTOR(I);TAB(64);TC(I)
15550 NEXT I
15650 COLOR 6:PRINT:PRINT "---------------------------------------------------
--------------------------":COLOR 3
15700 PRINT "press return when ready to continue . . .";
15750 INPUT CCCC
15800 IF (CHANGE$="Y") OR (CHANGE$="y") GOTO 22300
15850 '------------------------
15900 'RAINFALL INTENSITY CURVES
15950 '------------------------
16000 'FOR J=1 TO 11
16050 CLS:COLOR 3
16100 PRINT "Which of the following D.O.T. Rainfall Intensity Curves would you"
16150 PRINT "like to use?"
16200 PRINT "      1) ZONE 1"
16250 PRINT "      2) ZONE 2"
16300 PRINT "      3) ZONE 3"
16350 PRINT "      4) ZONE 4"
16400 PRINT "      5) ZONE 5"
16450 PRINT "      6) ZONE 6"
16500 PRINT "      7) ZONE 7"
16550 PRINT "      8) ZONE 8"
16600 PRINT "      9) ZONE 9"
16650 PRINT "     10) ZONE 10"
16700 PRINT "     11) ZONE 11"
16750 COLOR 7:INPUT ZONE$
16800 OPEN ZONE$ FOR INPUT AS #2
16850 IF (CHANGE$="Y") OR (CHANGE$="y") THEN GOTO 17300
16900 READ DUR(1),ONE(1)
16950 INPUT #2,DUR(1),ONE(1)
17000 FOR I=2 TO 37
17050   READ DUR(I),ONE(I)
17100 INPUT #2,DUR(I),ONE(I)
17150 NEXT I
17200 CLOSE #2
17250 'NEXT J
17300 FOR K=1 TO NNODES
17350 IF TC(K)=120 THEN INTEN(K)=ONE(37)
```

```
17400 IF TC(K))=8 THEN GOTO 17550
17450 INTEN(K)=ONE(1)
17500 GOTO 18000
17550 FOR I=1 TO 37
17600   IF (TC(K)(DUR(I-1)) OR (TC(K))DUR(I)) THEN GOTO 17950
17650   A=TC(K)-DUR(I-1)
17700   B=DUR(I)-DUR(I-1)
17750   C=ONE(I-1)-ONE(I)
17800   D=(C*A)/B
17850 INTEN(K)=ONE(I-1)-D
17900 IF (CHANGE$="Y") OR (CHANGE$="y") THEN GOTO 18000
17950 NEXT I
18000 NEXT K
18050 IF KIND=2 THEN UNITS=1
18100 IF KIND=5 THEN UNITS=1
18150 IF KIND=5 THEN AREA(1)=AREA(1)/.001562
18200 IF UNITS=1 THEN GOTO 18400
18250 FOR I=1 TO NNODES
18300   AREA(I)=AREA(I)/.001562
18350 NEXT I
18400 FOR I=1 TO NNODES
18450   FLOW(I)=CFACTOR(I)*INTEN(I)*AREA(I)
18500   INFLOW(I)=OLDCF(I)*INTEN(I)*SAREA(I)
18550 'CHECK TO SEE IF FLOW(I)(FLOW(I-1)
18600 NEXT I
18650 FOR P=1 TO NNODES
18700 IF FLOW(P)()0 GOTO 18900
18750 FOR A=1 TO THIS(P)
18800   FLOW(P)=FLOW(P)+FLOW(RFROM(P,A))
18850 NEXT A
18900 NEXT P
18950 CLS
19000 PRINT:PRINT:PRINT:COLOR 6,,8
19050 PRINT "_____
_____ "
19100 PRINT:PRINT
19150 PRINT "                              RESULTS FOR FILE  ";D$
19200 PRINT:PRINT
19250 PRINT "NODE  COMPOSITE   TIME OF   INTENSITY   SUB    TOTAL CUMULATIVE FL
OW INTO"
19300 PRINT "LABEL  C FACTOR  CONCENTRN   ZONE ";ZONE$;"   AREA     AREA    FLOW
RATE    INLET"
19350 PRINT "                   (MIN)     (IN/HR)  (ACRES) (ACRES)   (CFS)
(CFS)"
19400 PRINT "-----  --------- ---------  --------- ------- ------- --------- --
-------":COLOR 7
19450 FOR I=1 TO NNODES
19500 FLOW(I)=(INT(FLOW(I)*100+.5))/100
19550 INTEN(I)=(INT(INTEN(I)*100+.5))/100
19600 AREA(I)=(INT(AREA(I)*1000+.5))/1000
19650 TC(I)=(INT(TC(I)*100+.5))/100
```

```
19700 CFACTOR(I)=(INT(CFACTOR(I)*100+.5))/100
19750 NEXT I
19850 FOR I=1 TO NNODES
19950 IF INTEN(I)=8.100001 THEN INTEN(I)=8
20000 PRINT TAB(1);LABEL$(I);TAB(10);CFACTOR(I);TAB(17);TC(I);TAB(30);INT(INTEN(
I)*100)/100;TAB(40);SAREA(I);TAB(49);INT(AREA(I)*1000)/1000;TAB(58);FLOW(I);TAB(
68);INT(INFLOW(I)*1000)/1000
20050 NEXT I
20150 PRINT:PRINT:COLOR 6
20200 PRINT "_____
_____":COLOR 3
20250 PRINT "press return when ready to continue . . . ";
20300 INPUT CCCC
20350 ' RE INPUT DATA INTO FILE TO INCLUDE ALL CHANGES
20400 OPEN D$ FOR OUTPUT AS #1
20450 OPEN "FLOWS.DAT" FOR OUTPUT AS #2
20500 PRINT #1,CCHOICE
20550 PRINT #1,NNODES
20600 NSTAGES=NNODES-1
20650 PRINT #2,NSTAGES
20700 FOR I=1 TO NNODES
20750 PRINT #2,FLOW(I),INFLOW(I)
20800 PRINT #2,THIS(I)
20850    PRINT #1,LABEL$(I)
20900    PRINT #1,THIS(I)
20950    FOR J=1 TO THIS(I)
21000       PRINT #1,FROM(I,J)
21050       PRINT #1,RFROM(I,J)
21100 PRINT #2,FROM(I,J)
21150    NEXT J
21200    PRINT #1,SAREA(I)
21250    PRINT #1,IMPAREA(I)
21300    PRINT #1,CIMP(I)
21350    PRINT #1,CPERV(I)
21400    PRINT #1,CFACTOR(I)
21450 PRINT #1,OLDCF(I)
21500    NEXT I
21550 FOR I=1 TO NNODES
21600       PRINT #1,AREA(I)
21650 NEXT I
21700 FOR I=1 TO NNODES
21750    PRINT #1,TC(I)
21800 NEXT I
21850 CLOSE #1
21900 CLOSE #2
21950 '
22000 PRINT "Do you want to make any changes? (Y/N)":COLOR 7
22050 INPUT CHANGE$:COLOR 3
22100 IF CHANGE$="" THEN GOTO 22000
22150 IF (CHANGE$="N") OR (CHANGE$="n") THEN GOTO 24250
22200 UNITS=1
```

```
22250 GOTO 14100
22300 PRINT "Which category do you need to change?"
22350 PRINT "  1) Sub Area"
22400 PRINT "  2) Impervious Area"
22450 PRINT "  3) Pervious C Factor"
22500 PRINT "  4) Impervious C Factor"
22550 PRINT "  5) Time of Concentration"
22600 IF ((CCHOICE=1) OR (CCHOICE=2)) GOTO 22700
22650 PRINT "  6) Composite C Factor"
22700 COLOR 7:INPUT KIND:COLOR 3
22750 IF ((CCHOICE=3) AND (KIND=6)) THEN GOTO 3350
22800 IF (KIND=3) AND (CCHOICE=1) THEN GOTO 23300
22850 IF (KIND=4) AND (CCHOICE=1) THEN GOTO 23300
22900 PRINT "Which structure number do you need to make the change for?"
22950 COLOR 7:INPUT NUMBER:COLOR 3
23000 IF KIND=1 THEN GOTO 23650
23050 IF KIND=5 THEN GOTO 23950
23100 P=NUMBER
23150 IF (KIND=3) OR (KIND=4) GOTO 6750
23200 IF KIND=6 THEN GOTO 23400
23250 GOTO 6450
23300 UNITS=1
23350 IF CCHOICE=1 THEN GOTO 23600
23400 COLOR 3:PRINT "Enter the C factor for structure ";NUMBER:COLOR 7
23450 INPUT CFACTOR(NUMBER)
23500 OLDCF(NUMBER)=CFACTOR(NUMBER)
23550 IF ((KIND=6) AND (CCHOICE=4)) THEN GOTO 9150
23600 GOTO 3250
23650 PRINT "Enter the new area for structure ";NUMBER;:COLOR 7
23700 INPUT AREA(NUMBER)
23750 SAREA(NUMBER)=AREA(NUMBER)
23800 UNITS=1
23850 P=NUMBER
23900 GOTO 9150
23950 PRINT "Enter the new time of concentration for structure ";NUMBER;:COLOR 7
24000 INPUT TC(NUMBER)
24050 FOR I=1 TO NSTRUC
24100   AREA(I)=AREA(I)*.001562
24150 NEXT I
24200 GOTO 17300
24250 IF (HARD$="N") OR (HARD$="n") GOTO 29100
24300 COLOR 6+16:PRINT "*** Make Printer Ready and Press Return***":INPUT" ",CCC
CC:    COLOR 3:WIDTH "LPT1:",255
24350 LPRINT CHR$(27);CHR$(108);CHR$(15);
24400 LPRINT CHR$(27);CHR$(114);CHR$(5);
24450 LPRINT CHR$(27);CHR$(78);CHR$(5);
24500 LPRINT CHR$(27);CHR$(67);CHR$(66);
24550 LPRINT CHR$(15)
24600 LPRINT CHR$(27);CHR$(71);
24650 LPRINT "                          RATIONAL METHOD"
24700 LPRINT "                   DONALD W. MCINTOSH ASSOCIATES, INC."
```

```
24750 LPRINT
24800 LPRINT "                    PROJECT : ";PROJ$
24850 FOR L=1 TO 5:LPRINT:NEXT L
24900 LPRINT CHR$(27);CHR$(72);
24950 LPRINT "-----------------------------------------------------------------
--------------"
25000 LPRINT CHR$(27);CHR$(71);
25050 LPRINT:LPRINT "                    INPUT DATA FOR FILE ";D$
25100 LPRINT CHR$(27);CHR$(72);
25150 LPRINT
25200 IF ((CCHOICE=3) OR (CCHOICE=4)) THEN GOTO 25900
25250 LPRINT " NODE    USER     SUB      IMPERVIOUS    C FACTOR    C FACTOR
   TIME OF "
25300 LPRINT "  #     LABEL    AREA       AREA        PERVIOUS    IMPERVIOUS
 CONCENTRATION"
25350 LPRINT "                (ACRES)    (ACRES)
  (MINUTES)"
25400 LPRINT "------ ------ --------   ----------   ---------   ----------
-------------"
25450 LPRINT
25550 FOR I=1 TO NNODES
25600 TC(I)=INT(TC(I)*100+.5)/100
25700 LPRINT TAB(2);I;TAB(9);LABEL$(I);TAB(16);SAREA(I);TAB(29);IMPAREA(I);TAB(4
2);CPERV(I);TAB(55);CIMP(I);TAB(70);TC(I)
25750 NEXT I
25850 GOTO 26500
25900 LPRINT "          NODE    USER     SUB     COMPOSITE   WEIGHTED        TIM
E OF "
25950 LPRINT "           #     LABEL    AREA    C FACTOR    COMPOSITE    CONCEN
TRATION"
26000 LPRINT "                         (ACRES)              C FACTOR     (MIN
UTES)"
26050 LPRINT "          ------ ------ --------   ----------  ---------   ------
-------"
26100 LPRINT
26200 FOR I=1 TO NNODES
26250 TC(I)=INT(TC(I)*100+.5)/100
26350 LPRINT TAB(12);I;TAB(19);LABEL$(I);TAB(26);SAREA(I);TAB(39);OLDCF(I);TAB(5
2);CFACTOR(I);TAB(62);TC(I)
26400 NEXT I
26500 LPRINT:LPRINT "--------------------------------------------------------------
---------------------"
26550 NPIPES=NNODES-1
26600 IF NNODES)5 THEN LPRINT CHR$(12)
26650 LPRINT:LPRINT:LPRINT
26700 LPRINT "      PIPE #               FROM NODE           TO NOD
E       "
26750 LPRINT "      ----------           -------------       -------
---"
26800 COUNT=0
26850 FOR I=1 TO NNODES
```

```
26900 FOR J=1 TO THIS(I)
26950 COUNT=COUNT+1
27000 LPRINT "              ";COUNT;"                    ";FROM(I,J);"
         ";I
27050 NEXT J
27100 NEXT I
27150 LPRINT:LPRINT:LPRINT:LPRINT:LPRINT
27200 LPRINT "_____
_____"
27250 LPRINT:LPRINT
27300 LPRINT CHR$(27);CHR$(71);
27350 LPRINT "                    RESULTS FOR FILE  ";D$
27400 LPRINT CHR$(27);CHR$(72);
27450 LPRINT:LPRINT
27500 LPRINT
27550 LPRINT "STRUCTURE  COMPOSITE      TIME OF      INTENSITY    SUB     TOTA
L   CUMULATIVE    FLOW INTO"
27600 LPRINT " LABEL     C FACTOR   CONCENTRATION    ZONE  ";ZONE$;"      AREA
     AREA     FLOWRATE        INLET"
27650 LPRINT "                       (MINUTES)      (IN/HR)     (ACRES)  (ACR
ES)  (CFS)         (CFS)"
27700 LPRINT "--------- --------- --------------    ---------   ------- ----
--- ---------    ---------"
27750 FOR I=1 TO NNODES
27800 FLOW(I)=(INT(FLOW(I)*100+.5))/100
27850 INTEN(I)=(INT(INTEN(I)*100+.5))/100
27900 AREA(I)=(INT(AREA(I)*1000+.5))/1000
27950 TC(I)=(INT(TC(I)*100+.5))/100
28000 NEXT I
28100 FOR I=1 TO NNODES
28200 IF INTEN(I)=8.100001 THEN INTEN(I)=8
28250 LPRINT TAB(3);LABEL$(I);TAB(12);
28300 LPRINT USING ".##";CFACTOR(I);
28350 LPRINT TAB(27);
28400 LPRINT USING "###.##";TC(I);
28450 LPRINT TAB(42);
28500 LPRINT USING "##.##";INTEN(I);
28550 LPRINT TAB(55);
28600 LPRINT USING "###.##";SAREA(I);
28650 LPRINT TAB(64);
28700 LPRINT USING "###.##";AREA(I);
28750 LPRINT TAB(72);
28800 LPRINT USING "###.##";FLOW(I);
28850 LPRINT TAB(86);
28900 LPRINT USING "###.##";INFLOW(I);
28950 NEXT I
29000 LPRINT:LPRINT
29050 LPRINT "_____
_____"
29100 RUN "MENU.BAS"
29150 END
```

```
29200 'ZONE 1
29250 DATA 8,7.20
29300 DATA 9,7.05
29350 DATA 10,6.90
29400 DATA 11,6.80
29450 DATA 12,6.60
29500 DATA 13,6.40
29550 DATA 14,6.20
29600 DATA 15,6.05
29650 DATA 16,6.00
29700 DATA 17,5.82
29750 DATA 18,5.78
29800 DATA 19,5.60
29850 DATA 20,5.40
29900 DATA 22,5.30
29950 DATA 24,5.05
30000 DATA 26,4.90
30050 DATA 28,4.80
30100 DATA 30,4.60
30150 DATA 32,4.40
30200 DATA 34,4.25
30250 DATA 36,4.20
30300 DATA 38,4.00
30350 DATA 40,4.05
30400 DATA 42,3.85
30450 DATA 44,3.75
30500 DATA 46,3.65
30550 DATA 48,3.60
30600 DATA 50,3.50
30650 DATA 52,3.40
30700 DATA 54,3.35
30750 DATA 56,3.30
30800 DATA 58,3.20
30850 DATA 60,3.17
30900 DATA 75,2.80
30950 DATA 90,2.50
31000 DATA 105,2.30
31050 DATA 120,2.10
31100 'ZONE 2
31150 DATA 8,7.30
31200 DATA 9,7.20
31250 DATA 10,7.00
31300 DATA 11,6.80
31350 DATA 12,6.60
31400 DATA 13,6.50
31450 DATA 14,6.40
31500 DATA 15,6.20
31550 DATA 16,6.00
31600 DATA 17,5.90
31650 DATA 18,5.80
31700 DATA 19,5.65
```

```
31750 DATA 20,5.50
31800 DATA 22,5.30
31850 DATA 24,5.05
31900 DATA 26,4.97
31950 DATA 28,4.80
32000 DATA 30,4.60
32050 DATA 32,4.50
32100 DATA 34,4.35
32150 DATA 36,4.20
32200 DATA 38,4.02
32250 DATA 40,4.00
32300 DATA 42,3.90
32350 DATA 44,3.80
32400 DATA 46,3.70
32450 DATA 48,3.60
32500 DATA 50,3.50
32550 DATA 52,3.40
32600 DATA 54,3.30
32650 DATA 56,3.25
32700 DATA 58,3.15
32750 DATA 60,3.10
32800 DATA 75,2.75
32850 DATA 90,2.45
32900 DATA 105,2.20
32950 DATA 120,2.00
33000 'ZONE 3
33050 DATA 8,7.5
33100 DATA 9,7.2
33150 DATA 10,7.0
33200 DATA 11,6.8
33250 DATA 12,6.6
33300 DATA 13,6.4
33350 DATA 14,6.2
33400 DATA 15,6.1
33450 DATA 16,6.0
33500 DATA 17,5.8
33550 DATA 18,5.7
33600 DATA 19,5.6
33650 DATA 20,5.5
33700 DATA 22,5.3
33750 DATA 24,5.0
33800 DATA 26,5.9
33850 DATA 28,5.7
33900 DATA 30,5.6
33950 DATA 32,5.4
34000 DATA 34,5.3
34050 DATA 36,5.2
34100 DATA 38,5.1
34150 DATA 40,4.95
34200 DATA 42,4.80
34250 DATA 44,4.70
```

```
34300 DATA 46,4.60
34350 DATA 48,4.5
34400 DATA 50 4.4
34450 DATA 52,4.35
34500 DATA 54,4,30
34550 DATA 56,4.20
34600 DATA 58,4.10
34650 DATA 60,4.00
34700 DATA 75,2.60
34750 DATA 90,2.30
34800 DATA 105,2.05
34850 DATA 120,1.85
34900 'ZONE 4
34950 DATA 8,7.6
35000 DATA 9,7.2
35050 DATA 10,7.0
35100 DATA 11,6.8
35150 DATA 12,6.6
35200 DATA 13,6.4
35250 DATA 14,6.2
35300 DATA 15,6.0
35350 DATA 16,5.8
35400 DATA 17,5.7
35450 DATA 18,5.6
35500 DATA 19,5.5
35550 DATA 20,5.4
35600 DATA 22,5.2
35650 DATA 24,5.0
35700 DATA 26,4.8
35750 DATA 28,4.6
35800 DATA 30,4.5
35850 DATA 32,4.4
35900 DATA 34,4.2
35950 DATA 36,4.1
36000 DATA 38,4.0
36050 DATA 40,3.9
36100 DATA 42,3.8
36150 DATA 44,3.7
36200 DATA 46,3.5
36250 DATA 48,3.4
36300 DATA 50,3.3
36350 DATA 52,3.2
36400 DATA 54,3.1
36450 DATA 56,3.05
36500 DATA 58,3.0
36550 DATA 60,2.9
36600 DATA 75,2.6
36650 DATA 90,2.3
36700 DATA 105,2.05
36750 DATA 120,1.85
36800 'ZONE 5
```

```
36850 DATA 8,7.8
36900 DATA 9,7.5
36950 DATA 10,7.2
37000 DATA 11,6.9
37050 DATA 12,6.6
37100 DATA 13,6.4
37150 DATA 14,6.3
37200 DATA 15,6.1
37250 DATA 16,6.0
37300 DATA 17,5.8
37350 DATA 18,5.7
37400 DATA 19,5.6
37450 DATA 20,5.4
37500 DATA 22,5.2
37550 DATA 24,5.0
37600 DATA 26,4.9
37650 DATA 28,4.7
37700 DATA 30,4.6
37750 DATA 32,4.4
37800 DATA 34,4.3
37850 DATA 36,4.2
37900 DATA 38,4.1
37950 DATA 40,4.0
38000 DATA 42,3.9
38050 DATA 44,3.8
38100 DATA 46,3.7
38150 DATA 48,3.6
38200 DATA 50,3.55
38250 DATA 52,3.50
38300 DATA 54,3.40
38350 DATA 56,3.30
38400 DATA 58,3.20
38450 DATA 60,3.15
38500 DATA 75,2.80
38550 DATA 90,2.40
38600 DATA 105,2.20
38650 DATA 120,2.00
38700 'ZONE 6
38750 DATA 8,7.8
38800 DATA 9,7.5
38850 DATA 10,7.4
38900 DATA 11,7.2
38950 DATA 12,7.0
39000 DATA 13,6.8
39050 DATA 14,6.6
39100 DATA 15,6.4
39150 DATA 16,6.3
39200 DATA 17,6.2
39250 DATA 18,6.0
39300 DATA 19,5.8
39350 DATA 20,5.7
```

```
39400 DATA 22,5.5
39450 DATA 24,5.3
39500 DATA 26,5.05
39550 DATA 28,4.8
39600 DATA 30,4.7
39650 DATA 32,4.6
39700 DATA 34,4.4
39750 DATA 36,4.2
39800 DATA 38,4.1
39850 DATA 40,4.0
39900 DATA 42,3.9
39950 DATA 44,3.8
40000 DATA 46,3.7
40050 DATA 48,3.6
40100 DATA 50,3.5
40150 DATA 52,3.4
40200 DATA 54,3.35
40250 DATA 56,3.3
40300 DATA 58,3.25
40350 DATA 60,3.15
40400 DATA 75,2.75
40450 DATA 90,2.45
40500 DATA 105,2.20
40550 DATA 120,2.05
40600 'ZONE 7
40650 DATA 8,8.00
40700 DATA 9,7.55
40750 DATA 10,7.35
40800 DATA 11,7.10
40850 DATA 12,6.87
40900 DATA 13,6.65
40950 DATA 14,6.50
41000 DATA 15,6.32
41050 DATA 16,6.20
41100 DATA 17,6.05
41150 DATA 18,5.90
41200 DATA 19,5.80
41250 DATA 20,5.68
41300 DATA 22,5.50
41350 DATA 24,5.30
41400 DATA 26,5.12
41450 DATA 28,4.98
41500 DATA 30,4.83
41550 DATA 32,4.70
41600 DATA 34,4.55
41650 DATA 36,4.42
41700 DATA 38,4.30
41750 DATA 40,4.20
41800 DATA 42,4.08
41850 DATA 44,3.98
41900 DATA 46,3.85
```

```
41950 DATA 48,3.77
42000 DATA 50,3.68
42050 DATA 52,3.59
42100 DATA 54,3.49
42150 DATA 56,3.40
42200 DATA 58,3.31
42250 DATA 60,3.25
42300 DATA 75,2.75
42350 DATA 90,2.4
42400 DATA 105,2.15
42450 DATA 120,2.00
42500 'ZONE 8
42550 DATA 8,8.0
42600 DATA 9,7.6
42650 DATA 10,7.5
42700 DATA 11,7.2
42750 DATA 12,7.0
42800 DATA 13,6.8
42850 DATA 14,6.6
42900 DATA 15,6.5
42950 DATA 16,6.4
43000 DATA 17,6.2
43050 DATA 18,6.0
43100 DATA 19,5.9
43150 DATA 20,5.8
43200 DATA 22,5.6
43250 DATA 24,5.4
43300 DATA 26,5.2
43350 DATA 28,5.0
43400 DATA 30,4.9
43450 DATA 32,4.8
43500 DATA 34,4.7
43550 DATA 36,4.5
43600 DATA 38,4.4
43650 DATA 40,4.2
43700 DATA 42,4.17
43750 DATA 44,4.1
43800 DATA 46,3.95
43850 DATA 48,3.9
43900 DATA 50,3.8
43950 DATA 52,3.7
44000 DATA 54,3.6
44050 DATA 56,3.5
44100 DATA 58,3.4
44150 DATA 60,3.3
44200 DATA 75,2.8
44250 DATA 90,2.5
44300 DATA 105,2.3
44350 DATA 120,2.0
44400 'ZONE 9
44450 DATA 8,8.25
```

```
44500 DATA 9,8.0
44550 DATA 10,7.7
44600 DATA 11,7.5
44650 DATA 12,7.2
44700 DATA 13,7.0
44750 DATA 14,6.8
44800 DATA 15,6.7
44850 DATA 16,6.6
44900 DATA 17,6.4
44950 DATA 18,6.2
45000 DATA 19,6.1
45050 DATA 20,6.0
45100 DATA 22,5.8
45150 DATA 24,5.6
45200 DATA 26,5.4
45250 DATA 28,5.2
45300 DATA 30,5.05
45350 DATA 32,4.95
45400 DATA 34,4.8
45450 DATA 36,4.6
45500 DATA 38,4.5
45550 DATA 40,4.4
45600 DATA 42,4.2
45650 DATA 44,4.1
45700 DATA 46,4.05
45750 DATA 48,3.95
45800 DATA 50,3.85
45850 DATA 52,3.75
45900 DATA 54,3.70
45950 DATA 56,3.6
46000 DATA 58,3.5
46050 DATA 60,3.40
46100 DATA 75,2.9
46150 DATA 90,2.55
46200 DATA 105,2.3
46250 DATA 120,2.1
46300 'ZONE 10
46350 DATA 8,8.1
46400 DATA 9,8.0
46450 DATA 10,7.7
46500 DATA 11,7.5
46550 DATA 12,7.2
46600 DATA 13,7.0
46650 DATA 14,6.8
46700 DATA 15,6.7
46750 DATA 16,6.6
46800 DATA 17,6.4
46850 DATA 18,6.3
46900 DATA 19,6.2
46950 DATA 20,6.0
47000 DATA 22,5.9
```

```
47050 DATA 24,5.6
47100 DATA 26,5.5
47150 DATA 28,5.4
47200 DATA 30,5.2
47250 DATA 32,5.0
47300 DATA 34,4.9
47350 DATA 36,4.7
47400 DATA 38,4.6
47450 DATA 40,4.5
47500 DATA 42,4.4
47550 DATA 44,4.3
47600 DATA 46,4.2
47650 DATA 48,4.05
47700 DATA 50,3.95
47750 DATA 52,3.90
47800 DATA 54,3.8
47850 DATA 56,3.7
47900 DATA 58,3.6
47950 DATA 60,3.55
48000 DATA 75,3.0
48050 DATA 90,2.7
48100 DATA 105,2.4
48150 DATA 120,2.2
48200 'ZONE 11
48250 DATA 8,6.9
48300 DATA 9,6.8
48350 DATA 10,6.4
48400 DATA 11,6.2
48450 DATA 12,6.0
48500 DATA 13,5.9
48550 DATA 14,5.6
48600 DATA 15,5.5
48650 DATA 16,5.4
48700 DATA 17,5.3
48750 DATA 18,5.2
48800 DATA 19,5.1
48850 DATA 20,5.0
48900 DATA 22,4.9
48950 DATA 24,4.8
49000 DATA 26,4.6
49050 DATA 28,4.4
49100 DATA 30,4.2
49150 DATA 32,4.1
49200 DATA 34,4.05
49250 DATA 36,4.00
49300 DATA 38,3.95
49350 DATA 40,3.90
49400 DATA 42,3.75
49450 DATA 44,3.70
49500 DATA 46,3.65
49550 DATA 48,3.50
```

```
49600 DATA 50,3.40
49650 DATA 52,3.35
49700 DATA 54,3.25
49750 DATA 56,3.20
49800 DATA 58,3.15
49850 DATA 60,3.10
49900 DATA 75,2.8
49950 DATA 90,2.45
50000 DATA 105,2.20
50050 DATA 120,2.00
```

```
100 CLS:COLOR 6,,8:KEY OFF
200 'FILENAME : EDITCOST.BAS
300 'DATE : DECEMBER 8, 1985
400 PRINT "********************************************************************
********"
500 PRINT "*
       *"
600 PRINT "*                         PIPE COST DATA EDITOR
       *"
700 PRINT "*
       *"
800 PRINT "********************************************************************
********"
900 PRINT:PRINT
1000 PRINT "WHICH OF THE FOLLOWING WOULD YOU LIKE TO DO : "
1100 PRINT:PRINT
1200 PRINT "      1)   EDIT EXISTING PIPE SIZE COST FILE"
1300 PRINT "      2)   CREATE NEW PIPE SIZE COST FILE"
1400 COLOR 7:INPUT WHICH:COLOR 3
1500 IF (WHICH()1) AND (WHICH()2) THEN GOTO 1000
1600 IF WHICH=2 THEN GOTO 1200
1700 PRINT:PRINT
1800 PRINT"WHAT IS THE PIPE SIZE YOU NEED TO EDIT THE COSTS FOR ?";:COLOR 7:
     INPUT" ",PIPESIZE:COLOR 3
1900 F$="C"+RIGHT$(STR$(PIPESIZE),LEN(STR$(PIPESIZE))-1)
2000 OPEN F$ FOR INPUT AS #1
2100 INPUT #1,NPOINTS
2200 MAXDEPTH(0)=0
2300 FOR I=1 TO NPOINTS
2400   INPUT #1,MAXDEPTH(I),DOLLARS(I)
2500 NEXT I
2600 INPUT #1,ADDVLF
2700 CLOSE #1
2800 CLS:COLOR 6,,8
2900 PRINT "         ---------------------------------------------"
3000 PRINT "         EXISTING COSTS FOR PIPE SIZE ";PIPESIZE;"INCHES"
3100 PRINT "         ---------------------------------------------"
3200 PRINT:PRINT
3300 PRINT " LINE #     FROM DEPTH, FT      TO DEPTH, FT     COST, $/LF     "
3400 PRINT " ------     --------------      ------------     ----------     "
3500 PRINT:COLOR 7
3600 FOR I=1 TO NPOINTS
3700 PRINT TAB(3);I;TAB(18);MAXDEPTH(I-1);TAB(35);MAXDEPTH(I);TAB(51);DOLLARS(I)
3800 PRINT
3900 NEXT I
4000 PRINT
4100 PRINT TAB(3);NPOINTS+1;:COLOR 3:PRINT" COST PER ADDITIONAL VERTICAL LINEAR
 FOOT = $";:COLOR 7:PRINT ADDVLF;"/LF"
4200 PRINT:PRINT:COLOR 3
4300 PRINT "WHICH LINE # DO YOU WANT TO MAKE CHANGES IN ";:COLOR 7:INPUT " ",LNE
4400 PRINT:COLOR 3
```

```
4500 IF LNE=NPOINTS+1 THEN GOTO 5000
4600 PRINT "  FROM DEPTH ";:COLOR 7:INPUT" ",MAXDEPTH(LNE-1):COLOR 3
4700 PRINT "  TO DEPTH ";:COLOR 7 :INPUT " ",MAXDEPTH(LNE):COLOR 3
4800 PRINT "  COST ";:COLOR 7:INPUT " ",DOLLARS(LNE):COLOR 3
4900 GOTO 5100
5000 PRINT "  COST PER ADDITIONAL VLF ";:COLOR 7:INPUT" ",ADDVLF
5100 OPEN F$ FOR OUTPUT AS #1
5200 PRINT #1,NPOINTS
5300 FOR I=1 TO NPOINTS
5400  PRINT #1,MAXDEPTH(I),DOLLARS(I)
5500 NEXT I
5600 PRINT #1,ADDVLF
5700 CLOSE #1
5800 RUN "MENU.BAS"
```

```
100 CLEAR
200 DIM NTIMES(20),HGL(20),CONFIG#(20),DIAMETER(20),ELEV(20),LENGTH(20)
300 DIM HEADLOSS(20),VELOCITY(20),FINALELEV(20),MAXDEPTH(20),FIRSTF(20),OPDIAM(2
0)
400 DIM OPCOST(20),OPVEL(20),OPLENGTH(20),OPTW(20),OPHW(20),HGLHW(20),OPSLOPE(20
)
500 DIM SLOP(20),N(20),TOPUP(20),TOPDN(20),SLOPE(20),HGSLOPE(20),SUM(20),TOP(20)
600 DIM CTER(20),COUNTER(20),SS(20),NEXTC#(20),LASTC#(20)
700 DIM FLOW(20),INLETFLW(20),THIS(20),FROM(20,50),COMPARE(500)
800 DIM ENDGR(20),ELEVATON(20),KVALUE(20),GROUND(20),MINLEN(20)
900 DIM COSTPIPE(20),G(20),F(20),FOPTIMUM(20),S(20),PRICE(20)
1000 DIM NCONFIG(20),AVGROUND(20)
1100 ' ============================================================
1200 ' FILENAME : OPTIMIZE.BAS
1300 ' DATE :     MARCH 16, 1986 , 5:00 P.M.    latest: COVER
1400 '           NOTE:  LINE NUMBERING CANNOT GO PAST 65500
1500 ' PROGRAM WRITTEN ON IBM AT USING IBM BASIC LANGUAGE
1600 '============================================================
1700 CLS:KEY OFF:COLOR 6,,8
1800 '50 STAGES AND 10 PIPES
1900 '
2000 '
2100 DIM PIPESLOP(20),HWINVERT(20),TWINVERT(20)
2200 PRINT "        ************************************************************
****"
2300 PRINT "        *
  *"
2400 PRINT "        *              STORM SEWER PIPING NETWORK OPTIMIZATION
  *"
2500 PRINT "        *
  *"
2600 PRINT "        *          Written by Dawn E. Fetter
  *"
2700 PRINT "        *            under instruction by Dr. Martin P. Wanielista
  *"
2800 PRINT "        *            for Master's Thesis at U.C.F.
  *"
2900 PRINT "        *
  *"
3000 PRINT "        ************************************************************
****"
3100 PRINT:PRINT "Which do you want to do :"
3200 PRINT "       1)   Use existing data file "
3300 PRINT "       2)   Create a new data file "
3400 COLOR 7:INPUT WHATFILE:COLOR 3
3500 CHOICE=2
3600 IF ((WHATFILE () 1) AND (WHATFILE () 2)) THEN GOTO 3100
3700 IF WHATFILE=1 THEN GOTO 4000
3800 PRINT:PRINT "What is the name of the data file you'll be creating ";:COLOR
7:INPUT " ",N$:COLOR 3
3900 GOTO 4500
```

```
4000 ON ERROR GOTO 51500
4100 PRINT:PRINT "What is the name of the data file you'll be using ";:COLOR 7:I
NPUT" ",N$:COLOR 3
4200 OPEN N$ FOR INPUT AS #1:CLOSE #1
4300 GOSUB 47400
4400 GOTO 4900
4500 PRINT:PRINT:PRINT "Enter the elevation of the tailwater at the most downstr
eam end of your system ";:COLOR 7:INPUT" ",INITELEV:COLOR 3
4600 PRINT:PRINT "Enter the ground elevation at the most downstream end ";:COLOR
 7:INPUT" ",ENDGR(0):COLOR 3
4700 PRINT:PRINT "Any changes to the above  (Y=yes / Return=no)";:COLOR 7:INPUT"
 ",CHA$:COLOR 3
4800 IF ((CHA$="y") OR (CHA$="Y")) THEN GOTO 3100
4900 GOSUB 21400
5000 FOR STAGE = 1 TO NSTAGES
5100 FILE$="F"+RIGHT$(STR$(STAGE),LEN(STR$(STAGE))-1)
5200 OPEN FILE$ FOR INPUT AS #2
5300 FOR J=1 TO 100
5400 IF EOF(2) THEN GOTO 5700
5500 INPUT #2,MOREJUNK
5600 GOTO 5800
5700 NCONFIG(STAGE)=MOREJUNK:J=101
5800 NEXT J
5900 NTIMES(0)=1
6000    NTIMES(STAGE)=NCONFIG(STAGE)*NTIMES(STAGE-1)
6100 CLOSE #2
6200 NEXT STAGE
6300 '
6400 '
6500 CLS
6600 FLAGG=0
6700 GOSUB 43900
6800  OPEN "CEE" FOR INPUT AS #3
6900 FOR I = 1 TO NTIMES(NSTAGES)
7000 HGL(0)=DELELEV
7100 FOR STAGE=1 TO NSTAGES
7200 FILE$="F"+RIGHT$(STR$(STAGE),LEN(STR$(STAGE))-1)
7300 OPEN FILE$ FOR INPUT AS #2
7400 INPUT #3,CONFIG#(STAGE)
7500 'PRINT "TIME";I;"CONFIG#";CONFIG#(STAGE);"   STAGE";STAGE
7600 FOR L=1 TO (CONFIG#(STAGE)-1)
7700 INPUT #2,JUNK,JUNK,JUNK
7800 NEXT L
7900 INPUT #2,DIAMETER(STAGE),VELOCITY(STAGE),SLOP(STAGE)
8000 CLOSE #2
8100 ELEV(1)=INITELEV+(DIAMETER(1)/12)
8200 ELEVATON(1)=ELEV(1)
8300 IF STAGE=1 THEN DELELEV=INITELEV+(DIAMETER(STAGE)/12)
8400    LOCATE 25,10:PRINT "CALCULATING       STAGE ";STAGE;" PIPE DIAM ";DIAMET
ER(STAGE)
8500    DELELEV=DELELEV+(LENGTH(STAGE)*SLOP(STAGE))
```

```
8600 COUNT=0
8700 FOR J=1 TO THIS(STAGE)
8800  COUNT=COUNT+1
8900  ELEV(STAGE+COUNT)=ELEV(STAGE)+(LENGTH(STAGE+COUNT-1)*SLOP(STAGE+COUNT-1))
9000 ELEVATON(STAGE+COUNT)=ELEV(STAGE+COUNT)
9100 HEADLOSS(STAGE)=KVALUE(STAGE)*(VELOCITY(STAGE)^2)/64.4
9200 SUMHEAD=SUMHEAD+HEADLOSS(STAGE-1)
9300 FINALELEV(1)=ELEV(2)
9400 FINALELEV(STAGE)=ELEV(STAGE+COUNT)+SUMHEAD
9500 NEXT J
9600     AVGDEPTH=AVGROUND(STAGE)-(ELEV(STAGE)-(DIAMETER(STAGE)/12))
9700 ' CHECK FOR MINIMUM COVER AT POINT OF MINIMUM GROUND ELEVATION
9800 'PRINT "GROUND";GROUND(STAGE);"ELEV";ELEV(STAGE);"MINLEN";MINLEN(STAGE);"SL
OP";SLOP(STAGE)
9900     COVERMIN=GROUND(STAGE)-(ELEV(STAGE)+(MINLEN(STAGE)*SLOP(STAGE)))
10000    IF COVERMIN<3 THEN PRINT " ** WARNING : STAGE ";STAGE;", DIAM ";DIAME
TER(STAGE);", MIN COVER VIOLATED AT LENGTH ";MINLEN(STAGE);" **"
10100       ' ELEV ARE THE TOPS OF PIPES
10200       D$=STR$(DIAMETER(STAGE))
10300       C$="C"+RIGHT$(D$,LEN(D$)-1)
10400       OPEN C$ FOR INPUT AS #1
10500       INPUT #1,NUMPRICE
10600       FOR K=1 TO NUMPRICE
10700         INPUT #1,MAXDEPTH(K),PRICE(K)
10800         IF ((AVGDEPTH)MAXDEPTH(K)) AND (K()NUMPRICE)) THEN GOTO 11500
10900         IF (AVGDEPTH)MAXDEPTH(K)) AND (K=NUMPRICE) THEN GOTO 11200
11000         COSTPIPE(STAGE)=PRICE(K)*LENGTH(STAGE)
11100         GOTO 11400
11200         INPUT #1,ADDPRICE
11300         COSTPIPE(STAGE)=PRICE(NUMPRICE)+(ADDPRICE*(AVGDEPTH-MAXDEPTH(K)))
11400         K=NUMPRICE
11500       NEXT K
11600       CLOSE #1
11700       ' SLOPE(STAGE,PIPE)
11800 G(STAGE)=COSTPIPE(STAGE)
11900     F(STAGE)=G(STAGE) + F(STAGE-1)
12000 NEXT STAGE
12100 CLOSE #2
12200 FOR STAGE=0 TO NSTAGES
12300 IF I=1 THEN FIRSTF(STAGE)=F(STAGE) ELSE GOTO 12500
12400    FOPTIMUM(STAGE) = FIRSTF(STAGE)
12500       G(STAGE)=COSTPIPE(STAGE)
12600 FOPTIMUM(STAGE)=F(STAGE)
12700 'PRINT "FOPTIMUM ";FOPTIMUM(STAGE);"F";F(STAGE)
12800 IF STAGE=NSTAGES THEN OPTIMUM=FOPTIMUM(STAGE)
12900 'PRINT "OPTIMUM";OPTIMUM
13000 IF I=1 THEN TOTAL=OPTIMUM
13100 IF I=1 THEN OPDIAM(STAGE)=DIAMETER(STAGE)
13200 IF I=1 THEN OPCOST(STAGE)=G(STAGE)
13300 IF I=1 THEN OPVEL(STAGE)=VELOCITY(STAGE)
13400 IF I=1 THEN OPLENGTH(STAGE)=LENGTH(STAGE)
```

```
13500 IF I=1 THEN OPTW(STAGE)=ELEV(STAGE)-(DIAMETER(STAGE)/12)
13600 IF I=1 THEN OPHW(STAGE)=ELEV(STAGE+1)-(DIAMETER(STAGE)/12)
13700 IF I=1 THEN HGLHW(STAGE)=FINALELEV(STAGE)
13800 IF I=1 THEN OPSLOPE(STAGE)=SLOP(STAGE)
13900 '  OPCOST IS THE OPTIMAL COST OF OPTIMAL PIPE AT EACH STAGE
14000 '  OPDIAM IS THE OPTIMAL PIPE DIAM AT EACH STAGE
14100 IF STAGE<NSTAGES THEN GOTO 15500
14200 IF OPTIMUM)=TOTAL THEN GOTO 15500
14300 TOTAL=OPTIMUM
14400 FOR Q=0 TO NSTAGES
14500    OPDIAM(Q)=DIAMETER(Q)
14600    OPCOST(Q)=G(Q)
14700  OPVEL(Q)=VELOCITY(Q)
14800  OPLENGTH(Q)=LENGTH(Q)
14900 OPTW(Q)=ELEV(Q)-(DIAMETER(Q)/12)
15000 OPHW(Q)=ELEV(Q+1)-(DIAMETER(Q)/12)
15100 OPSLOPE(Q)=SLOP(Q)
15200 HGLHW(Q)=FINALELEV(Q)
15300   'PRINT "STAGE";Q;"OPCOST";OPCOST(Q)
15400 NEXT Q
15500 NEXT STAGE
15600 PRINT
15700 NEXT I
15800 'FOR I=1 TO NTIMES(NSTAGES)
15900 'IF OPTIMUM(I)(TOTAL THEN TOTAL=OPTIMUM(I)
16000 'NEXT I
16100 PRINT "-------------------------------------------------"
16200 PRINT:PRINT:PRINT "  GLOBAL OPTIMUM COST = ";:COLOR 7:PRINT TOTAL;" DOLLAR
S ":COLOR 3
16300 PRINT:PRINT "    OPTIMAL CONFIGURATION :"
16400 FOR J=1 TO NSTAGES:PRINT "PIPE ";:COLOR 7:PRINT NSTAGES+1-J;OPDIAM(J);:COL
OR 3:PRINT" in. ":NEXT J
16500 PRINT "-------------------------------------------------"
16600 LOCATE 25,1:PRINT "                        PRESS RETURN TO CONTINUE . . .";
:INPUT RET$
16700 CLS
16800 FOR I=0 TO NSTAGES
16900 PRINT "    PIPE #  ";:COLOR 7:PRINT NSTAGES+1-I:COLOR 3
17000 PRINT
17100 PRINT:PRINT "Diameter (in) ";:COLOR 7:PRINT OPDIAM(I):COLOR 3
17200 PRINT:PRINT "Length (ft) ";:COLOR 7:PRINT OPLENGTH(I):COLOR 3
17300 PRINT:PRINT "Velocity (fps) ";:COLOR 7:PRINT OPVEL(I):COLOR 3
17400 PRINT:PRINT "Slope ";:COLOR 7:PRINT OPSLOPE(I):COLOR 3
17500 PRINT:PRINT "Headwater Pipe Invert (ft) ";:COLOR 7:PRINT OPHW(I):COLOR 3
17600 PRINT:PRINT "Tailwater Pipe Invert (ft) ";:COLOR 7:PRINT OPTW(I):COLOR 3
17700 PRINT:PRINT "Hydraulic Grade Line Elev (ft) at Headwater ";:COLOR 7:PRINT
HGLHW(I):COLOR 3
17800 PRINT:PRINT "Cost of this Pipe Link ";:COLOR 7:PRINT OPCOST(I):COLOR 3
17900 PRINT:PRINT:PRINT
18000 LOCATE 25,1:PRINT "PRESS RETURN TO CONTINUE . . . ";:INPUT RET$
18100 NEXT I
```

```
18200 OPEN N$ FOR OUTPUT AS #1
18300 PRINT #1,INITELEV
18400 PRINT #1,ENDGR(0)
18500 PRINT #1,NSTAGES
18600 FOR I=1 TO NSTAGES
18700   PRINT #1,GROUND(I)
18800   PRINT #1,MINLEN(I)
18900   PRINT #1,AVGROUND(I)
19000   PRINT #1,ENDGR(I)
19100   PRINT #1,FLOW(I)
19200   PRINT #1,LENGTH(I)
19300   PRINT #1,N(I)
19400   PRINT #1,KVALUE(I)
19500 NEXT I
19600 ON ERROR GOTO 0
19700 FOR STAGE=0 TO NSTAGES
19800 FILE$="F"+RIGHT$(STR$(STAGE),LEN(STR$(STAGE))-1)
19900 OPEN FILE$ FOR INPUT AS #2
20000 FOR J=1 TO 100
20100 IF EOF(2) THEN GOTO 20700
20200 INPUT #2,DIAM,VEL,SLOP
20300 INPUT #2,NCONFIG
20400 PRINT #1,DIAM,VEL,SLOP
20500 IF EOF(2) THEN GOTO 20700
20600 GOTO 20900
20700 PRINT #1,0:PRINT#1,NCONFIG:J=101
20800 CLOSE #2
20900 NEXT J
21000 NEXT STAGE
21100 CLOSE #1
21200 RUN "MENU.BAS"
21300 END
21400 CLS
21500 OPEN "FLOWS.DAT" FOR INPUT AS #3
21600   INPUT #3,NSTAGES
21700   FOR I=(NSTAGES+1) TO 1 STEP -1
21800     INPUT #3,FLOW(I-1),INLETFLW(I)   'FLOW=FLOW FROM PREVIOUS PIPE FOR THES
E CALCS
21900   INPUT #3,THIS(I)
22000   FOR J=1 TO THIS(I)
22100     INPUT #3,FROM(I,J)
22200   NEXT J
22300   NEXT I
22400 CLOSE #3
22500 K=1
22600 IF WHATFILE=1 THEN GOTO 29900
22700 ON ERROR GOTO 50200
22800 FOR I=0 TO NSTAGES
22900 FILE$="F"+RIGHT$(STR$(K),LEN(STR$(K))-1)
23000 OPEN FILE$ FOR OUTPUT AS #2
23100 CLS:COLOR 6:PRINT "                           ==============="
```

```
23200 PRINT "                                    PIPE  ";:COLOR 7:PRINT NSTAGES+1-I
23300 COLOR 6:PRINT "                                 ==============="
23400 PRINT:PRINT:COLOR 3
23500 ' USE MINIMUM GROUND ELEVATION AND ELEV AT END TO CHECK FOR 3 FEET OF COVE
R
23600 PRINT "Enter the following ground elevations :"
23700 PRINT "          minimum ground elevation . . . . . . . . . . . . ";:COLOR
 7:INPUT " ",GROUND(I):COLOR 3
23800 PRINT "                  and length from downstream end of pipe . . .";:COLOR
 7:INPUT" ",MINLEN(I):COLOR 3
23900 ' USE AVERAGE GROUND ELEVATION TO ESTIMATE EXCAVATION DEPTH
24000 PRINT "          average ground elevation . . . . . . . . . . . .";:COLOR
7:INPUT" ",AVGROUND(I):COLOR 3
24100 PRINT "          ground elevation at the most upstream end . . .  ";:COLOR
 7:INPUT" ",ENDGR(I):COLOR 3
24200 PRINT:PRINT "Calculated flowrate (cfs) going thru this pipe link = ";:COLO
R 7:PRINT FLOW(I):COLOR 3
24300 PRINT
24400   PRINT "Enter the length (feet) of this pipe link ";:COLOR 7:INPUT" ",LEN
GTH(I):COLOR 3
24500 PRINT:PRINT "Manning's friction coefficient (return for .013) ";:COLOR 7:I
NPUT " ",N(I):COLOR 3
24600 IF KVALUE=0 THEN KVALUE=.5
24700 IF N(I)=0 THEN N(I)=.013
24800 IF N(I)=.013 THEN PRINT "
   ( n = ";N(I);" )"
24900 PRINT:PRINT "Enter a head loss coefficient for estimation energy loss thru
 manhole          (return for 0.5)";:COLOR 7:INPUT" ",KVALUE(I):COLOR 3
25000 IF KVALUE(I)=0 THEN KVALUE(I)=.5
25100 IF KVALUE(I)=.5 THEN PRINT "
     ( K = ";KVALUE(I);" )"
25200 LOCATE 25,1:PRINT"Any changes to above data ( Y / return ) ";:COLOR 7:INPU
T " ",CH1$:COLOR 3
25300 IF ((CH1$()"Y") AND (CH1$()"y")) THEN GOTO 25400 ELSE GOTO 23100
25400 FOR CONFIG=1 TO 100
25500 CLS:COLOR 6
25600 PRINT "                          ============"
25700 PRINT "                              PIPE  ";:COLOR 7:PRINT NSTAGES+1-I
25800 COLOR 6:PRINT "                          ============"
25900 PRINT
26000 PRINT "                    CONFIGURATION ";CONFIG
26100 PRINT
26200 PRINT:COLOR 3
26300 PRINT " Pipe Diameter (inches)              ";:COLOR 15,7:PRINT "
 "
26400 COLOR 7,0
26500 PRINT:PRINT
26600 COLOR 3,0
26700 PRINT " SAVE Current Configuration              ";:COLOR 15,7:PRINT "
   "
26800 COLOR 3,0
```

```
26900 PRINT:PRINT " CONTINUE to Next Stage                    ";:COLOR 15,7:PRINT
      "       "
27000 COLOR 7,0
27100 LOCATE 8,45:LINE INPUT DUMMY$
27200 IF CSRLIN=9 THEN DIAM=VAL(RIGHT$(DUMMY$,10)) ELSE GOTO 28600
27300    VELOCITY=FLOW(I)/((((DIAM/12))^2)*3.14159*.25)
27400     D$=STR$(DIAM)
27500     C$="C"+RIGHT$(D$,LEN(D$)-1)
27600     OPEN C$ FOR INPUT AS #1
27700     CLOSE #1
27800 IF DIAM=0 THEN GOTO 28600
27900    LOCATE 20,1:COLOR 3:PRINT "              Velocity = ";:COLOR 7
28000     PRINT USING "###.##";VELOCITY;
28100     COLOR 3:PRINT " ft/sec"
28200    SLOPE=((FLOW(I)*N(I))/(.463*((DIAM/12)^2.667)))^2
28300   PRINT "            Hydraulic Slope = ";:COLOR 7
28400    PRINT USING "##.####";SLOPE;:COLOR 3
28500    PRINT " ft/ft "
28600 IF CSRLIN=12 THEN GOTO 29200
28700 IF CSRLIN=14 THEN GOTO 28900
28800 GOTO 27100
28900 CONFIG=101
29000 K=K+1
29100 GOTO 29500
29200 IF DIAM=0 THEN GOTO 27100
29300 PRINT #2,DIAM,VELOCITY,SLOPE
29400 NCONFIG(I)=NCONFIG(I)+1
29500 NEXT CONFIG
29600 PRINT #2,NCONFIG(I)
29700 CLOSE #2
29800 NEXT I
29900 RETURN
30000 'FILENAME : PIPING.BAS
30100 'DATE :  OCTOBER 29, 84
30200 SCREEN 2
30300 'INPUT DATA
30400 KEY OFF
30500 CLS:COLOR 6,,8
30600 PRINT "============================================================="
30700 PRINT "||                                                         ||"
30800 PRINT "||              PIPING PROFILE PLOT                        ||"
30900 PRINT "||                                                         ||"
31000 PRINT "============================================================="
31100 PRINT:PRINT:PRINT:PRINT:COLOR 3
31200 PRINT:PRINT "Input the vertical scale ( 1 in =     ft) ";:COLOR 7
31300 INPUT VFT:COLOR 3
31400 PRINT:PRINT "Input the horizontal scale ( 1 in =     ft) ";:COLOR 7
31500 INPUT HFT
31600 NPOINTS=NPIPES+1
31700 FOR I=0 TO NSTAGES
31800 CLS
```

```
31900    INPUT GROUND(I)
32000 NEXT I
32100 FOR J=1 TO NPIPES
32200    TOPUP(J)=HWINVERT(J)+(DIAMETER(J)/12)
32300    TOPDN(J)=TWINVERT(J)+(DIAMETER(J)/12)
32400 SLOPE(J)=INT((PIPESLOP(J)*100)*100)/100
32500 NEXT J
32600 FOR I=1 TO (NPOINTS-1)
32700  HGSLOPE(I)=(HGL(I)-HGL(I+1))/LENGTH(I)
32800 HGSLOPE(I)=INT((HGSLOPE(I)*100)*100)/100
32900 NEXT I
33000 FOR J=1 TO NPOINTS
33100    SUM(J)=SUM(J-1)+LENGTH(J-1)
33200 NEXT J
33300 FOR J=1 TO NPOINTS
33400   TOP(J)=TOPUP(J)
33500   IF J=NPOINTS THEN TOP(J)=TOPDN(J-1)
33600 NEXT J
33700 CLS
33800 'HYDRAULIC GRADE LINE
33900 '=====================
34000 FOR I=1 TO NPOINTS
34100    HGL(I)=HGL(I)*35/VFT
34200    GROUND(I)=GROUND(I)*35/VFT
34300    TOP(I)=TOP(I)*35/VFT
34400 NEXT I
34500 FOR J=1 TO NSTAGES
34600   HWINVERT(J)=HWINVERT(J)*35/VFT
34700   TWINVERT(J)=TWINVERT(J)*35/VFT
34800 NEXT J
34900 YMIN=HGL(1)
35000 YMAX=HGL(1)
35100 FOR I=2 TO NPOINTS
35200    IF TOP(I))YMAX THEN YMAX=TOP(I)
35300  IF HGL(I))YMAX THEN YMAX=HGL(I)
35400  IF ENDGR(I))YMAX THEN YMAX=ENDGR(I)
35500    IF TOP(I)(YMIN THEN YMIN=TOP(I)
35600  IF HGL(I)(YMIN THEN YMIN=HGL(I)
35700  IF ENDGR(I)(YMIN THEN YMIN=ENDGR(I)
35800 NEXT I
35900 FOR J=1 TO NSTAGES
36000  IF HWINVERT(J))YMAX THEN YMAX=HWINVERT(J)
36100  IF TWINVERT(J)(YMIN THEN YMIN=TWINVERT(J)
36200 NEXT J
36300 FOR I=1 TO NPOINTS
36400   HGL(I)=HGL(I)-YMIN
36500 NEXT I
36600 FOR I=2 TO NPOINTS
36700   X1=(SUM(I-1)*72)/HFT
36800   X2=(SUM(I)*72)/HFT
36900   Y1=199-HGL(I-1)
```

```
37000   Y2=199-HGL(I)
37100   LINE (X1,Y1)-(X2,Y2)
37200 NEXT I
37300 'GROUND ELEVATION
37400 '================
37500 FOR I=2 TO NPOINTS
37600   X1=(SUM(I-1)*72)/HFT
37700   X2=(SUM(I)*72)/HFT
37800   Y1=199-(ENDGR(I-1)-YMIN)
37900   Y2=199-(ENDGR(I)-YMIN)
38000   LINE (X1,Y1)-(X2,Y2)
38100 NEXT I
38200 FOR I=2 TO NPOINTS
38300   X1=(SUM(I-1)*72)/HFT
38400   X2=(SUM(I)*72)/HFT
38500   Y1=199-(TOP(I-1)-YMIN)
38600   '
38700   LINE (X1,Y1)-(X2,Y2)
38800 NEXT I
38900 FOR J=2 TO NSTAGES
39000   X1=(SUM(J-1)*72)/HFT
39100   X2=(SUM(J)*72)/HFT
39200   X3=(SUM(J+1)*72)/HFT
39300   Y1=199-(HWINVERT(J-1)-YMIN)
39400   Y2=199-(TWINVERT(J-1)-YMIN)
39500   Y3=199-(HWINVERT(J)-YMIN)
39600   Y4=199-(TWINVERT(J)-YMIN)
39700 GOTO 5000
39800   LINE (X1,Y1)-(X2,Y2)
39900   LINE (X2,Y2)-(X2,Y3)
40000   LINE (X2,Y3)-(X3,Y4)
40100 NEXT J
40200 FOR I=1 TO NPOINTS
40300   LINE ((SUM(I)*72/HFT),10)-((SUM(I)*72/HFT),200)
40400 D=((SUM(I)*72/HFT))/8
40500 IF D=0 THEN D=1
40600 LOCATE 1,D:PRINT I
40700 NEXT I
40800 BEEP:COLOR 6+16:PRINT"   *** Make Printer Ready and Press Return ***":INPU
T"",CCCCC:COLOR 3
40900 FOR I=1 TO 1000:NEXT I
41000 LPRINT CHR$(27);CHR$(108);CHR$(15);
41100 LPRINT CHR$(15);
41200 WIDTH "LPT1:",255
41300 LPRINT:LPRINT:LPRINT
41400 LPRINT "                         ==============================================
============"
41500 LPRINT "                         ||
          ||"
41600 LPRINT "                         ||              PIPING PROFILE
          ||"
```

```
41700 LPRINT "                         ||
          ||"
41800 LPRINT "                         ||
          ||"
41900 LPRINT "                         =============================================
============="
42000 LPRINT:LPRINT:LPRINT:LPRINT:LPRINT
42100 LPRINT "Vertical Scale  :  1 inch = ";VFT;" feet"
42200 LPRINT "Horizontal Scale  :  1 inch = ";HFT;" feet"
42300 LPRINT:LPRINT:LPRINT:LPRINT:LPRINT
42400 LPRINT "POINT                   MAXIMUM ALLOWABLE HGL          ACTUAL HGL"
42500 LPRINT "                          ELEVATION  (FT)          ELEVATION  (FT)
"
42600 LPRINT "=====                   =====================          ===============
"
42700 FOR I=1 TO NPOINTS
42800 LPRINT TAB(2);I;TAB(30);(ENDGR(I)*VFT/35);TAB(60);(HGL(I)+YMIN)*VFT/35
42900 NEXT I
43000 LPRINT:LPRINT
43100 LPRINT:LPRINT
43200 LPRINT " PIPE      LENGTH      PIPE         PIPE          HGL
  INVERT  ELEVATION"
43300 LPRINT "              (FT)      DIAMETER     SLOPE         SLOPE
UPSTREAM    DOWNSTREAM  "
43400 LPRINT "                        (IN)      (FT/100 FT)   (FT/100 FT)
  (FT)        (FT)"
43500 LPRINT "========  ======     ========   ===========   ===========
======================= "
43600 FOR I=1 TO NSTAGES
43700 LPRINT I;"-";I+1;TAB(12);LENGTH(I);TAB(27);DIAMETER(I);TAB(38);SLOPE(I);TA
B(55);HGSLOPE(I);TAB(70);(HWINVERT(I)*VFT/35);TAB(85);(TWINVERT(I)*VFT/35)
43800 NEXT I
43900 'SHELL "ERASE CEE*.*"
44000 C$="CEE"
44100 'NSTAGES=3:NCONFIG(1)=2:NCONFIG(2)=2:NTIMES(3)=8:NCONFIG(3)=2
44200 OPEN C$ FOR OUTPUT AS #2
44300 FOR STAGE=1 TO NSTAGES
44400 CTER(STAGE)=1
44500 COUNTER(STAGE)=1
44600 NEXT STAGE
44700 S(1)=NTIMES(NSTAGES)/NCONFIG(1)
44800 FOR SKIP=1 TO NTIMES(NSTAGES)
44900 FOR STAGE=1 TO NSTAGES
45000 'S(STAGE)=2^(STAGE-1)
45100 IF STAGE=NSTAGES THEN GOTO 45300
45200 S(STAGE+1)=S(STAGE)/NCONFIG(STAGE+1)
45300 IF SKIP=1 THEN LASTC#(STAGE)=1
45400 NEXTC#(STAGE)=0
45500 IF CTER(STAGE)(S(STAGE) THEN GOTO 46000
45600 IF COUNTER(STAGE)()NCONFIG(STAGE) THEN COUNTER(STAGE)=COUNTER(STAGE)+1 ELS
E COUNTER(STAGE)=1
```

```
45700    NEXTC#(STAGE)=COUNTER(STAGE)
45800 CTER(STAGE)=S(STAGE)
45900 GOTO 46300
46000 '
46100 IF NEXTC#(STAGE)()0 THEN GOTO 46300
46200 NEXTC#(STAGE)=LASTC#(STAGE)
46300 '
46400 PRINT #2,LASTC#(STAGE);
46500 LASTC#(STAGE)=NEXTC#(STAGE)
46600 CTER(STAGE)=CTER(STAGE)+1
46700 IF COUNTER(STAGE))NCONFIG(STAGE) THEN COUNTER(STAGE)=0
46800 IF CTER(STAGE))S(STAGE) THEN CTER(STAGE)=1
46900 NEXT STAGE
47000 PRINT #2,
47100 NEXT SKIP
47200 CLOSE #2
47300 RETURN
47400 OPEN N$ FOR INPUT AS #1
47500 INPUT #1,INITELEV
47600 INPUT #1,ENDGR(0)
47700 INPUT #1,NSTAGES
47800 FOR I=1 TO NSTAGES
47900    INPUT #1,GROUND(I)
48000    INPUT #1,MINLEN(I)
48100    INPUT #1,AVGROUND(I)
48200    INPUT #1,ENDGR(I)
48300    INPUT #1,FLOW(I)
48400    INPUT #1,LENGTH(I)
48500    INPUT #1,N(I)
48600    INPUT #1,KVALUE(I)
48700 NEXT I
48800 ON ERROR GOTO 0
48900 FOR I=1 TO NSTAGES
49000 FILE$="F"+RIGHT$(STR$(I),LEN(STR$(I))-1)
49100 OPEN FILE$ FOR OUTPUT AS #2
49200 FOR J=1 TO 100
49300 INPUT #1,DIAM
49400 IF DIAM()0 THEN GOTO 49600
49500 INPUT #1,NCONFIG:PRINT #2,NCONFIG:J=101:GOTO 49700
49600 INPUT #1,VEL,SLOP:PRINT #2,DIAM,VEL,SLOP
49700 NEXT J
49800 CLOSE #2
49900 NEXT I
50000 CLOSE #1
50100 RETURN
50200 IF ERR()53 THEN RESUME
50300 BEEP:BEEP
50400 LOCATE 17,1
50500 COLOR 23:PRINT "--------------------------------------------------------
-------":COLOR 7:PRINT:PRINT
50600 PRINT "   You have either picked a NON-CONVENTIONAL pipe size "
```

```
50700 PRINT "                                                      "
50800 PRINT "   or you need to ADD this size to your COST FILES  ":PRINT:PRINT "
   try again . . ."
50900 PRINT "                                                      "
51000 PRINT "                                                      "
51100 COLOR 23:PRINT "------------------------------------------------------
-------":COLOR 7
51200 FOR M=1 TO 10000:NEXT M
51300 BEEP
51400 RESUME 25500
51500 IF ERR()53 THEN RESUME
51600 BEEP:BEEP
51700 COLOR 23:PRINT "------------------------------------------------------
--------------------":COLOR 7
51800 PRINT "   File  ";N$;"  does not exist on the drive specified - try again
. . . "
51900 COLOR 23:PRINT "------------------------------------------------------
--------------------":COLOR 7
52000 FOR M=1 TO 1000:NEXT M
52100 BEEP
52200 RESUME 3100
```

APPENDIX B

EXAMPLE DESIGN APPLICATION COMPUTER RUN

```
*****************************************************
*                                                   *
*           M A I N     M E N U                      *
*                                                   *
*         PIPE SYSTEM OPTIMIZATION FOR               *
*                                                   *
*         MINIMUM CONSTRUCTION COSTS                 *
*                                                   *
*****************************************************
```

        C   Cost data editting

        W   Watershed data input / editting

        P   Pipe data input / editting and Optimization

        X   eXit to system

? w

```
**********************************************************************
*                    RATIONAL METHOD                                 *
*              UNIVERSITY OF CENTRAL FLORIDA                          *
**********************************************************************
```

Enter a project name or description ? Example for Thesis

Do you want a hardcopy of your input data and results (Y/N) ? y

Place your data disk in drive & press return when ready ?

Which of the following do you want to do?
    1) Use an existing data file
    2) Create a new data file
? 2

Do you need to see a directory of your data disk ? (Y/N)
? y

```
C:\THESIS
            .    <DIR>         ..    <DIR>  COMMAND  .COM     OPTIMIZE.BAS
BASICA   .COM       C12                      C15               C18
C3Ø                 C36                      C42               CURSOR   .BAS
1                   2                        3                 4
5                   6                        C21               C24
C27                 NEWOP    .BAS            RATIONAL.BAS      7
8                   9                        11                1Ø
TEST     .RAT       OPTIMIZ2.BAS             COSTS             F1
NEWOP3   .BAS       NEWOP2   .BSA            F2                F3
THESISEX.DWG        NEWOP2   .BAS            FLOWS    .DAT     TEST     .DAT
CEE                 NEWOP7   .BAS            NEWOP8   .BAS     OPTIMIZE.BAT
MENU     .BAS       EDITCOST.BAS             FIGURE   .DEF     AUTOEXEC.BAT
TEST2    .DAT       TREEDIAG.DWG             THESIS   .DEF     THESIS   .DAT
OPTIMIZE.RUN        EXAMPLE  .RUN            EXAMPLE  .BAK
    1581Ø56 Bytes free
```

Enter the name of the data file you'll be creating (8 char max)
(B:FILENAME.EXT)
? thesis.dat

Enter the number of nodes in your stormwater collection system ? 4

```
-------------------
RUNOFF COEFFICIENT
-------------------
```

    Which option would you like to use:

    1) input 1 set of C factors to use for all structures
    2) input a different set of C factors for each structure
    3) input 1 composite C factor to use for all structures

        Enter the C factor of the impervious area ? .9

        Enter the C factor of the pervious area ? .2

```
----------------------------
  NODE  # :    1
----------------------------
```

Enter the node LABEL you have assigned to this node ? Stage 3
How many nodes flow into this node ? Ø
Enter the sub area (acres) that contributes to this node ? 5.24
Enter the impervious area (acres) ? 2.5

Is this correct (Y/N) ?

```
----------------------------
  NODE  # :    2
----------------------------
```

Enter the node LABEL you have assigned to this node ? Stage 2
How many nodes flow into this node ? 1
node   :? 1
Enter the sub area (acres) that contributes to this node ? 3.92
Enter the impervious area (acres) ? 2

Is this correct (Y/N) ?

```
---------------------------
  NODE  # :   3
---------------------------
```

Enter the node LABEL you have assigned to this node ? Stage 1
How many nodes flow into this node ? 1
node   :? 2
Enter the sub area (acres) that contributes to this node ? 3.56
Enter the impervious area (acres) ? 2

Is this correct (Y/N) ?

```
---------------------------
  NODE  # :   4
---------------------------
```

Enter the node LABEL you have assigned to this node ? Pond
How many nodes flow into this node ? 1
node   :? 3
Enter the sub area (acres) that contributes to this node ? Ø
Enter the impervious area (acres) ? Ø

Is this correct (Y/N) ?

TIME OF CONCENTRATION

   Which option would you like to use:

   1) input your own time of concentration
   2) use the SFWMD equation to calculate time of concentration
? 2

Structure   Time of Concentration (minutes)
---------   -------------------------------
    1   10.85
    2   14.35
    3   16.91
    4   16.91
press return when ready to continue . . .?

                     INPUT DATA FOR FILE thesis.dat

NODE #	USER LABEL	SUB AREA (ACRES)	IMPERVIOUS AREA (ACRES)	C FACTOR PERVIOUS	C FACTOR IMPERVIOUS	TIME OF CONCENTRATION (MINUTES)
1	Stage 3	5.24	2.5	.2	.9	10.86
2	Stage 2	3.92	2	.2	.9	14.35
3	Stage 1	3.56	2	.2	.9	16.91
4	Pond	0	0	.2	.9	16.91

----

press return when ready to continue . . .?

Which of the following D.O.T. Rainfall Intensity Curves would you
like to use?
        1) ZONE 1
        2) ZONE 2
        3) ZONE 3
        4) ZONE 4
        5) ZONE 5
        6) ZONE 6
        7) ZONE 7
        8) ZONE 8
        9) ZONE 9
       10) ZONE 10
       11) ZONE 11
? 7

RESULTS FOR FILE   thesis.dat

NODE LABEL	COMPOSITE C FACTOR	TIME OF CONCENTRN (MIN)	INTENSITY ZONE 7 (IN/HR)	SUB AREA (ACRES)	TOTAL AREA (ACRES)	CUMULATIVE FLOWRATE (CFS)	FLOW INTO INLET (CFS)
Stage 3	.53	10.86	7.14	5.24	5.24	19.82	19.815
Stage 2	.54	14.35	6.44	3.92	9.16	31.76	13.878
Stage 1	.55	16.91	6.06	3.56	12.72	42.65	12.735
Pond	.55	16.91	6.06	0	12.72	42.65	0

press return when ready to continue . . . ?

Do you want to make any changes? (Y/N)
? n

RATIONAL METHOD
DONALD W. MCINTOSH ASSOCIATES, INC.

PROJECT : Example for Thesis

INPUT DATA FOR FILE thesis.dat

NODE #	USER LABEL	SUB AREA (ACRES)	IMPERVIOUS AREA (ACRES)	C FACTOR PERVIOUS	C FACTOR IMPERVIOUS	TIME OF CONCENTRATION (MINUTES)
1	Stage 3	5.24	2.5	.2	.9	1Ø.86
2	Stage 2	3.92	2	.2	.9	14.35
3	Stage 1	3.56	2	.2	.9	16.91
4	Pond	Ø	Ø	.2	.9	16.91

PIPE #	FROM NODE	TO NODE
1	1	2
2	2	3
3	3	4

RESULTS FOR FILE thesis.dat

STRUCTURE LABEL	COMPOSITE C FACTOR	TIME OF CONCENTRATION (MINUTES)	INTENSITY ZONE 7 (IN/HR)	SUB AREA (ACRES)	TOTAL AREA (ACRES)	CUMULATIVE FLOWRATE (CFS)
Stage 3	.53	1Ø.86	7.14	5.24	5.24	19.82
Stage 2	.54	14.35	6.44	3.92	9.16	31.76
Stage 1	.55	16.91	6.Ø6	3.56	12.72	42.65
Pond	.55	16.91	6.Ø6	Ø.ØØ	12.72	42.65

```
********************************************************
*                                                      *
*              M  A  I  N      M  E  N  U               *
*                                                      *
*            PIPE SYSTEM OPTIMIZATION FOR              *
*                                                      *
*            MINIMUM CONSTRUCTION COSTS                *
*                                                      *
********************************************************
```

C   Cost data editting

W   Watershed data input / editting

P   Pipe data input / editting and Optimization

X   eXit to system

? p


```
****************************************************************
*                                                              *
*            STORM SEWER PIPING NETWORK OPTIMIZATION           *
*                                                              *
*        Written by Dawn E. Fetter                             *
*        under instruction by Dr. Martin P. Wanielista         *
*        for Master's Thesis at U.C.F.                         *
*                                                              *
****************************************************************
```

Which do you want to do :
        1)   Use existing data file
        2)   Create a new data file
? 2

What is the name of the data file you'll be creating thesis.cst

Enter the elevation of the tailwater at the most downstream end of your system
    68

Enter the ground elevation at the most downstream end   76.2

Any changes to the above   (Y=yes / Return=no)

```
==============
   PIPE   3
==============
```

Enter the following ground elevations :
            minimum ground elevation 75
                and length from downstream end of pipe . . . 250
            average ground elevation 75.5
            ground elevation at the most upstream end . . .   75

Calculated flowrate (cfs) going thru this pipe link = 42.65

Enter the length (feet) of this pipe link 250

Manning's friction coefficient (return for .013)

                                                (n = .013)

Enter a head loss coefficient for estimation energy loss thru manhole
(return for 0.5)

                                                (K = .5)

Any changes to above data (Y / return) n

```
============
  PIPE   3
============
```

CONFIGURATION 1

Pipe Diameter (inches) 36

SAVE Current Configuration

CONTINUE to Next Stage

            Velocity =   6.03 ft/sec
            Hydraulic Slope = 0.0041 ft/ft

```
============
  PIPE   3
============
```

CONFIGURATION 2

Pipe Diameter (inches)   42

SAVE Current Configuration

CONTINUE to Next Stage

            Velocity =   4.43 ft/sec
            Hydraulic Slope = 0.0018 ft/ft

```
=================
PIPE    2
=================
```

Enter the following ground elevations :
            minimum ground elevation   75
                    and length from downstream end of pipe . . . 0
            average ground elevation 76
            ground elevation at the most upstream end . . .   77

Calculated flowrate (cfs) going thru this pipe link = 31.76

Enter the length (feet) of this pipe link 200

Manning's friction coefficient (return for .013)
                                                (n = .013)

Enter a head loss coefficient for estimation energy loss thru manhole
(return for 0.5)
                                                (K = .5)

Any changes to above data (Y / return)
```
=============
PIPE    2
=============
```

CONFIGURATION   1

Pipe Diameter (inches) 30

SAVE Current Configuration

CONTINUE to Next Stage

            Velocity =   6.47 ft/sec
            Hydraulic Slope = 0.0060 ft/ft

            Velocity =   6.47 ft/sec
            Hydraulic Slope = 0.0060 ft/ft

```
=============
PIPE    2
=============
```

CONFIGURATION   2

Pipe Diameter (inches) 36

SAVE Current Configuration

CONTINUE to Next Stage

            Velocity =   4.49 ft/sec
            Hydraulic Slope = 0.0023 ft/ft

```
■■■■■■■■■■■■■■■■
    PIPE    1
■■■■■■■■■■■■■■■■
```

Enter the following ground elevations :
                minimum ground elevation 77
                    and length from downstream end of pipe . . . 0
                average ground elevation 77.3
                ground elevation at the most upstream end . . .   78

Calculated flowrate (cfs) going thru this pipe link = 19.82

Enter the length (feet) of this pipe link 200

Manning's friction coefficient (return for .013)
                                                    (n = .013)

Enter a head loss coefficient for estimation energy loss thru manhole
(return for 0.5)
                                                    (K = .5)

Any changes to above data (Y / return)
                        ============
                        PIPE   1
                        ============

                CONFIGURATION   1

 Pipe Diameter (inches) 24

SAVE Current Configuration

CONTINUE to Next Stage

                Velocity =   6.31 ft/sec
                Hydraulic Slope = 0.0077 ft/ft

                        ============
                        PIPE   1
                        ============

                CONFIGURATION   2

Pipe Diameter (inches) 27

SAVE Current Configuration

CONTINUE to Next Stage

                Velocity =   4.98 ft/sec
                Hydraulic Slope = 0.0041 ft/ft

```
-------------------------------------------------

   GLOBAL OPTIMUM COST =  52850  DOLLARS

     OPTIMAL CONFIGURATION :
PIPE  3  36  in.
PIPE  2  30  in.
PIPE  1  24  in.
-------------------------------------------------
                        PRESS RETURN TO CONTINUE . . .?
```

PIPE #   3

Diameter (in) 36

Length (ft) 250

Velocity (fps) 6.033746

Slope 4.08882E-03

Headwater Pipe Invert (ft) 69.0222

Tailwater Pipe Invert (ft) 68

Hydraulic Grade Line Elev (ft) at Headwater 72.0222

Cost of this Pipe Link 23250

PRESS RETURN TO CONTINUE . . . ?

PIPE # 2

Diameter (in) 30
Length (ft) 200
Velocity (fps) 6.4701
Slope 5.996168E-03
Headwater Pipe Invert (ft) 70.72144
Tailwater Pipe Invert (ft) 69.5222
Hydraulic Grade Line Elev (ft) at Headwater 73.50409
Cost of this Pipe Link 16200

PRESS RETURN TO CONTINUE . . . ?

PIPE # 1

Diameter (in) 24
Length (ft) 200
Velocity (fps) 6.308907
Slope 7.677827E-03
Headwater Pipe Invert (ft) 72.75701
Tailwater Pipe Invert (ft) 71.22144
Hydraulic Grade Line Elev (ft) at Headwater 75.36468
Cost of this Pipe Link 13400

PRESS RETURN TO CONTINUE . . . ?

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[3] Hoang, Dong. "Storm Sewer Optimum Design," EPA, pp. 272-280.

[4] Walters, G. A. "Designing New Sewer Networks to a Minimum Cost by the Use of Dynamic Programming," Proceeds from the International Conference on Urban Storm Drainage, Pentech Press Limited, Plymouth, Devon, Great Britain, pp. 636-647, 1978.

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