THE DESIGN OF TEMPORARY SEDIMENT CONTROLS FOR SOIL LOSSES FROM HIGHWAY CUT SLOPES

by

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Research Analyst

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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PREFACE

Acting upon a request by the Environmental Quality Division of the Virginia Department of Highways & Transportation, the Research Council conducted an overview evaluation of the Department's erosion and siltation control program. Much of the evaluation deals with the maintenance of the environment during highway construction. A most important consideration appears to be the accurate prediction of soil loss from highway construction and the prediction of the temporary sediment controls needed to abate this loss on the construction site.

To this end, this manual was prepared in an attempt to estimate the soil loss and to design a set of adequate abatement structures along the ditch line of the roadway. These tasks are accomplished by a computer program which is intended to be used on the IBM Model 370 computer of the Central Office of the Virginia Highway & Transportation Department.

The manual is intended to be used by the personnel of the Location and Design Division and Environmental Quality Division as part of the initial phases of planning and design and by environmental personnel at the district level for updating of control structures as construction progresses or maintenance of the structures is required.

The manual consists of a general introduction to the problem and this is followed by a brief description of the information which must be input into the computer as well as a description of the calculated results. A simple example is used to show typical input and output. Greater detail on various aspects of the computer program are given in the Appendices. These include a description of the general mathematical procedure used in the calculation of the soil-loss prediction, description and arrangement of input cards and a complete listing of the computer program.

This manual contains the updated version of the computer program first discussed in Council report VHRC 73-R51 (May 1974), entitled "Design Program for the Estimation and Abatement of Soil Losses From Highway Slopes".

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INTRODUCTION

This manual describes a computer program which estimates the soil loss from a highway cut slope. Input into the program consists of a basic description of the slope (location, soil erodibility, slope length and gradient) and duration of construction. The output consists of an estimated annual soil loss and a peak loss assuming a 2-year, 6-hour storm event. The preventive measures required to prevent this peak soil loss from getting into streams are in terms of the number of straw flow barriers required.

Several studies suggest that soil loss from highway construction can be estimated by use of the Universal Soil Loss Equation.[1,2,3,4,5] This soil loss prediction equation was developed by the U. S. Soil Conservation Service for soil losses from agricultural areas of low and uniform steepness. Two difficulties arise in its application to highway construction. These are that the typical highway slope is commonly irregularly shaped in cross section and that at least part of the slope is usually very steep. Recently, a modification of the equation by Foster and Wischmeier allows for the prediction of soil loss from irregular slopes.[6]

The program described here is intended to be used for new construction and scheduled erosion control maintenance of existing projects. It is designed for the IBM Model 370 of the Central Office of the Virginia Department of Highways & Transportation so that during the initial phases of planning, personnel of the Location and Design Division and Environmental Quality Division will have access to its use. Environmental personnel at the district level can also use their remote computer terminals to maintain and redesign siltation controls as the construction proceeds. A brief description of the method of calculation is found in Appendix A.

INPUT PROCEDURE

Three basic input items are used to determine the soil loss from a highway slope using the Universal Soil Loss Equation. These are:

1. The location of the slope in terms of district, residency, and the county rainfall index.
2. a description of the topographic profile and soils of the slope, and
3. the period of construction or any selected time interval in which the soil of the slope will be disturbed.

Coded values of the district, residency, and county are used to determine the annual regional rainfall distribution and the rainfall-energy index (see Appendix A) for the particular location of the highway construction. These values are used in the computational procedure along with the project period of construction and soil erodibility factor (see Appendix A) to produce the estimated annual soil loss as well as the soil loss occurring over selected time intervals.

The technique for describing an irregular profile slope such as found along a roadway undergoing construction is to divide the slope cross section into a series of straight-line segments. Each segment may have a different slope length and percent gradient. The simplest number of segments would be two (as is shown in the nearly completed slope in Figure 1). The percent gradient of each segment is found from:

$$\text{Percent gradient of a segment} = \frac{\text{Vertical change in feet}}{\text{Horizontal change in feet}} \times 100$$

The program assumes that the last segment of the profile description will be in the ditch line and that all controls will be placed in this final segment. Only one segment in the ditch line may be used to describe the profile. Should a change of grade be called for in the ditch line, another profile description will have to be used from the point of grade change. The program allows calculation of the soil loss for complex slopes with up to five segments.

In Figure 1, the first slope segment would be a cut slope from which most of the soil loss would be generated and the second segment would be the drainage ditch running parallel to the roadway. This latter segment also contributes to the overall soil loss and is the location at which most of the sediment control measures are used.

OUTPUT

The basic unit of sediment control utilized in this program is the multiple bale flow barrier (Figure 2). The program generates estimates of the length slope factor (LS); the annual soil loss for the slope described; the soil loss during the construction period, and the sediment source area found by multiplying the final segment of the slope times the sum of all other segments. In addition, the number of cubic yards of material lost during construction and the number of tons and cubic yards of material which could be lost from a single 2-year, 6-hour storm event is also shown. This storm can be considered to be an "average" storm because it can be expected to occur 50 percent of the time, and the 6-hour duration has been found by the U. S. Soil Conservation Service to be the most frequently occurring storm length.

For the slope shown in Figure 1, the results of the program are given in Figure 3. The gradient percents and the segment lengths (25 and 400 feet, respectively) are shown. The estimated segment length slope factor (LS) and the percentage contribution of each segment to the total loss are also shown.

The estimated (LS) for the slope of Figure 1 was 2.84. The estimated annual soil loss from the example was 158.86 tons per acre, and during the construction period (June through August) the soil loss was 59.43 cubic yards per acre. A single storm loss for a 2-year, 6-hour rainfall was 9.52 cubic yards.

The estimated number of barriers required in the final segment are 16 three-bale barriers (spaced 25 feet apart) or 8 five-bale barriers (spaced 50 feet apart). The reader is referred to Appendix A for the method of calculation.

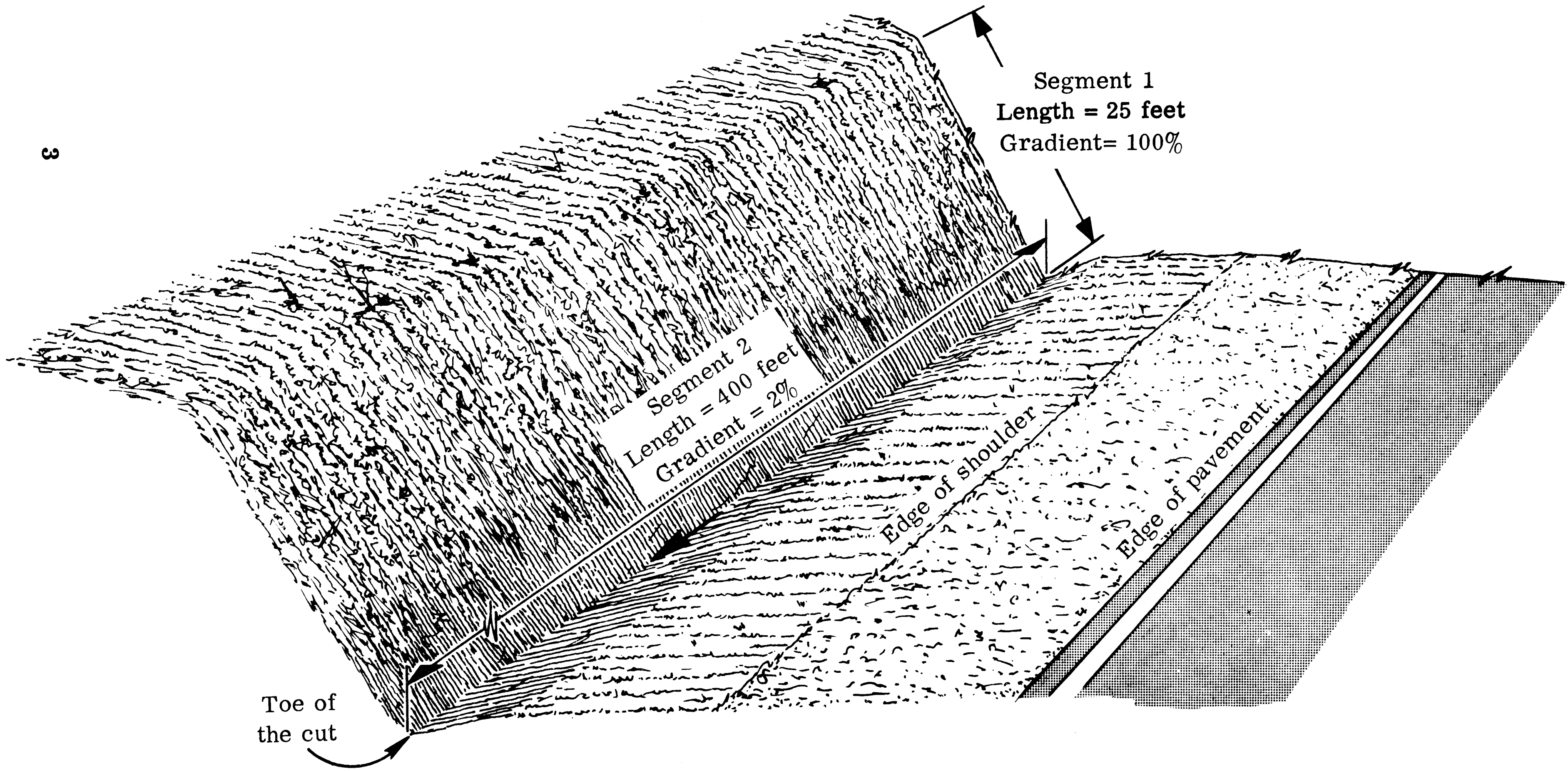

Figure 1. Typical highway slope divided into segments. (Segments are not necessarily to scale.)

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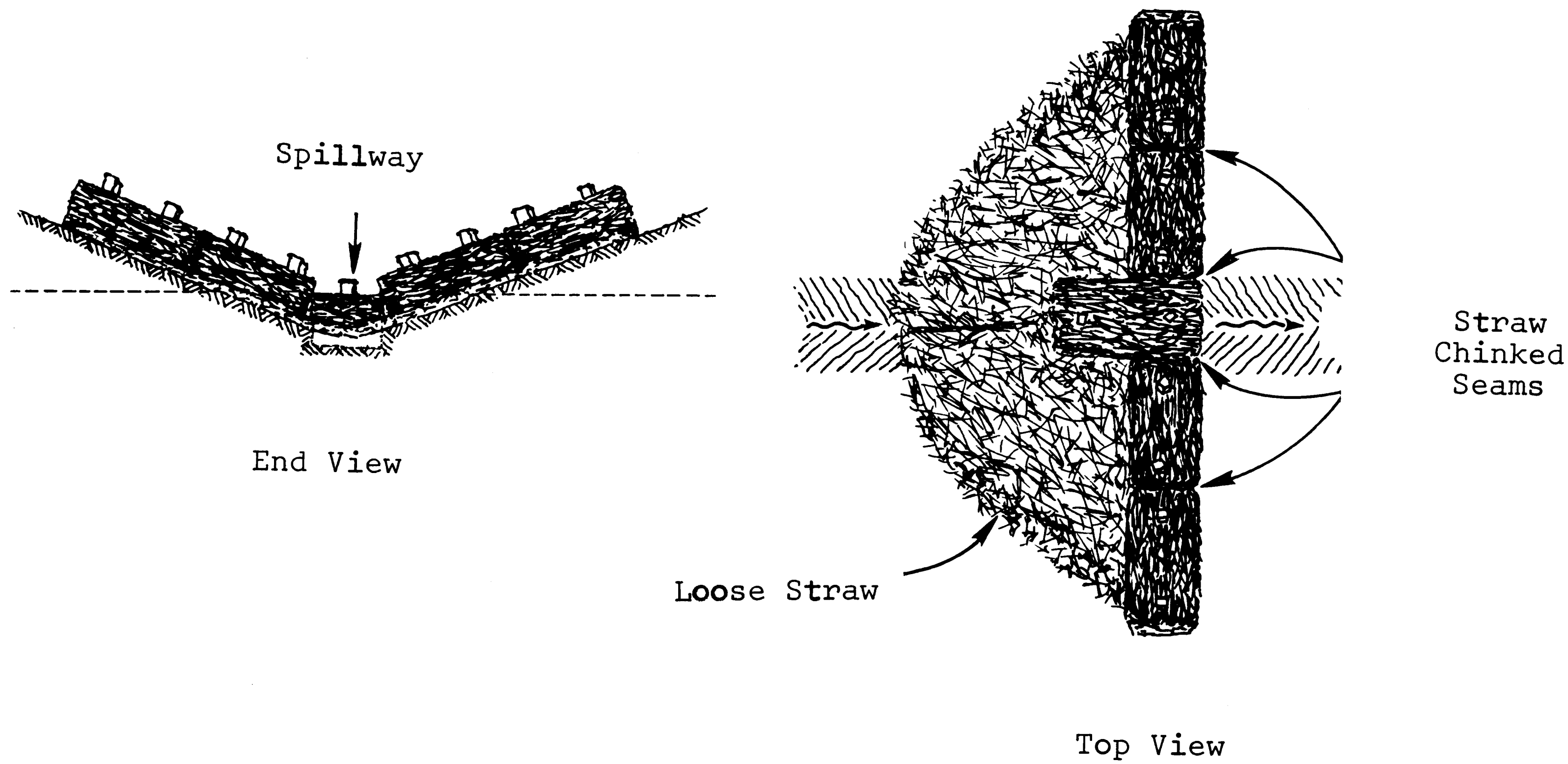

Figure 2. Multiple bale straw flow barrier to be used in ditchline. The number of bales of any barrier is variable in both size and trapping capacity. The assumption of the program is that a three-bale barrier will trap 1 cubic yard and a five-bale barrier will trap 2 cubic yards. Barriers must be built such that the top of the keystone or center bale is lower in elevation than the bottom end of the outermost bale. Wood cellulose fiber (750 ton/acre) may be sprayed in the up-flow end of the barrier as a substitute for chinking straw and loose straw may also be tacked with this mixture.

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DESIGNING MAINTENANCE OF TEMPORARY SILTATION CONTROLS

DISTRICT 7 RESIDENCY 43

K VALUE 0.28 R VALUE 175.

BEGINNING MONTH 9
ENDING MONTH 12

SEGMENT	GRADIENT PERCENT	SEGMENT LENGTH	SEGMENT LS	PERCENT CONTRIBUTION OF TOTAL LOSS
1	100.0	25	40.86	84.7
2	2.0	400	0.46	15.3

E S T I M A T E S

LENGTH SLOPE FACTOR = 2.84

ANNUAL SOIL-LOSS IN TONS PER ACRE = 139.01
IN CUBIC YARDS PER ACRE = 120.94

SOIL-LOSS IN CUBIC YARDS PER ACRE DURING CONSTRUCTION PERIOD = 22.98
IN CUBIC METERS PER ACRE = 17.57

AREA OF INTEREST IN ACRES = 0.23
IN HECTARES = 0.09

NUMBER OF CUBIC YARDS LOST DURING CONSTRUCTION PERIOD = 5.27

SINGLE STORM LOSS (TONS FROM 2YR/6HR EVENT) = 10.94
SINGLE STORM LOSS (CUBIC YARDS) = 9.52

A B A T E M E N T

TOTAL NUMBER OF BARRIERS IN FINAL SEGMENT:
3 BALE BARRIERS = 10 (40 FOOT SPACING)
5 BALE BARRIERS = 5 (80 FOOT SPACING)

FIGURE 3. COMPUTED SOIL LOSS AND ABATEMENT FOR SLOPE SHOWN IN FIGURE 1.

ACKNOWLEDGEMENTS

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The project was conducted under the general direction of Jack H. Dillard, Head, Virginia Highway and Transportation Research Council, and under the specific direction of Mehmet C. Anday, head of the Soils, Geology and Physical Environment Section.

REFERENCES

1. National Cooperative Highway Research Program, "Erosion Control on Highway Construction," Synthesis No. 18, p. 52, 1973.

2. Wischmeier, W. H., and L. D. Meyer, "Soil Erodibility on Construction Areas," Highway Research Special Report 135, Highway Research Board, pp. 20-29, 1973.

3. Soil Conservation Service, "Guidelines for the Control of Erosion and Sediment in Urban Areas of the Northeast," U. S. Department of Agriculture, Upper Darby, Pa., 1970.

4. Wischmeier, W. H., C. B. Johnson, and B. V. Cross, "A Soil Erodibility Nomograph for Farm Land and Construction Sites," Jour. Soil Water Conservation, Vol. 28, No. 5, pp. 189-193, 1971.

5. Swerdon, P. M., and R. R. Koontz, "Sediment Runoff Control at Highway Construction Sites," Engineering Res. Bulletin B-108, Pennsylvania State College of Engineering, p. 70, 1973.

6. Foster, G. R., and W. H. Wischmeier, "Evaluating Irregular Slopes for Soil Loss Prediction," ASAE Paper No. 73-227, p. 16, 1973.

7. Hotes, F. L., K. H. Ateshian, and B. Sheikh, "Comparative Costs of Erosion and Sediment Control, Construction Activities," U. S. EPA Office of Water Program Operations, EPA-43019-73-016, U. S. Government Printing Office, 1973, 205 pp.

8. Poché, D. J., "Design of Temporary Sediment Controls with Special Reference to Water Quality," Virginia Highway & Transportation Research Council, VHTRC 76-R4, September 1975.

APPENDIX A

METHOD OF CALCULATION

Appendix A contains a very brief mathematical discourse on the method of calculation found in the computer program. For a more detailed treatment of the method used in the computer program the reader is referred to reference 6.

The basic assumptions of the Universal Soil Loss Equation are that the average soil loss per unit area (in this case, of roadside) is a product of a rainfall factor (termed R), a soil erodibility factor (K), a slope length factor (L) and a steepness factor (S). Thus,

$$A = RKLS \tag{1}$$

where A is the soil loss per unit area. For the purpose of calculation the slope length and steepness factors have been combined into a series of tables involving a length-steepness factor (LS).

As indicated by the equation, the calculation of A assumes a uniform steepness. However, Foster and Wischmeier found that in the case of irregular slopes the sediment yields are not accurately estimated by the assumption of a uniform overall average steepness. They observed that the sediment load at any location on an irregular slope must be a function of the slope's erosion characteristics, such as its local soil detachment rate and the transport capacity of the runoff. They proposed that a slope of irregular steepness be divided into a series of N segments such that the slope steepness or gradient and soil type, and thereby the soil detachment rate, within each segment could be considered to be uniform. The total soil loss from the slope is thus the sum of the losses from the N segments.

The Universal Soil Loss Equation then becomes,

$$A = RK \left\{ \frac{\sum_{j=1}^{N} \left(S_j \lambda_j^{1.5} - S_j \lambda_{j-1} \right)}{\lambda_e \, (72.6)^{0.5}} \right\} \tag{2}$$

where the bracketed expression replaces the topographic factor LS in Equation 1. The term λ_j is the distance, in feet, from the top of the slope to the lower end of any segment, j; λ_{j-1} is the slope length above segment j; and λ_e is the overall slope length. The term S_j is the value of the factor S from segment j, where $$S = \frac{0.043\sigma^2 + 0.30\sigma + 0.43}{6.613} \qquad (3)$$

and σ is the slope gradient or steepness in percent. The bracketed expression of Equation 2 may be simplified for computation purposes to

$$LS = \frac{1}{\lambda_e} \sum_{j=1}^{N} (U_{2j} - U_{1j}) \qquad (4)$$

The LS value determined by this procedure is a function of all the segment lengths and slope gradients or steepnesses and of their particular sequence on the slope. The percentage of the total sediment yield that comes from each of the N slope segments is also obtained by this computational procedure. The relative sediment contribution of segment j to the total soil loss is

$$(U_{2j} - U_{1j}) / \sum_{j=1}^{N} (U_{2j} - U_{1j}).$$

The computer program assumes that the last segment of the profile is the only one in the ditch line and is the segment at which all sediment controls will be placed. The annual soil loss in tons/acre for the area is found by a determination of the annual R values (reference 7), which are shown in Appendix B. The annual soil loss in cubic yards is found by multiplying the tons per acre estimate by .87 (assuming all material is a silty loam).[3] The number of cubic yards per acre is estimated by multiplying the annual loss by that portion of the annual cumulative rainfall distribution indicated by the construction months. Three distributions are used in the program and the appropriate selection depends upon the location within the state by District. The loss in cubic meters per acre is estimated by multiplying the cubic yards per acre by .7646.

The area of interest is determined by multiplying the last segment by the summation of all other segments. Should a single segment be attempted a computer diagnostic will appear. The number of cubic yards of material is found by multiplying the cubic yards per acre by the number of acres.

The soil loss in tons for a single storm event is found by resolving equation 2 with the R value set at 70.[7] This value is the resulting R value for a 2-year, 6-hour rainfall event. The results are then multiplied by the area in acres to obtain the amount in tons lost during the event.

The abatement output is based on the assumption that a well positioned and maintained 3-bale barrier can trap as much as 1 cubic yard of material and a 5-bale barrier can trap 2 cubic yards. The number of barriers is determined by an empirical equation based in part upon successful barrier designs in Virginia.[8] Figure A-1 is a graph of the equation relating cubic yards generated during construction to the number of 5-bale flow barriers. Approximately twice as many 3-bale barriers are required for the same soil loss. The spacing of the barriers in the last segment is found by dividing the number of barriers into the length of the last segment.

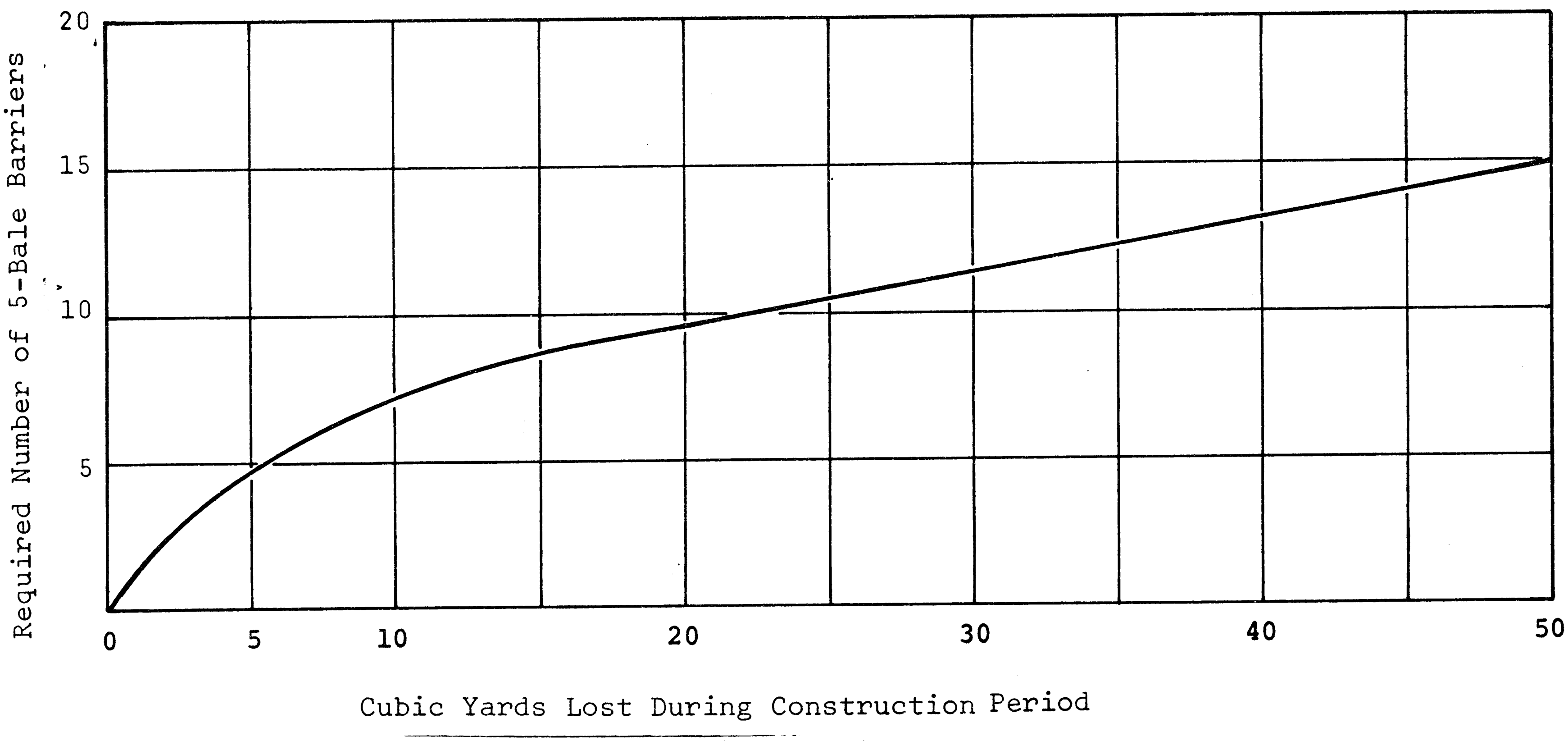

Figure A-1. Empirical curve for the determination of flow barriers.

APPENDIX B

DATA INPUT FORMAT

Location Card

Code the district, residency and R value as indicated below.

District (card 1, column 1)

District	Code
Bristol	1
Salem	2
Lynchburg	3
Richmond	4
Suffolk	5
Fredericksburg	6
Culpeper	7
Staunton	8

Residency (card 1, columns 4-5)

District	Residency	Code
Bristol	Wise	01
	Abingdon	03
	Lebanon	04
	Tazewell	06
	Wytheville	08
	Jonesville	58
Salem	Hillsville	09
	Christiansburg	11
	Martinsville	12
	Rocky Mount	13
	Salem	14
	Bedford	16
Lynchburg	Chatham	17
	Halifax	18
	Dillwyn	19
	Appomattox	20
	Amherst	22

District	Residency	Code
Richmond	South Hill	23
	Amelia	24
	Petersburg	25
	Chesterfield	26
	Sandston	27
	Ashland	28
Suffolk	Franklin	31
	Waverly	32
	Suffolk	33
	Norfolk	34
	Williamsburg	35
	Accomac	36
Fredericksburg	Saluda	37
	Warsaw	39
	Fredericksburg	40
	Bowling Green	41
Culpeper	Louisa	42
	Charlottesville	43
	Culpeper	45
	Warrenton	46
	Fairfax	47
	Manassas	48
	Leesburg	49
Staunton	Lexington	50
	Staunton-Verona	53
	Harrisonburg	54
	Edinburg	55
	Luray	56

Rainfall Value (card 1, columns 10-12)

Residency	County	R Values
Wise	Wise	150
	Dickenson	150
Abingdon	Washington	175
	Smyth	175
Lebanon	Russel	175
	Buchanan	150
Tazewell	Tazewell	175
	Bland	175
Wytheville	Wythe	175
	Grayson	200
Jonesville	Lee	150
	Scott	175
Hillsville	Carroll	200
	Floyd	200
Christiansburg	Montgomery	175
	Giles	175
	Pulaski	175
Martinsville	Henry	200
	Patrick	200
Rocky Mount	Franklin	200
Salem	Craig	175
	Roanoke	200
	Botetourt	200
Bedford	Bedford	200
Chatham	Pittsylvania	225
Halifax	Halifax	225
	Charlotte	225
Dillwyn	Buckingham	225
	Cumberland	225
	Prince Edward	225

Residency	County	R Values
Appomattox	Appomattox	225
	Campbell	225
Amherst	Amherst	200
	Nelson	200
South Hill	Brunswick	250
	Mecklenburg	250
Amelia	Amelia	250
	Nottoway	250
	Lunenburg	250
Petersburg	Dinwiddie	250
	Prince George	250
Chesterfield	Chesterfield	250
	Powhatan	225
Sandston	Charles City	250
	Henrico	250
	New Kent	250
Ashland	Goochland	225
	Hanover	225
Franklin	Greensville	250
	Southampton	250
Waverly	Surry	250
	Sussex	250
Suffolk	Isle of Wight	275
	Nansemond	300
Norfolk	Norfolk	300
	Princess Ann	300
Williamsburg	James City	275
	York	275
	Warwick	275
Accomac	Accomac	250
	Northampton	275

Residency	County	R Values
Saluda	King and Queen	250
	Gloucester	250
	Middlesex	250
	Mathews	275
Warsaw	Richmond	225
	Lancaster	250
	Northumberland	250
	Westmoreland	225
Fredericksburg	Spotsylvania	225
	Stafford	225
	King George	225
Bowling Green	Caroline	225
	Essex	225
	King William	250
Louisa	Fluvanna	225
	Louisa	225
Charlottesville	Albemarle	200
	Greene	200
Culpeper	Culpeper	200
	Orange	200
	Madison	200
Warrenton	Fauquier	200
	Rappahannock	200
Fairfax	Fairfax	200
	Arlington	200
Manassas	Prince William	200
Leesburg	Loudoun	200
Lexington	Alleghany	175
	Rockbridge	200
	Bath	175
Staunton-Verona	Augusta	200
	Highland	175
Harrisonburg	Rockingham	200

Residency	County	R Values
Edinburg	Frederick	175
	Shenandoah	200
Luray	Clark	200
	Page	200
	Warren	200

K Value (card 1, columns 15-19)

Note: The K value will be obtained from county soil conservation maps and/or preconstruction geological survey reports. General soils of low erodibility range in K value from .10-.23. Medium erodibility soils range from .24 to .36, and highly erodible soils have K values in the range .37 to .49.

Number of segments (card 1, column 27)

Code the number of segments of the slope in column 27 of the first card. Five segments may be used. Last segment must be only one in ditch line.

Segment Length and Gradient Card(s)

The next data card codes the segment length and its gradient in percent. One length and gradient is required per card. If the slope is divided into three segments then three segment length and gradient cards are required.

Code the segment length and gradient as indicated:

Columns 1 through 4 — Length of segment in feet. For values less than 100 feet use columns 3 and 4.

Columns 8 through 18 — Slope gradient of segment in percent with decimal point in column 11.

Note: Segment cards must be ordered from upslope to downslope.

Construction Period Card

Columns 1 and 2 — Code with a value from 1 to 12 the beginning month of construction of period of interest.

Columns 7 and 8 — Code with a value from 1 to 12 the ending month of period of interest.

Typical Program Deck Setup

The typical program deck setup for the problem solved in the main text is shown in Figure B-1. More than one problem may be worked at a time by repeating the data input set (location card, slope length and gradient card(s), etc.) before the last card of the deck.

```
//SOIL      JOB (00822HWY10),17T0878,MSGLEVEL=(1,1),CLASS=G
//   EXEC FORTGCLG
//FORT.SYSIN DD *
                          } PROGRAM DECK PLACED HERE.

/*
//GO.SYSIN DD *
7  43     200     .28        2      } DATA CARDS (MULTIPLE PROBLEMS MAY BE
  25    100.0                       }  SOLVED BY REPEATING DATA CARD SE-
 400      2.0                       }  QUENCE)
 7      9
/*
//
```

Figure B-1. Typical deck setup for problem solved in main text.

APPENDIX C

```
FORTRAN IV G LEVEL  21              MAIN            DATE = 75234         10/17/22              PAGE 0001

0001              REAL A1,A2,A3,A4
0002              REALSLOPEL(6),SEGMEL (6),SLOPEG (6),LIST(12,3),
                 $LS(6),SJ(6),QJ(6),PLS(6),SLPMN1 (6),U1(6),U2(6)
0003              REAL KVALUE,RVALUE,SUMSEL ,SUMSLG ,LS1,SUMQJ,ELS,SUMPLS,RVALE1
0004              INTEGER DIST,RESIDN ,NUMSEG,COUNT(6),MONTH1,MONTH2
0005              INTEGER ICOUNT
            C-----------------------------------------------------------------------------C
            C
            C     DATA STATEMENT-LIST-CONTAINS 36 ELEMENTS FOR LIST-A,LIST-B,LIST-C
            C
            C-----------------------------------------------------------------------------C
0006              DATA LIST/0.01,0.02,0.03,0.06,0.10,0.20,0.35,0.55,0.75,0.85,0.92,
                 $0.97,0.01,0.04,0.07,0.12,0.17,0.25,0.35,0.55,0.78,0.87,0.92,0.97,
                 $0.01,0.02,0.03,0.06,0.10,0.20,0.40,0.65,0.82,0.91,0.95,0.96/
0007         5004 FORMAT (F5.2)
0008         1    SI = 0.
0009              LS1=0.
0010              SUMSLG =0.
0011              SUMPLS=0.
0012              A = 0.
0013              A1 = 0.
0014              A2 = 0.
0015              A3 = 0.
0016              A4 = 0.
0017              RVALE1 = 0.
0018              B = 0.
0019              E =0.
0020              F = 0.
0021              Y = 0.
0022              X = 0.
0023              SUMSEL =0.
0024              SUMQJ=0.
0025              SUMSG2 = 0.
0026              ELS = 0.
0027              DO 2 I = 1,6
0028              SLOPEL(I) = 0.
0029              SLOPEG (I) = 0.
0030              SEGMEL (I) = 0.
0031              LS(I) = 0.
0032              SJ(I) = 0.
0033              QJ(I) = 0.
0034              SLPMN1  (I) = 0.
0035              PLS(I) = 0.
0036              COUNT(I) = 0
0037              U1(I) = 0.
0038              U2(I) = 0.
0039        2     CONTINUE
            C-----------------------------------------------------------------------------C
            C
            C
            C     READ DISTRICT,RESIDENCY,RVALUE,KVALUE AND NUMBER OF SEGMENTS
            C     FORMAT(I1,2X,I2,4X,F3.0,4X,F3.0,7X,I1)
            C     VARIABLE(S)-DIST,RESIDIN,KVALUE AND NUMSEG
            C
            C
            C-----------------------------------------------------------------------------C
0040              READ(5,5000,END=300)DIST,RESIDN,RVALUE,KVALUE,NUMSEG
0041         5000 FORMAT (I1,2X,I2,4X,F3.0,4X,F3.0,7X,I1)
```

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```
      RVALE1=60
C-----------------------------------------------------------------------C
C
C     READ SEGMENT LENGTHS AND SLOPE GRADIENTS
C     FORMAT(F4.0.3X.F6.2)
C     VARIABLE(S)-SEGMEL(I).SLOPEG(I)
C
C-----------------------------------------------------------------------C
      IF (NUMSEG .GT. 0) GO TO 4
      WRITE (6.6028)
 6028 FORMAT(1X.27HERROR IN NUMBER OF SEGMENTS)
      STOP
 4    DO 5 I = 1.NUMSEG
      READ (5.5001) SEGMEL (I).SLOPEG (I)
 5001 FORMAT ( F4.0.3X.F6.2)
      COUNT(I) = I
 5    CONTINUE
      GO TO 15
C-----------------------------------------------------------------------C
C
C
C     CALCULATE SLOPE LENGTHS
C     VARIABLE(S)-SLOPEL(I)
C
C
C-----------------------------------------------------------------------C
 10   DO 11 I = 1.6
 11   SLOPEL(I) = 0.
 15   IF (NUMSEG .EQ. 1) GO TO 54
      SLOPEL(1) = SEGMEL(1)
      DO 20 I = 2.NUMSEG
      J = I - 1
      SLOPEL(I) = SLOPEL(J) + SEGMEL (I)
 20   CONTINUE
C-----------------------------------------------------------------------C
C
C
C     CALCULATE SLOPE LENGTH - 1
C     VARIABLE(S)-SLPMN1(I)
C
C
C-----------------------------------------------------------------------C
 25   DO 30 I = 1.NUMSEG
      SLPMN1 (I) = SLOPEL(I) - SEGMEL (I)
 30   CONTINUE
C-----------------------------------------------------------------------C
C
C
C     SUM THE SEGMENT LENGTHS
C     VARIABLE(S)-SUMSEL
C
C
C-----------------------------------------------------------------------C
      DO 50 I = 1.NUMSEG
      SUMSEL = SUMSEL + SEGMEL (I)
 50   CONTINUE
C-----------------------------------------------------------------------C
C
```

```
                C      READ BEGINNING AND ENDING MONTH
                C      FORMAT(I2,4X,I2)
                C      VARIABLE(S)-MONTH1,MONTH2
                C
                C-----------------------------------------------------------------------C
0067             54    READ (5,5003) MONTH1,MONTH2
0068             5003 FORMAT (I2,4X,I2)
0069                   IF (NUMSEG .EQ. 1) GO TO 115
                C-----------------------------------------------------------------------C
                C
                C
                C      CALCULATE SJ,U2,U1,AND QJ=U2-U1
                C      SUM THE QJ.S
                C      VARIABLE(S)-SJ(I),U2(I),U1(I),QJ(I),SUMQJ
                C
                C
                C-----------------------------------------------------------------------C
0070             70    DO 72 I = 1,NUMSEG
0071                   SJ(I) = (0.043*SLOPEG (I)**2. + 0.30 * SLOPEG (I)+0.43)/6.613
0072                   U2(I) = (SJ(I) * SLOPEL (I) **1.5)/(72.6)**0.5
0073                   U1(I) = (SJ(I) * SLEMN1 (I) **1.5)/(72.6)**0.5
0074                   QJ(I) = U2(I) - U1(I)
0075                   SUMQJ = SUMQJ + QJ(I)
0076             72    CONTINUE
0077                   GO TO 85
                C-----------------------------------------------------------------------C
                C
                C
                C      CALCULATE ELS
                C      VARIABLE(S)-ELS
                C
                C
                C-----------------------------------------------------------------------C
0078             85    ELS = SUMQJ / SUMSEL
                C-----------------------------------------------------------------------C
                C
                C
                C      CALCULATE LS,PLS,SUM OF PLS.S
                C      VARIABLE(S)-LS(I),PLS(I),SUMPLS
                C
                C
                C-----------------------------------------------------------------------C
0079             90    DO 95 I = 1,NUMSEG
0080                   LS(I) = QJ(I) / SEGMEL (I)
0081                   PLS(I) =(QJ(I) / SUMQJ) * 100
0082                   SUMPLS = SUMPLS + PLS(I)
0083             95    CONTINUE
0084                   GO TO 130
0085             100   DO 105 I = 1,6
0086                   LS(I) =0.
0087             105   PLS(I) = 0.
0088                   SUMPLS = 0.
0089                   GO TO 90
                C-----------------------------------------------------------------------C
                C
                C
                C      CALCULATE LS FOR 1 SEGMENT
                C      VARIABLE(S)-LS1
```


2151

```
            C
            C
            C-----------------------------------------------------------------------C
0090          115  IF (SEGMEL (1) .LE. 800. .AND. SLOPEG (1) .LE. .20) GO TO 120
0091               IF (SEGMEL (1) .GT. 800. .OR. SLOPEG (1) .GT. .20) LS1=(SEGMEL (1)
                  $/75.)**0.6*(SLOPEG(1)/9.)**1.4
0092               GO TO 125
0093          120  LS1 = SEGMEL (1) **0.5*(0.0076+0.0053*SLOPEG (1)+0.0076*SLOPEG (1)
                  $**2.)
0094          125  LS(1) = LS1
0095          130  WRITE(6,6017)
0096          6017 FORMAT(1H1)
0097               WRITE (6,6000)
0098          6000 FORMAT(44X,53HDESIGNING MAINTENANCE OF TEMPORARY SILTATION CONTROL
                  $S,/)
0099               WRITE(6,6001) DIST,RESIDN
0100          6001 FORMAT (51X,8HDISTRICT,7X,I1,7X,9HRESIDENCY,4X,I2/)
0101               IF (RESIDN .LE. 0 .OR. RESIDN .GT. 58) GO TO 265
0102               IF (RVALUE .LE. 0.) GO TO 270
0103               WRITE (6,6002) KVALUE,RVALUE
0104          6002 FORMAT (51X,7HK VALUE,7X,F5.2,6X,7HR VALUE,2X,F5.0/)
0105               WRITE(6,6003)MONTH1
0106          6003 FORMAT(59X,15HBEGINNING MONTH,1X,I2)
0107               WRITE (6,6004) MONTH2
0108          6004 FORMAT(59X,12HENDING MONTH,4X,I2//)
0109               IF (NUMSEG .EQ. 1) GO TO 155
0110               WRITE(6,6005)
0111          6005 FORMAT (48X,8HGRADIENT,6X,7HSEGMENT,6X,7HSEGMENT,5X,20HPERCENT CON
                  -TRIBUTION)
0112               WRITE(6,6006)
0113          6006 FORMAT (35X,7HSEGMENT,6X,7HPERCENT,7X,6HLENGTH,9X,2HLS,11X,
                  - 13HOF TOTAL LOSS,/,
                  -1H+,34X,7H_______,6X,8H________,6X,7H_______,6X,7H_______,5X,
                  -20H____________________,/)
0114               DO 140 I = 1,NUMSEG
0115               ISEGML = IFIX(SEGMEL(I))
0116               WRITE (6,6007) I, SLOPEG(I), ISEGML, LS(I), PLS(I)
0117          6007 FORMAT (38X,I1,9X,F5.1,10X,I4,9X,F5.2,12X,F6.1)
0118          140  CONTINUE
0119               WRITE (6,6008) ELS
0120          6008 FORMAT (//62X,17HE S T I M A T E S,/,1H+,61X,17H_________________,
                  - //,56X,22HLENGTH SLOPE FACTOR = ,F7.2,/)
0121          150  IF (NUMSEG .EQ. 1) GO TO 155
            C-----------------------------------------------------------------------C
            C
            C
            C      CALCULATE A IN T/A (ANNUAL LOSS)
            C      VARIABLE(S)-A
            C
            C
            C-----------------------------------------------------------------------C
0122               A = RVALUE  * KVALUE * ELS
0123               A1 = RVALE1 * KVALUE * ELS
0124               GO TO 160
            C-----------------------------------------------------------------------C
            C
            C
            C      CALCULATE A IN T/A (ANNUAL LOSS) FOR 1 SEGMENT
```

```
              C      VARIABLE(S)-A
              C
              C
              C-----------------------------------------------------------------------C
0125           155  A = RVALUE * KVALUE * LS(1)
0126                A1 = RVALE1 * KVALUE * LS(1)
              C-----------------------------------------------------------------------C
              C
              C      CALCULATE B IN (ANNUAL LOSS) IN CUBIC YARDS
              C      VARIABLE(S)-B
              C
              C-----------------------------------------------------------------------C
0127            160 B = .87 * A
0128                WRITE (6,6009) A
0129           6009 FORMAT (42X,36HANNUAL SOIL-LOSS IN TONS PER ACRE = ,F7.2)
0130                WRITE(6,6010) B
0131           6010 FORMAT(25X,50H                     IN CUBIC YARDS PER ACRE,
                 -   3H = ,F7.2,/)
              C-----------------------------------------------------------------------C
              C
              C
              C      ADJUST FOR SEASON BY READING DATA FROM DATA LIST USING THE ARRAY (LIST)
              C      IF DISTRICT CODE IS-STAUNTON,SALEM OR BRISTOL
              C                          THE ELEMENTS  1-12 OF ARRAY LIST ARE USED
              C      IF DISTRICT CODE IS-CULPEPER OR LYNCHBURG
              C                          THE ELEMENTS 13-24 OF ARRAY LIST ARE USED
              C      IF DISTRICT CODE IS-RICHMOND,FREDERICKBURG OR SUFFOLK
              C                          THE ELEMENTS 25-36 OF ARRAY LIST ARE USED
              C      VARIABLE(S)-C
              C
              C
              C-----------------------------------------------------------------------C
0132                IF(DIST .EQ. 1 .OR. DIST .EQ. 2 .OR. DIST .EQ. 8) M = 1
0133                IF (DIST .EQ. 3 .OR. DIST .EQ. 7) M = 2
0134                IF (DIST .EQ. 4 .OR. DIST .EQ. 5 .OR. DIST .EQ. 6) M = 3
0135                IF (MONTH2-MONTH1)170,175,180
0136           170  C1 = 1. - LIST(MONTH1,M)
0137                C = C1 + LIST(MONTH2,M)
0138                GO TO 185
0139           175  C = 1.
0140                GO TO 185
0141           180  C = LIST(MONTH2,M) - LIST(MONTH1,M)
              C
              C
              C      CALCULATE ESTIMATED SOIL-LOSS IN CUBIC YARDS PER ACRE OVER
              C      CONSTRUCTION PERIOD
              C      VARIABLE(S)-D
              C
              C
              C-----------------------------------------------------------------------C
0142            185 D = B * C
0143                WRITE(6,6011) D
0144           6011 FORMAT(15X,63HSOIL-LOSS IN CUBIC YARDS PER ACRE DURING CONSTRUCTIO
                 -N PERIOD = ,F7.2)
              C-----------------------------------------------------------------------C
              C
              C      CALCULATE ESTIMATED SOIL-LOSS IN CUBIC METERS OVER CONSTRUCTION PERIOD
              C      VARIABLE(S)-E
```

2454


```
            C
            C-----------------------------------------------------------------------C
0145                 F = D * .7646
0146                 WRITE(6,6018)F
0147           6018 FORMAT(51X,27HIN CUBIC METERS PER ACRE = ,F7.2,/)
0148                 IF (NUMSEG .EQ. 1) GO TO 275
0149                 NUM1 = NUMSEG - 1
            C-----------------------------------------------------------------------C
            C
            C
            C        SUM ALL EXCEPT LAST SEGMENT LENGTHS
            C        VARIABLE(S)-SUMSG2
            C
            C
            C-----------------------------------------------------------------------C
0150                 SUMSG2 = 0.
0151                 DO 215 I = 1,NUM1
0152           215  SUMSG2 = SUMSG2 + SEGMEL (I)
            C-----------------------------------------------------------------------C
            C
            C
            C        CALCULATE AREA IN FT**2
            C        VARIABLE(S)-AREA
            C
            C
            C-----------------------------------------------------------------------C
0153                 AREA = SUMSG2  * SEGMEL (NUMSEG)
            C-----------------------------------------------------------------------C
            C
            C
            C        CALCULATE AREA OF INTEREST IN ACRES
            C        VARIABLE(S)-AREA1
            C
            C
            C-----------------------------------------------------------------------C
0154           225  AREA1 = AREA * (1./43560.)
0155                 A2=A1*AREA1
0156                 A3 = D * AREA1
0157                 WRITE(6,6014) AREA1
0158           6014 FORMAT(50X,28HAREA OF INTEREST IN ACRES = ,F7.2)
            C-----------------------------------------------------------------------C
            C
            C
            C        CALCULATE AREA OF INTEREST IN HECTARES
            C        VARIABLE(S)-F
            C
            C
            C-----------------------------------------------------------------------C
0159                 F = .4047 * AREA1
0160                 A4 = A3
0161                 WRITE(6,6019)F
0162           6019 FORMAT(64X,14HIN HECTARES = ,F7.2,/)
0163                 WRITE (6,6039) A3
0164           6039 FORMAT (22X,53HNUMBER OF CUBIC YARDS LOST DURING CONSTRUCTION PERI
                    -OD,3H = ,F7.2,/)
0165                 WRITE(6,6040) A2
0166           6040 FORMAT(22X,46HSINGLE STORM LOSS (TONS FROM 2YR/6HR EVENT) = ,F7.2)
0167                 YE?A? = A2 * .?7
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```
0168           WRITE (6,6041) YD3A2
0169      6041 FORMAT (44X,34HSINGLE STORM LOSS (CUBIC YARDS) = ,F7.2,/)
0170           WRITE(6,6012)
0171      6012 FORMAT (//,62X,17HA B A T E M E N T,/,1H+,61X,17H_________________
              - ,/)
          C-----------------------------------------------------------------------C
          C
          C
          C    CALCULATE A * AREA FOR YIELD IN YD**3
          C    VARIABLE(S)-AREA2
          C
          C
          C-----------------------------------------------------------------------C
0172           AREA2 = D * AREA1
          C-----------------------------------------------------------------------C
          C
          C
          C    CALCULATE NO. OF STRAW BARRIER(S) NEEDED PER 100 FT.
          C    VARIABLE(S)-Y
          C
          C
          C-----------------------------------------------------------------------C
0173           Y = AREA2 * 100. / SEGMEL(NUMSEG)
0174           X = (Y * SEGMEL (NUMSEG)) / 100.
0175           XII = SEGMEL(NUMSEG)/X
0176           BALE = (6.5 + .17 * A4) - 6.23 * EXP(-.1737 * A4)
0177           IBALE5 = IFIX(BALE + .5)
0178           IBALE3 = IFIX(BALE * 2. + .5)
0179           IXII = IFIX(SEGMEL(NUMSEG)/IBALE3)
0180           IXIII = IFIX(SEGMEL(NUMSEG)/IBALE5)
0181           WRITE (6,6015) IBALE3,IXII, IBALE5, IXIII
0182      6015 FORMAT (38X,42HTOTAL NUMBER OF BARRIERS IN FINAL SEGMENT:,/,50X,
              -18H3 BALE BARRIERS = ,I3,5H    (,I3,14H FOOT SPACING),/,50X,
              -18H5 BALE BARRIERS = ,I3,5H    (,I3,14H FOOT SPACING))
          C-----------------------------------------------------------------------C
          C
          C
          C    CALCULATE TOTAL NUMBER OF BARRIERS NEEDED IN FINAL SEGMENT
          C
          C
          C-----------------------------------------------------------------------C
0183           GO TO 1
0184       265 WRITE (6,6025)
0185      6025 FORMAT(1X,23HERROR IN RESIDENCY CODE)
0186       270 WRITE(6,6027)
0187      6027 FORMAT(1X,37HERROR IN R VALUE CODE-REFER TO MANUAL)
0188           GO TO 300
0189       275 WRITE (6,6029)
0190      6029 FORMAT(25X,91HNUMBER OF SEGMENTS EQUAL 1-MULTIPLY DRAINAGE AREA TI
              $MES SOIL LOSS IN CUBIC YARDS )
0191           WRITE (6,6030)
0192      6030 FORMAT(25X,81HPER ACRE TO OBTAIN SOIL LOSS.  ASSUME ONE BARRIER RE
              $QUIRED PER CUBIC YARD PERIOD.)
0193       300 STOP
0194           END
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2465

2456