

APPENDIX E

A FORTRAN COMPUTER PROGRAM FOR CALCULATING
STEADY UPWARD FLUX FROM THE WATER TABLE

The programs reads in layer depths and soil water tension - hydraulic conductivity table for surface and a steady state upward flux and calculates the water table position that would give that flux. Sample input data and program output are given.

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UPFLUX VS WATERTABLE DEPTH

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A PROGRAM TO CALCULATE THE WATERTABLE DEPTH (Z) CORRESPONDING
TO A MAXIMUM POTENTIAL STEADY STATE UPWARD FLUX RATE.

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THE SOIL MAY HAVE UP TO 10 LAYERS

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THE EQUATION USED IS A TRAPEZOIDAL APPROXIMATION OF THE
INTEGRAL FORM OF THE DARCY-BUCKINGHAM EQUATION:

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$$Z = \text{SUM} (0.5*(S(I)-S(I-1)) * (\frac{1}{Q/K(I)+1} + \frac{1}{Q/K(I-1)+1}))$$

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DIMENSION S(10,100),DPTH(10),NNOD(10)

REAL K(10,100),KB,KT,MAL

C

INPUT SOIL DATA

READ(1,100) A1,A2,A3,A4

WRITE(6,100) A1,A2,A3,A4

READ(1,101) NLAYR

DO 10 LAYR=1,NLAYR

READ(1,102) NNOD(LAYR),DPTH(LAYR)

WRITE(6,301) LAYR,DPTH(LAYR)

NNOD=NNOD(LAYR)

DO 10 NOD=1,NNOD

READ(1,103) S(LAYR,NOD),K(LAYR,NOD)

WRITE(6,302) S(LAYR,NOD),K(LAYR,NOD)

10

CONTINUE

C

ENTER SURFACE TENSION

READ(1,104) SINIT

C

ENTER AN UPFLUX VALUE AND BEGIN CALCULATIONS

15

READ(1,104,END=99) UPFLX

ZMAX=0.0

LAYR=1

NOD=NNOD(LAYR)

C

DETERMINE CONDUCTIVITY AND NEXT LOWER ARRAY ELEMENT

C

CORRESPONDING TO THE SURFACE TENSION

IF(SINIT.GE.S(1,NOD)) SINIT=S(1,NOD)

DO 30 N=1,NOD

NN=N

IF(SINIT.LE.S(1,N)) GO TO 32

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30 CONTINUE
32 ST=SINIT
   NOD=NN-1
   KT=(ST-S(1,NN-1))/(S(1,NN)-S(1,NN-1))*(K(1,NN)-K(1,NN-1))+K(1,NN-1
   S)
C   GO TO THE NEXT INCREMENT
35 SB=S(LAYR,NOD)
   KB=K(LAYR,NOD)
45 DZ=(ST-SB)*0.5*(1/(UPFLX/KT+1)+1/(UPFLX/KB+1))
   IF((DZ+ZMAX).GT.DPTH(LAYR)) GO TO 54
C   THE WATERTABLE IS NOT REACHED UNTIL H=0; I.E. WHEN NOD=1
   ZMAX=ZMAX+DZ
   IF(ZMAX.GT.DPTH(NLAYR)) GO TO 92
   IF(NOD.EQ.1) GO TO 50
   KT=KB
   ST=SB
   NOD=NOD-1
   GO TO 35
50 WRITE(6,303) UPFLX,SINIT,ZMAX
C   END OF CALCULATIONS FOR ONE UPFLUX, GO TO NEXT UPFLUX
   GO TO 15
C   FIND TENSION AND CONDUCTIVITY AT BOTTOM OF A LAYER
54 FLAGG=2
   FRAC=0.5
   ZTOL=0.1
55 SB=S(LAYR,NOD+1)-FRAC*(S(LAYR,NOD+1)-S(LAYR,NOD))
   KB=K(LAYR,NOD+1)-FRAC*(K(LAYR,NOD+1)-K(LAYR,NOD))
   DZ=(ST-SB)*0.5*(1/(UPFLX/KT+1)+1/(UPFLX/KB+1))
   IF(ABS(ZMAX+DZ-DPTH(LAYR)).LT.ZTOL) GO TO 65
   IF((ZMAX+DZ-DPTH(LAYR)).GT.ZTOL) XMAL=1.0
   IF((ZMAX+DZ-DPTH(LAYR)).LE.ZTOL) XMAL=-1.0
   FLAGG=FLAGG*2
   IF(FLAGG.GT.5500) GO TO 91
   FRAC=FRAC-XMAL/FLAGG
   GO TO 55
C   BOTTOM OF A LAYER HAS BEEN FOUND, GO TO NEXT LAYER AND
C   FIND CONDUCTIVITY FOR TENSION EQUAL TO BOTTOM OF LAST LAYER
65 ZMAX=ZMAX+DZ
   IF(ZMAX.GT.DPTH(NLAYR)) GO TO 92
   IF(LAYR.GE.NLAYR) GO TO 92
   LAYR=LAYR+1
   ST=SB
   NND=NNOD(LAYR)
   DO 70 II=1,NND
     NN=II
     IF(ST.LE.S(LAYR,II)) GO TO 75
70 CONTINUE
   ST=S(LAYR,NND)
   WRITE(6,903) UPFLX,LAYR,ST,S(LAYR,NODE)
75 NOD=NN-1
   KT=(ST-S(LAYR,NN-1))/(S(LAYR,NN)-S(LAYR,NN-1))*(K(LAYR,NN)
   S-K(LAYR,NN-1))+K(LAYR,NN-1)
   GO TO 35
91 WRITE(6,901) UPFLX,LAYR
   STOP
92 WRITE(6,902) UPFLX,LAYR
   GO TO 15

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100  FORMAT(4A4)
101  FORMAT(I2)
102  FORMAT(I3,7X,F10.5)
103  FORMAT(2F10.5)
104  FORMAT(F10.5)
301  FORMAT(//,1X,'LAYER ',I3,' GOES DOWN TO ',F6.0,'CM.',
        $1X,'AND HAS THE TENSION-CONDUCTIVITY VALUES:',//,
        $1X,' TENSION  CONDUCTIVITY',/,
        $1X,' (CM)      (CM/HR)')
302  FORMAT(F8.2,4X,E10.4)
303  FORMAT(//,1X,'FOR UPFLUX OF',F8.4,'CM/HR AND SURFACE TENSION=',
        $F6.0,'CM',/,15X,'MAXIMUM STEADY STATE WATERTABLE DEPTH =',F7.2,
        $' CM')
901  FORMAT(//,1X,'FOR UPFLUX=',F10.5,' PROGRAM CANNOT FIND THE ',
        $'TENSION AND CONDUCTIVITY AT BOTTOM OF LAYER',I3)
902  FORMAT(1X,'FOR UPFLUX=',F10.5,' WATERTABLE IS BELOW BOTTOM',
        $' OF LAYER',I3,' GO TO NEXT UPFLUX')
903  FORMAT(//,1X,'FOR UPFLUX=',F10.5,'TENSION AT TOP OF LAYER ',I2,
        $' IS ',F10.5,/,1X,'THIS IS REDUCED TO ',F10.5)
C*****
C          SOME DEFINITIONS
C*****
C          ST=TENSION AT UPPER END OF INCREMENT
C          SB=TENSION AT LOWER END OF INCREMENT
C          KT=TENSION AT UPPER END OF INCREMENT
C          KB=TENSION AT LOWER END OF INCREMENT
C          S(I,J)=TENSION ARRAY      (INPUT AS +CM)
C          K(I,J)=CONDUCTIVITY ARRAY (INPUT AS +CM/HR)
C          SINIT =SURFACE TENSION   (INPUT AS +CM)
C          UPFLX =UPWARD FLUX VALUE  (INPUT AS +CM/HR)
C          LAYR=LAYER NUMBER : 1 IS TOPMOST LAYER
C          NOD= NODE NUMBER : 1 IS FOR ZERO TENSION
C          DZ= CHANGE IN DEPTH ACROSS INCREMENT
C          ZMAX=DEPTH OF THE WATERTABLE FROM THE SURFACE CORRESPONDING TO
C                   THE 'UPFLX' VALUE      (OUTPUT AS CM)
C          FLAGG=MULTIPLIER USED IN FINDING TENSION AND CONDUCTIVITY AT BOTTOM
C                   OF EACH LAYER
C*****
C          INPUTS
C*****
C LINE 1:  SOIL ID
C LINE 2:  TOTAL NUMBER OF LAYERS
C   FOR EACH LAYER---
C LINE 3:  NO. OF DATA POINTS AND DEPTH OF LAYER(CM)  --(I3,7X,F10.5)
C   FOR EACH DATA ENTRY---
C LINE 4:  TENSION (CM) AND CONDUCTIVITY (CM/HR)  --(F10.5,F10.5)
C   ....
C ---WHEN ALL SOIL DATA IS ENTERED---
C LINE N:  SURFACE TENSION (CM)  --(F10.5)
C LINE N+1: UPFLUX (CM/HR)  --(F10.5)
C LINE N+1: UPFLUX (CM/HR)
C   ....
C*****
99  STOP
    END

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SAMPLE INPUT DATA FOR UPFLUX PROGRAM

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'PONZER MUCK'

| | |
|-------|-----------|
| 03 | |
| 017 | 20.0 |
| 0.0 | 22. |
| 6.666 | 7.218 |
| 12.63 | 3.849 |
| 17.89 | 2.197 |
| 24.3 | 1.286 |
| 32.0 | 0.7659 |
| 42.5 | 0.4623 |
| 55.0 | 0.2814 |
| 70.9 | 0.1715 |
| 91.1 | 0.1034 |
| 113. | 0.06055 |
| 136. | 0.03354 |
| 162. | 0.01702 |
| 194. | 0.007591 |
| 257. | 0.002742 |
| 329. | 0.0005867 |
| 1000. | 0.000002 |
| 022 | 95.0 |
| 0.0 | 26.0 |
| 13.3 | 17.13 |
| 20.2 | 12.86 |
| 22.9 | 9.681 |
| 25.7 | 7.246 |
| 28.6 | 5.38 |
| 32.0 | 3.959 |
| 36.0 | 2.883 |
| 40.0 | 2.074 |
| 45.7 | 1.471 |
| 51.4 | 1.024 |
| 57.1 | 0.6963 |
| 64.3 | 0.4606 |
| 73.0 | 0.2946 |
| 82.5 | 0.1809 |
| 95.0 | 0.1059 |
| 114. | 0.05853 |
| 138. | 0.02976 |
| 167. | 0.01322 |
| 200. | 0.00463 |
| 271. | 0.0009475 |
| 1000. | 0.000002 |
| 012 | 480.0 |
| 0.0 | 8.0 |
| 20.0 | 3.677 |
| 30.0 | 2.182 |
| 40.0 | 1.299 |
| 48.7 | 0.7454 |

| | |
|--------|----------|
| 57.4 | 0.4000 |
| 68.7 | 0.1937 |
| 82.0 | 0.07981 |
| 104. | 0.02494 |
| 142. | 0.004356 |
| 300. | 0.0001 |
| 1000. | 0.000002 |
| 400. | |
| 0.0166 | |
| 0.0140 | |
| 0.0120 | |
| 0.0100 | |
| 0.0080 | |
| 0.0060 | |
| 0.0040 | |
| 0.0020 | |

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SAMPLE OUTPUT FOR UPFLUX PROGRAM

CC
'PONZER MUCK'

LAYER 1 GOES DOWN TO 20. CM. AND HAS THE TENSION-CONDUCTIVITY VALUE

| TENSION (CM) | CONDUCTIVITY (CM/HR) |
|-----------------|-------------------------|
| 0.0 | 0.2200E+02 |
| 6.67 | 0.7218E+01 |
| 12.63 | 0.3849E+01 |
| 17.89 | 0.2197E+01 |
| 24.30 | 0.1286E+01 |
| 32.00 | 0.7659E+00 |
| 42.50 | 0.4623E+00 |
| 55.00 | 0.2814E+00 |
| 70.90 | 0.1715E+00 |
| 91.10 | 0.1034E+00 |
| 113.00 | 0.6055E-01 |
| 136.00 | 0.3354E-01 |
| 162.00 | 0.1702E-01 |
| 194.00 | 0.7591E-02 |
| 257.00 | 0.2742E-02 |
| 329.00 | 0.5867E-03 |
| 1000.00 | 0.2000E-05 |

LAYER 2 GOES DOWN TO 95. CM. AND HAS THE TENSION-CONDUCTIVITY VALUE

| TENSION (CM) | CONDUCTIVITY (CM/HR) |
|-----------------|-------------------------|
| 0.0 | 0.2600E+02 |
| 13.30 | 0.1713E+02 |
| 20.20 | 0.1286E+02 |
| 22.90 | 0.9681E+01 |
| 25.70 | 0.7246E+01 |
| 28.60 | 0.5380E+01 |
| 32.00 | 0.3959E+01 |
| 36.00 | 0.2883E+01 |
| 40.00 | 0.2074E+01 |
| 45.70 | 0.1471E+01 |
| 51.40 | 0.1024E+01 |
| 57.10 | 0.6963E+00 |
| 64.30 | 0.4606E+00 |
| 73.00 | 0.2946E+00 |
| 82.50 | 0.1809E+00 |
| 95.00 | 0.1059E+00 |
| 114.00 | 0.5853E-01 |
| 138.00 | 0.2976E-01 |

| | |
|---------|------------|
| 167.00 | 0.1322E-01 |
| 200.00 | 0.4630E-02 |
| 271.00 | 0.9475E-03 |
| 1000.00 | 0.2000E-05 |

LAYER 3 GOES DOWN TO 480.CM. AND HAS THE TENSION-CONDUCTIVITY VALUE

| TENSION (CM) | CONDUCTIVITY (CM/HR) |
|-----------------|-------------------------|
| 0.0 | 0.8000E+01 |
| 20.00 | 0.3677E+01 |
| 30.00 | 0.2182E+01 |
| 40.00 | 0.1299E+01 |
| 48.70 | 0.7454E+00 |
| 57.40 | 0.4000E+00 |
| 68.70 | 0.1937E+00 |
| 82.00 | 0.7981E-01 |
| 104.00 | 0.2494E-01 |
| 142.00 | 0.4356E-02 |
| 300.00 | 0.1000E-03 |
| 1000.00 | 0.2000E-05 |

FOR UPFLUX OF 0.0166CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 171.22 CM

FOR UPFLUX OF 0.0140CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 177.22 CM

FOR UPFLUX OF 0.0120CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 182.82 CM

FOR UPFLUX OF 0.0100CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 189.38 CM

FOR UPFLUX OF 0.0080CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 196.94 CM

FOR UPFLUX OF 0.0060CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 207.31 CM

FOR UPFLUX OF 0.0040CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 220.33 CM

FOR UPFLUX OF 0.0020CM/HR AND SURFACE TENSION= 400.CM
 MAXIMUM STEADY STATE WATERTABLE DEPTH = 245.06 CM

