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Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter C2

COMPUTER MODEL OF TWO-DIMENSIONAL SOLUTE TRANSPORT AND DISPERSION IN GROUND WATER

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Book 7

AUTOMATED DATA PROCESSING AND COMPUTATIONS

Attachment I

FORTRAN IV Program Listing

```
C     ****************************************************************     A  10
C     *                                                              *     A  20
C     *      SOLUTE TRANSPORT AND DISPERSION IN A POROUS MEDIUM      *     A  30
C     *       NUMERICAL SOLUTION --- METHOD OF CHARACTERISTICS       *     A  40
C     *       PROGRAMMED BY J. D. BREDEHOEFT AND L. F. KONIKOW       *     A  50
C     *                                                              *     A  60
C     ****************************************************************     A  70
      DOUBLE PRECISION DMIN1,DEXP,DLOG,DABS                                 A  80
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE               A  90
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR         A 100
      REAL *8TINT,ALPHA1,ANITP                                              A 110
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO    A 120
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N    A 130
     2PNCHV,NPDELC                                                          A 140
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB    A 150
     1S(5)                                                                  A 160
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR     A 170
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,    A 180
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T    A 190
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       A 200
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,    A 210
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM    A 220
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM                 A 230
C     ****************************************************************     A 240
C      ---LOAD DATA---                                                      A 250
      INT=0                                                                 A 260
      CALL PARLOD                                                           A 270
      CALL GENPT                                                            A 280
C     ****************************************************************     A 290
C     ---START COMPUTATIONS---                                              A 300
C        ---COMPUTE ONE PUMPING PERIOD---                                   A 310
      DO 150 INT=1,NPMP                                                     A 320
      IF (INT.GT.1) CALL PARLOD                                             A 330
C        ---COMPUTE ONE TIME STEP---                                        A 340
      DO 130 N=1,NTIM                                                       A 350
      IPRNT=0                                                               A 360
C        ---LOAD NEW DELTA T---                                             A 370
      TINT=SUMT-PYR*(INT-1)                                                 A 380
      TDEL=DMIN1(TIM(N),PYR-TINT)                                           A 390
      SUMT=SUMT+TDEL                                                        A 400
      TIM(N)=TDEL                                                           A 410
      REMN=MOD(N,NPNT)                                                      A 420
C     ****************************************************************     A 430
      CALL ITERAT                                                           A 440
      IF (REMN.EQ.0.0.OR.N.EQ.NTIM) CALL OUTPT                              A 450
      CALL VELO                                                             A 460
      CALL MOVE                                                             A 470
C     ****************************************************************     A 480
C     ---STORE OBS. WELL DATA FOR TRANSIENT FLOW PROBLEMS---                A 490
      IF (S.EQ.0.0) GO TO 120                                               A 500
      IF (NUMOBS.LE.0) GO TO 120                                            A 510
      J=MOD(N,50)                                                           A 520
      IF (J.EQ.0) J=50                                                      A 530
      TMOBS(J)=SUMT                                                         A 540
      DO 110 I=1,NUMOBS                                                     A 550
      TMWL(I,J)=HK(IXOBS(I),IYOBS(I))                                       A 560
      TMCN(I,J)=CONC(IXOBS(I),IYOBS(I))                                     A 570
  110 CONTINUE                                                              A 580
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FORTRAN IV program listing—Continued

```
C     ****************************************************************      A 590
C     ---OUTPUT ROUTINES---                                                 A 600
  120 IF (REMN.EQ.0.0.OR.N.EQ.NTIM.OR.MOD(N,50).EQ.0) CALL CHMOT            A 610
      IF (SUMT.GE.(PYR*INT)) GO TO 140                                      A 620
  130 CONTINUE                                                              A 630
C     ****************************************************************      A 640
C     ---SUMMARY OUTPUT---                                                  A 650
  140 CONTINUE                                                              A 660
      IPRNT=1                                                               A 670
      CALL CHMOT                                                            A 680
  150 CONTINUE                                                              A 690
C     ****************************************************************      A 700
      STOP                                                                  A 710
C     ****************************************************************      A 720
      END                                                                   A 730-
      SUBROUTINE PARLOD                                                     B  10
      DOUBLE PRECISION DMIN1,DEXP,DLOG,DABS                                 B  20
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE               B  30
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR         B  40
      REAL *8FCTR,TIMX,TINIT,PIES,YNS,XNS,RAT,HMX,HMY                       B  50
      REAL *8TINT,ALPHA1,ANITP                                              B  60
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO    B  70
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N    B  80
     2PNCHV,NPDELC                                                          B  90
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB    B 100
     1S(5)                                                                  B 110
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR     B 120
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,    B 130
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T    B 140
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       B 150
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,    B 160
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM    B 170
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM                 B 180
      COMMON /BALM/ TOTLQ                                                   B 190
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                                B 200
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)                   B 210
C     ****************************************************************      B 220
      IF (INT.GT.1) GO TO 10                                                B 230
      WRITE (6,750)                                                         B 240
      READ (5,720) TITLE                                                    B 250
      WRITE (6,730) TITLE                                                   B 260
C     ****************************************************************      B 270
C     ---INITIALIZE TEST AND CONTROL VARIABLES---                           B 280
      STORMI=0.0                                                            B 290
      TEST=0.0                                                              B 300
      TOTLQ=0.0                                                             B 310
      SUMT=0.0                                                              B 320
      SUMTCH=0.0                                                            B 330
      INT=0                                                                 B 340
      IPRNT=0                                                               B 350
      NCA=0                                                                 B 360
      N=0                                                                   B 370
      IMOV=0                                                                B 380
      NMOV=0                                                                B 390
C     ****************************************************************      B 400
C     ---LOAD CONTROL PARAMETERS---                                         B 410
      READ (5,740) NTIM,NPMP,NX,NY,NPMAX,NPNT,NITP,NUMOBS,ITMAX,NREC,NPT    B 420
     1PND,NCODES,NPNTMV,NPNTVL,NPNTD,NPDELC,NPNCHV                          B 430
      READ (5,800) PINT,TOL,POROS,BETA,S,TIMX,TINIT,XDEL,YDEL,DLTRAT,CEL    B 440
     1DIS,ANFCTR                                                            B 450
      PYR=PINT*86400.0*365.25                                               B 460
      NNX=NX-1                                                              B 470
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FORTRAN IV program listing—Continued

```
      NNY=NY-1                                                                  B 480
      NP=NPMAX                                                                  B 490
      DXINV=1.0/XDEL                                                            B 500
      DYINV=1.0/YDEL                                                            B 510
      ARINV=DXINV*DYINV                                                         B 520
      PORINV=1.0/POROS                                                          B 530
C     ---PRINT CONTROL PARAMETERS---                                            B 540
      WRITE (6,760)                                                             B 550
      WRITE (6,770) NX,NY,XDEL,YDEL                                             B 560
      WRITE (6,780) NTIM,NPMP,PINT,TIMX,TINIT                                   B 570
      WRITE (6,790) S,POROS,BETA,DLTRAT,ANFCTR                                  B 580
      WRITE (6,870) NITP,TOL,ITMAX,CELDIS,NPMAX,NPTPND                          B 590
      IF (NPTPND.LT.4.OR.NPTPND.GT.9.OR.NPTPND.EQ.6.OR.NPTPND.EQ.7) WRIT        B 600
     1E (6,880)                                                                 B 610
      WRITE (6,890) NPNT,NPNTMV,NPNTVL,NPNTD,NUMOBS,NREC,NCODES,NPNCHV,N        B 620
     1PDELC                                                                     B 630
      IF (NPNTMV.EQ.0) NPNTMV=999                                               B 640
      GO TO 20                                                                  B 650
C     ************************************************************************  B 660
C     ---READ DATA TO REVISE TIME STEPS AND STRESSES FOR SUBSEQUENT             B 670
C        PUMPING PERIODS---                                                     B 680
   10 READ (5,1060) ICHK                                                        B 690
      IF (ICHK.LE.0) RETURN                                                     B 700
      READ (5,1070) NTIM,NPNT,NITP,ITMAX,NREC,NPNTMV,NPNTVL,NPNTD,NPDELC        B 710
     1,NPNCHV,PINT,TIMX,TINIT                                                   B 720
      WRITE (6,1080) INT                                                        B 730
      WRITE (6,1C90) NTIM,NPNT,NITP,ITMAX,NREC,NPNTMV,NPNTVL,NPNTD,NPDEL        B 740
     1C,NPNCHV,PINT,TIMX,TINIT                                                  B 750
C     ************************************************************************  B 760
C     ---LIST TIME INCREMENTS---                                                B 770
   20 DO 30 J=1,100                                                             B 780
      TIM(J)=0.0                                                                B 790
   30 CONTINUE                                                                  B 800
      TIM(1)=TINIT                                                              B 810
      IF (S.EQ.0.0) GO TO 50                                                    B 820
      DO 40 K=2,NTIM                                                            B 830
   40 TIM(K)=TIMX*TIM(K-1)                                                      B 840
      WRITE (6,470)                                                             B 850
      WRITE (6,490) TIM                                                         B 860
      GO TO 60                                                                  B 870
   50 TIM(1)=PYR                                                                B 880
      WRITE (6,480) TIM(1)                                                      B 890
C     ************************************************************************  B 900
C     ---INITIALIZE MATRICES---                                                 B 910
   60 IF (INT.GT.1) GO TO 100                                                   B 920
      DO 70 IY=1,NY                                                             B 930
      DO 70 IX=1,NX                                                             B 940
      VPRM(IX,IY)=0.0                                                           B 950
      PERM(IX,IY)=0.0                                                           B 960
      THCK(IX,IY)=0.0                                                           B 970
      RECH(IX,IY)=0.0                                                           B 980
      CNRECH(IX,IY)=0.0                                                         B 990
      REC(IX,IY)=0.0                                                           B1000
      NODEID(IX,IY)=0                                                          B1010
      TMRX(IX,IY,1)=0.0                                                        B1020
      TMRX(IX,IY,2)=0.0                                                        B1030
      HI(IX,IY)=0.0                                                            B1040
      HR(IX,IY)=0.0                                                            B1050
      HC(IX,IY)=0.C                                                            B1060
      HK(IX,IY)=0.0                                                            B1070
      WT(IX,IY)=0.0                                                            B1080
      VX(IX,IY)=0.0                                                            B1090
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FORTRAN IV program listing—Continued

```
      VY(IX,IY)=0.0                                                     B1100
      VXBDY(IX,IY)=0.0                                                  B1110
      VYBDY(IX,IY)=0.0                                                  B1120
      CONC(IX,IY)=0.0                                                   B1130
      CONINT(IX,IY)=0.0                                                 B1140
      SUMC(IX,IY)=0.0                                                   B1150
   70 CONTINUE                                                          B1160
C     ******************************************************************B1170
C     ---READ OBSERVATION WELL LOCATIONS---                             B1180
      IF (NUMOBS.LE.0) GO TO 100                                        B1190
      WRITE (6,900)                                                     B1200
      DO 80 J=1,NUMOBS                                                  B1210
      READ (5,700) IX,IY                                                B1220
      WRITE (6,810) J,IX,IY                                             B1230
      IXOBS(J)=IX                                                       B1240
   80 IYOBS(J)=IY                                                       B1250
      DO 90 I=1,NUMOBS                                                  B1260
      DO 90 J=1,50                                                      B1270
      TMWL(I,J)=0.0                                                     B1280
   90 TMCN(I,J)=0.0                                                     B1290
C     ******************************************************************B1300
C     ---READ PUMPAGE DATA -- (X-Y COORDINATES AND RATE IN CFS)---       B1310
C        ---SIGNS : WITHDRAWAL = POS.;  INJECTION = NEG.---             B1320
C        ---IF INJ. WELL, ALSO READ CONCENTRATION OF INJECTED WATER---  B1330
  100 IF (NREC.LE.0) GO TO 120                                          B1340
      WRITE (6,910)                                                     B1350
      DO 110 I=1,NREC                                                   B1360
      READ (5,710) IX,IY,FCTR,CNREC                                     B1370
      IF (FCTR.LT.0.0) CNRECH(IX,IY)=CNREC                              B1380
      REC(IX,IY)=FCTR                                                   B1390
  110 WRITE (6,820) IX,IY,REC(IX,IY),CNRECH(IX,IY)                     *B1400
C     ******************************************************************B1410
  120 IF (INT.GT.1) RETURN                                              B1420
      AREA=XDEL*YDEL                                                    B1430
      WRITE (6,690) AREA                                                B1440
      WRITE (6,600)                                                     B1450
      WRITE (6,610) XDEL                                                B1460
      WRITE (6,610) YDEL                                                B1470
C     ******************************************************************B1480
C     ---READ TRANSMISSIVITY IN FT**2/SEC INTO VPRM ARRAY---            B1490
C        ---FCTR = TRANSMISSIVITY MULTIPLIER  --->  FT**2/SEC---        B1500
      WRITE (6,530)                                                     B1510
      READ (5,550) INPUT,FCTR                                           B1520
      DO 160 IY=1,NY                                                    B1530
      IF (INPUT.EQ.1) READ (5,560) (VPRM(IX,IY),IX=1,NX)                B1540
      DO 150 IX=1,NX                                                    B1550
      IF (INPUT.NE.1) GO TO 130                                         B1560
      VPRM(IX,IY)=VPRM(IX,IY)*FCTR                                      B1570
      GO TO 140                                                         B1580
  130 VPRM(IX,IY)=FCTR                                                  B1590
  140 IF (IX.EQ.1.OR.IX.EQ.NX) VPRM(IX,IY)=0.0                          B1600
      IF (IY.EQ.1.OR.IY.EQ.NY) VPRM(IX,IY)=0.0                          B1610
  150 CONTINUE                                                          B1620
  160 WRITE (6,520) (VPRM(IX,IY),IX=1,NX)                               B1630
C     ******************************************************************B1640
C     ---SET UP COEFFICIENT MATRIX --- BLOCK-CENTERED GRID---            B1650
C     ---AVERAGE TRANSMISSIVITY --- HARMONIC MEAN---                    B1660
      IF (ANFCTR.NE.0.0) GO TO 170                                      B1670
      WRITE (6,1050)                                                    B1680
      ANFCTR=1.0                                                        B1690
  170 PIES=3.1415927*3.1415927/2.0                                      B1700
      YNS=NY*NY                                                         B1710
```

FORTRAN IV program listing—Continued

```
      XNS=NX*NX                                                          B1720
      HMIN=2.0                                                           B1730
      DO 180 IY=2,NNY                                                    B1740
      DO 180 IX=2,NNX                                                    B1750
      IF (VPRM(IX,IY).EQ.0.0) GO TO 180                                  B1760
      TMRX(IX,IY,1)=2.0*VPRM(IX,IY)*VPRM(IX+1,IY)/(VPRM(IX,IY)*XDEL+VPRM B1770
     1(IX+1,IY)*XDEL)                                                    B1780
      TMRX(IX,IY,2)=2.0*VPRM(IX,IY)*VPRM(IX,IY+1)/(VPRM(IX,IY)*YDEL+VPRM B1790
     1(IX,IY+1)*YDEL)                                                    B1800
C        ---ADJUST COEFFICIENT FOR ANISOTROPY---                         B1810
      TMRX(IX,IY,2)=TMRX(IX,IY,2)*ANFCTR                                 B1820
C        ---COMPUTE MINIMUM ITERATION PARAMETER (HMIN)---                B1830
      IF (TMRX(IX,IY,1).EQ.0.0) GO TO 180                                B1840
      IF (TMRX(IX,IY,2).EQ.0.0) GO TO 180                                B1850
      RAT=TMRX(IX,IY,1)*YDEL/(TMRX(IX,IY,2)*XDEL)                        B1860
      HMX=PIES/(XNS*(1.0+RAT))                                           B1870
      HMY=PIES/(YNS*(1.0+(1.0/RAT)))                                     B1880
      IF (HMX.LT.HMIN) HMIN=HMX                                          B1890
      IF (HMY.LT.HMIN) HMIN=HMY                                          B1900
  180 CONTINUE                                                           B1910
C     ********************************************************************B1920
C     ---READ AQUIFER THICKNESS---                                       B1930
      WRITE (6,510)                                                      B1940
      READ (5,550) INPUT,FCTR                                            B1950
      DO 210 IY=1,NY                                                     B1960
      IF (INPUT.EQ.1) READ (5,540) (THCK(IX,IY),IX=1,NX)                 B1970
      DO 200 IX=1,NX                                                     B1980
      IF (INPUT.NE.1) GO TO 190                                          B1990
      THCK(IX,IY)=THCK(IX,IY)*FCTR                                       B2000
      GO TO 200                                                          B2010
  190 IF (VPRM(IX,IY).NE.0.0) THCK(IX,IY)=FCTR                           B2020
  200 CONTINUE                                                           B2030
  210 WRITE (6,500) (THCK(IX,IY),IX=1,NX)                                B2040
C     ********************************************************************B2050
C     ---READ DIFFUSE RECHARGE AND DISCHARGE---                          B2060
      WRITE (6,830)                                                      B2070
      READ (5,550) INPUT,FCTR                                            B2080
      DO 240 IY=1,NY                                                     B2090
      IF (INPUT.EQ.1) READ (5,560) (RECH(IX,IY),IX=1,NX)                 B2100
      DO 230 IX=1,NX                                                     B2110
      IF (INPUT.NE.1) GO TO 220                                          B2120
      RECH(IX,IY)=RECH(IX,IY)*FCTR                                       B2130
      GO TO 230                                                          B2140
  220 IF (THCK(IX,IY).NE.0.0) RECH(IX,IY)=FCTR                           B2150
  230 CONTINUE                                                           B2160
  240 WRITE (6,840) (RECH(IX,IY),IX=1,NX)                                B2170
C     ********************************************************************B2180
C     ---COMPUTE PERMEABILITY FROM TRANSMISSIVITY---                     B2190
C     ---COUNT NO. OF CELLS IN AQUIFER---                                B2200
C     ---SET NZCRIT = 2% OF THE NO. OF CELLS IN THE AQUIFER---           B2210
      DO 250 IX=1,NX                                                     B2220
      DO 250 IY=1,NY                                                     B2230
      IF (THCK(IX,IY).EQ.0.0) GO TO 250                                  B2240
      PERM(IX,IY)=VPRM(IX,IY)/THCK(IX,IY)                                B2250
      NCA=NCA+1                                                          B2260
  250 VPRM(IX,IY)=0.0                                                    B2270
C                                                                        B2280
      AAQ=NCA*AREA                                                       B2290
      NZCRIT=(NCA+25)/50                                                 B2300
      WRITE (6,620)                                                      B2310
      DO 260 IY=1,NY                                                     B2320
  260 WRITE (6,650) (PERM(IX,IY),IX=1,NX)                                B2330
```

FORTRAN IV program listing—Continued

```
      WRITE (6,630) NCA,AAQ,NZCRIT                                          B2340
C     ********************************************************************  B2350
C     ---READ NODE IDENTIFICATION CARDS---                                  B2360
C        ---SET VERT. PERM.,  SOURCE CONC.,  AND DIFFUSE RECHARGE---        B2370
C           ---SPECIFY CODES TO FIT YOUR NEEDS---                          B2380
      WRITE (6,570)                                                         B2390
      READ (5,550) INPUT,FCTR                                               B2400
      DO 280 IY=1,NY                                                        B2410
      IF (INPUT.EQ.1) READ (5,640) (NODEID(IX,IY),IX=1,NX)                  B2420
      DO 270 IX=1,NX                                                        B2430
  270 IF (INPUT.NE.1.AND.THCK(IX,IY).NE.0.0) NODEID(IX,IY)=FCTR             B2440
  280 WRITE (6,580) (NODEID(IX,IY),IX=1,NX)                                 B2450
      WRITE (6,920) NCODES                                                  B2460
      IF (NCODES.LE.0) GO TO 310                                            B2470
      WRITE (6,930)                                                         B2480
      DO 300 IJ=1,NCODES                                                    B2490
      READ (5,850) ICODE,FCTR1,FCTR2,FCTR3,OVERRD                           B2500
      DO 290 IX=1,NX                                                        B2510
      DO 290 IY=1,NY                                                        B2520
      IF (NODEID(IX,IY).NE.ICODE) GO TO 290                                 B2530
      VPRM(IX,IY)=FCTR1                                                     B2540
      CNRECH(IX,IY)=FCTR2                                                   B2550
      IF (OVERRD.NE.0) RECH(IX,IY)=FCTR3                                    B2560
  290 CONTINUE                                                              B2570
      WRITE (6,860) ICODE,FCTR1,FCTR2                                       B2580
  300 IF (OVERRD.NE.0) WRITE (6,1100) FCTR3                                 B2590
  310 WRITE (6,590)                                                         B2600
      DO 320 IY=1,NY                                                        B2610
  320 WRITE (6,520) (VPRM(IX,IY),IX=1,NX)                                   B2620
C     ********************************************************************  B2630
C     ---READ WATER-TABLE ELEVATION---                                      B2640
      WRITE (6,670)                                                         B2650
      READ (5,550) INPUT,FCTR                                               B2660
      DO 350 IY=1,NY                                                        B2670
      IF (INPUT.EQ.1) READ (5,660) (WT(IX,IY),IX=1,NX)                      B2680
      DO 340 IX=1,NX                                                        B2690
      IF (INPUT.NE.1) GO TO 330                                             B2700
      WT(IX,IY)=WT(IX,IY)*FCTR                                              B2710
      GO TO 340                                                             B2720
  330 IF (THCK(IX,IY).NE.0.0) WT(IX,IY)=FCTR                                B2730
  340 CONTINUE                                                              B2740
  350 WRITE (6,680) (WT(IX,IY),IX=1,NX)                                     B2750
C     ********************************************************************  B2760
C     ---SET INITIAL HEADS---                                               B2770
      DO 360 IX=1,NX                                                        B2780
      DO 360 IY=1,NY                                                        B2790
      HI(IX,IY)=WT(IX,IY)                                                   B2800
      HC(IX,IY)=HI(IX,IY)                                                   B2810
      HR(IX,IY)=HI(IX,IY)                                                   B2820
  360 HK(IX,IY)=HI(IX,IY)                                                   B2830
C                                                                           B2840
      CALL OUTPT                                                            B2850
C     ********************************************************************  B2860
C     ---COMPUTE ITERATION PARAMETERS---                                    B2870
      DO 370 ID=1,20                                                        B2880
      AOPT(ID)=0.0                                                          B2890
  370 CONTINUE                                                              B2900
      ANITP=NITP-1                                                          B2910
      ALPHA1=DEXP(DLOG(1.0/HMIN)/ANITP)                                     B2920
      AOPT(1)=HMIN                                                          B2930
      DO 380 IP=2,NITP                                                      B2940
  380 AOPT(IP)=AOPT(IP-1)*ALPHA1                                            B2950
```

FORTRAN IV program listing—Continued

```
C                                                                       B2960
      WRITE (6,450)                                                     B2970
      WRITE (6,460) AOPT                                                B2980
C     ******************************************************************B2990
C     ---READ INITIAL CONCENTRATIONS AND COMPUTE INITIAL MASS STORED---  B3000
      READ (5,550) INPUT,FCTR                                           B3010
      DO 420 IY=1,NY                                                    B3020
      IF (INPUT.EQ.1) READ (5,660) (CONC(IX,IY),IX=1,NX)                B3030
      DO 410 IX=1,NX                                                    B3040
      IF (INPUT.NE.1) GO TO 390                                         B3050
      CONC(IX,IY)=CONC(IX,IY)*FCTR                                      B3060
      GO TO 400                                                         B3070
  390 IF (THCK(IX,IY).NE.0.0) CONC(IX,IY)=FCTR                          B3080
  400 CONINT(IX,IY)=CONC(IX,IY)                                         B3090
  410 STORMI=STORMI+CONINT(IX,IY)*THCK(IX,IY)*AREA*POROS                B3100
  420 CONTINUE                                                          B3110
C     ******************************************************************B3120
C     ---CHECK DATA SETS FOR INTERNAL CONSISTENCY---                    B3130
      DO 440 IX=1,NX                                                    B3140
      DO 440 IY=1,NY                                                    B3150
      IF (THCK(IX,IY).GT.0.0) GO TO 430                                 B3160
      IF (TMRX(IX,IY,1).GT.0.0) WRITE (6,940) IX,IY                     B3170
      IF (TMRX(IX,IY,2).GT.0.0) WRITE (6,950) IX,IY                     B3180
      IF (NODEID(IX,IY).GT.0) WRITE (6,960) IX,IY                       B3190
      IF (WT(IX,IY).NE.0.0) WRITE (6,970) IX,IY                         B3200
      IF (RECH(IX,IY).NE.0.0) WRITE (6,980) IX,IY                       B3210
      IF (REC(IX,IY).NE.0.0) WRITE (6,990) IX,IY                        B3220
  430 IF (PERM(IX,IY).GT.0.0) GO TO 440                                 B3230
      IF (NODEID(IX,IY).GT.0.0) WRITE (6,1000) IX,IY                    B3240
      IF (WT(IX,IY).NE.0.0) WRITE (6,1010) IX,IY                        B3250
      IF (RECH(IX,IY).NE.0.0) WRITE (6,1020) IX,IY                      B3260
      IF (REC(IX,IY).NE.0.0) WRITE (6,1030) IX,IY                       B3270
      IF (THCK(IX,IY).GT.0.0) WRITE (6,1040) IX,IY                      B3280
  440 CONTINUE                                                          B3290
C     ******************************************************************B3300
      RETURN                                                            B3310
C     ******************************************************************B3320
C                                                                       B3330
C                                                                       B3340
C                                                                       B3350
  450 FORMAT (1H1,20HITERATION PARAMETERS)                              B3360
  460 FORMAT (3H   ,1G20.6)                                             B3370
  470 FORMAT (1H1,27HTIME INTERVALS (IN SECONDS))                       B3380
  480 FORMAT (1H1,15X,17HSTEADY-STATE FLOW//5X,57HTIME INTERVAL (IN SEC)B3390
     1 FOR SOLUTE-TRANSPORT SIMULATION = ,G12.5)                        B3400
  490 FORMAT (3H   ,10G12.5)                                            B3410
  500 FORMAT (3H   ,20F5.1)                                             B3420
  510 FORMAT (1H1,22HAQUIFER THICKNESS (FT))                            B3430
  520 FORMAT (3H   ,20F5.2)                                             B3440
  530 FORMAT (1H1,30HTRANSMISSIVITY MAP (FT*FT/SEC))                    B3450
  540 FORMAT (20G3.0)                                                   B3460
  550 FORMAT (I1,G10.0)                                                 B3470
  560 FORMAT (20G4.1)                                                   B3480
  570 FORMAT (1H1,23HNODE IDENTIFICATION MAP//)                         B3490
  580 FORMAT (1H ,20I5)                                                 B3500
  590 FORMAT (1H1,45HVERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC)))     B3510
  600 FORMAT (1H0,10X,12HX-Y SPACING:)                                  B3520
  610 FORMAT (1H ,12X,10G12.5)                                          B3530
  620 FORMAT (1H1,24HPERMEABILTY MAP (FT/SEC))                          B3540
  630 FORMAT (1H0,////10X,44HNO. OF FINITE-DIFFERENCE CELLS IN AQUIFER = B3550
     1 ,I4//10X,28HAREA OF AQUIFER IN MODEL  = ,G12.5,10H   SQ. FT.////1B3560
     20X,47HNZCRIT   (MAX. NO. OF CELLS THAT CAN BE VOID OF/20X,56HPARTI B3570
```

FORTRAN IV program listing—Continued

```
     3CLES;  IF EXCEEDED, PARTICLES ARE REGENERATED)    = ,I4/)                B3580
  640 FORMAT (20I1)                                                           B3590
  650 FORMAT (3H    ,20F5.3)                                                  B3600
  660 FORMAT (20G4.0)                                                         B3610
  670 FORMAT (1H1,11HWATER TABLE)                                             B3620
  680 FORMAT (1H ,20F5.0)                                                     B3630
  690 FORMAT (1HO,10X,19HAREA OF ONE CELL = ,G12.4)                           B3640
  700 FORMAT (2I2)                                                            B3650
  710 FORMAT (2I2,2G8.2)                                                      B3660
  720 FORMAT (10A8)                                                           B3670
  730 FORMAT (1HO,10A8)                                                       B3680
  740 FORMAT (17I4)                                                           B3690
  750 FORMAT (1H1,77HU.S.G.S. METHOD-OF-CHARACTERISTICS MODEL FOR SOLUTE      B3700
     1 TRANSPORT IN GROUND WATER)                                             B3710
  760 FORMAT (1HO,21X,21HI N P U T     D A T A)                               B3720
  770 FORMAT (1HO,23X,16HGRID DESCRIPTORS//13X,30HNX     (NUMBER OF COLUM    B3730
     1NS) =  ,I4/13X,28HNY     (NUMBER OF ROWS)      =,I6/13X,29HXDEL  (X    B3740
     2-DISTANCE IN FEET) = ,F7.1/13X,29HYDEL  (Y-DISTANCE IN FEET) = ,F7     B3750
     3.1)                                                                     B3760
  780 FORMAT (1HO,23X,16HTIME  PARAMETERS//13X,40HNTIM   (MAX. NO. OF TI     B3770
     1ME STEPS)       = ,I6/13X,40HNPMP   (NO. OF PUMPING PERIODS)          B3780
     2 = ,I6/13X,39HPINT    (PUMPING PERIOD IN YEARS)      =,F10.2/13X,39    B3790
     3HTIMX    (TIME INCREMENT MULTIPLIER)    =,F10.2/13X,39HTINIT  (INIT    B3800
     4IAL TIME STEP IN SEC.)     =,F8.0)                                      B3810
  790 FORMAT (1HO,14X,34HHYDROLOGIC AND CHEMICAL PARAMETERS//13X,1HS,7X,     B3820
     129H(STORAGE COEFFICIENT)       =,5X,F9.6/13X,28HPOROS   (EFFECTIVE     B3830
     2 POROSITY),8X,3H=  ,F8.2/13X,39HBETA     (CHARACTERISTIC LENGTH)      B3840
     3  =  ,F7.1/13X,31HDLTRAT  (RATIO OF TRANSVERSE TO/21X,30HLONGITUDI     B3850
     4NAL DISPERSIVITY)  = ,F9.2/13X,39HANFCTR  (RATIO OF T-YY TO T-XX)      B3860
     5    =  ,F12.6)                                                         B3870
  800 FORMAT (12G5.0)                                                         B3880
  810 FORMAT (1H ,16X,I2,5X,I2,4X,I2)                                         B3890
  820 FORMAT (1H ,7X,2I4,3X,F7.2,5X,F7.1)                                     B3900
  830 FORMAT (1H1,39HDIFFUSE RECHARGE AND DISCHARGE (FT/SEC))                 B3910
  840 FORMAT (1H ,1P10E10.2)                                                  B3920
  850 FORMAT (I2,3G10.2,I2)                                                   B3930
  860 FORMAT (1HO,7X,I2,7X,E10.3,5X,F9.2)                                     B3940
  870 FORMAT (1HO,21X,20HEXECUTION PARAMETERS//13X,39HNITP   (NO. OF ITE     B3950
     1RATION PARAMETERS) = ,I4/13X,39HTOL    (CONVERGENCE CRITERIA - ADI     B3960
     2P) = ,F9.4/13X,39HITMAX  (MAX.NO.OF ITERATIONS - ADIP) = ,I4/13X,3     B3970
     34HCELDIS (MAX.CELL DISTANCE PER MOVE/24X,28HOF PARTICLES - M.O.C.)     B3980
     4    = ,F8.3/13X,30HNPMAX  (MAX. NO. OF PARTICLES),7X,2H= ,I4/12X,3     B3990
     52H NPTPND (NO. PARTICLES PER NODE),6X,3H=  ,I4)                         B4000
  880 FORMAT (1HO,5X,47H*** WARNING ***  NPTPND MUST EQUAL 4,5,8, OR 9.)      B4010
  890 FORMAT (1HO,23X,15HPROGRAM OPTIONS//13X,30HNPNT   (TIME STEP INTER     B4020
     1VAL FOR/21X,18HCOMPLETE PRINTOUT),7X,3H=  ,I4/13X,31HNPNTMV (MOVE      B4030
     2INTERVAL FOR CHEM./21X,28HCONCENTRATION PRINTOUT)  =  ,I4/13X,29HN     B4040
     3PNTVL (PRINT OPTION-VELOCITY/21X,24HO=NO; 1=FIRST TIME STEP;/21X,1     B4050
     47H2=ALL TIME STEPS),8X,3H=  ,I4/13X,31HNPNTD  (PRINT OPTION-DISP.C     B4060
     5OEF./21X,24HO=NO; 1=FIRST TIME STEP;/21X,17H2=ALL TIME STEPS),8X,3     B4070
     6H=  ,I4/13X,32HNUMOBS (NO. OF OBSERVATION WELLS/21X,28HFOR HYDROGR     B4080
     7APH PRINTOUT) =  ,I4/13X,35HNREC   (NO. OF PUMPING WELLS)    = ,I5     B4090
     8/13X,24HNCODES (FOR NODE IDENT.),9X,2H= ,I5/13X,25HNPNCHV (PUNCH V     B4100
     9ELOCITIES),8X,2H= ,I5/13X,36HNPDELC (PRINT OPT.-CONC. CHANGE) =  ,     B4110
     $I4)                                                                     B4120
  900 FORMAT (1HO,10X,29HLOCATION OF OBSERVATION WELLS//17X,3HNO.,5X,1HX     B4130
     1,5X,1HY/)                                                               B4140
  910 FORMAT (1HO,10X,28HLOCATION  OF  PUMPING  WELLS//11X,28HX    Y    RA    B4150
     1TE(IN CFS)   CONC./)                                                    B4160
  920 FORMAT (1HO,5X,37HNO. OF NODE IDENT. CODES SPECIFIED = ,I2)             B4170
  930 FORMAT (1HO,10X,41HTHE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:/5X,51     B4180
     1HCODE NO.     LEAKANCE     SOURCE CONC.     RECHARGE)                   B4190
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FORTRAN IV program listing—Continued

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  940 FORMAT (1H ,5X,61H*** WARNING ***    THCK.EQ.0.0 AND TMRX(X).GT.0.0   B4200
     1 AT NODE IX =,I4,6H, IY =,I4)                                        B4210
  950 FORMAT (1H ,5X,61H*** WARNING ***    THCK.EQ.0.0 AND TMRX(Y).GT.0.0   B4220
     1 AT NODE IX =,I4,6H, IY =,I4)                                        B4230
  960 FORMAT (1H ,5X,61H*** WARNING ***     THCK.EQ.0.0 AND NODEID.GT.0.0   B4240
     1 AT NODE IX =,I4,6H, IY =,I4)                                        B4250
  970 FORMAT (1H ,5X,56H*** WARNING ***    THCK.EQ.0.0 AND WT.NE.0.0 AT N   B4260
     1ODE IX =,I4,6H, IY =,I4)                                             B4270
  980 FORMAT (1H ,5X,58H*** WARNING ***    THCK.EQ.0.0 AND RECH.NE.0.0 AT   B4280
     1 NODE IX =,I4,6H, IY =,I4)                                           B4290
  990 FORMAT (1H ,5X,58H*** WARNING ***     THCK.EQ.0.0 AND REC.NE.0.0 AT   B4300
     1 NODE IX =,I4,6H, IY =,I4)                                           B4310
 1000 FORMAT (1H ,5X,61H*** WARNING ***     PERM.EQ.0.0 AND NODEID.GT.0.0   B4320
     1 AT NODE IX =,I4,6H, IY =,I4)                                        B4330
 1010 FORMAT (1H ,5X,56H*** WARNING ***    PERM.EQ.0.0 AND WT.NE.0.0 AT N   B4340
     1ODE IX =,I4,6H, IY =,I4)                                             B4350
 1020 FORMAT (1H ,5X,58H*** WARNING ***    PERM.EQ.0.0 AND RECH.NE.0.0 AT   B4360
     1 NODE IX =,I4,6H, IY =,I4)                                           B4370
 1030 FORMAT (1H ,5X,58H*** WARNING ***     PERM.EQ.0.0 AND REC.NE.0.0 AT   B4380
     1 NODE IX =,I4,6H, IY =,I4)                                           B4390
 1040 FORMAT (1H ,5X,58H*** WARNING ***    PERM.EQ.0.0 AND THCK.GT.0.0 AT   B4400
     1 NODE IX =,I4,6H, IY =,I4)                                           B4410
 1050 FORMAT (1HO,5X,45H*** WARNING ***    ANFCTR WAS SPECIFIED AS 0.0/23   B4420
     1X,34HDEFAULT ACTION: RESET ANFCTR = 1.0)                             B4430
 1060 FORMAT (I1)                                                          B4440
 1070 FORMAT (10I4,3G5.0)                                                  B4450
 1080 FORMAT (1H1,5X,25HSTART PUMPING PERIOD NO. ,I2//2X,75HTHE FOLLOWIN   B4460
     1G TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:/)    B4470
 1090 FORMAT (1HC,14X,9HNTIM    = ,I4/15X,9HNPNT    = ,I4/15X,9HNITP    = ,  B4480
     1I4/15X,9HITMAX  = ,I4/15X,9HNREC    = ,I4/15X,9HNPNTMV = ,I4/15X,9H   B4490
     2NPNTVL = ,I4/15X,9HNPNTD  = ,I4/15X,9HNPDELC = ,I4/15X,9HNPNCHV =     B4500
     3,I4/15X,9HPINT    = ,F10.3/15X,9HTIMX    = ,F10.3/15X,9HTINIT  = ,F1  B4510
     40.3/)                                                                B4520
 1100 FORMAT (1H ,46X,E10.3)                                               B4530
      END                                                                  B4540-
      SUBROUTINE ITERAT                                                    C  10
      DOUBLE PRECISION DMIN1,DEXP,DLOG,DABS                                C  20
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE              C  30
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR        C  40
      REAL *8B,G,W,A,C,E,F,DR,DC,TBAR,TMK,COEF,BLH,BRK,CHK,QL,BRH          C  50
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO   C  60
     1BS,NMOV,IMCV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N   C  70
     2PNCHV,NPDELC                                                         C  80
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB   C  90
     1S(5)                                                                 C 100
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR    C 110
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,   C 120
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T   C 130
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR      C 140
      COMMON /BALM/ TOTLQ                                                  C 150
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                               C 160
      DIMENSION W(20), B(20), G(20)                                        C 170
C     ********************************************************************* C 180
      KOUNT=0                                                              C 190
C     ---COMPUTE ROW AND COLUMN---                                         C 200
C        ---CALL NEW ITERATION PARAMETER---                                C 210
   10 REMN=MOD(KOUNT,NITP)                                                 C 220
      IF (REMN.EQ.0) NTH=0                                                 C 230
      NTH=NTH+1                                                            C 240
      PARAM=AOPT(NTH)                                                      C 250
C     ********************************************************************* C 260
C     ---ROW COMPUTATIONS---                                               C 270
```

FORTRAN IV program listing—Continued

```
      TEST=0.0                                                                C 280
      RHO=S/TIM(N)                                                            C 290
      BRK=-RHO                                                                C 300
      DO 50 IY=1,NY                                                           C 310
      DO 20 M=1,NX                                                            C 320
      W(M)=0.0                                                                C 330
      B(M)=0.0                                                                C 340
      G(M)=0.0                                                                C 350
   20 CONTINUE                                                                C 360
      DO 30 IX=1,NX                                                           C 370
      IF (THCK(IX,IY).EQ.0.0) GO TO 30                                        C 380
      COEF=VPRM(IX,IY)                                                        C 390
      QL=-COEF*WT(IX,IY)                                                      C 400
      A=TMRX(IX-1,IY,1)*DXINV                                                 C 410
      C=TMRX(IX,IY,1)*DXINV                                                   C 420
      E=TMRX(IX,IY-1,2)*DYINV                                                 C 430
      F=TMRX(IX,IY,2)*DYINV                                                   C 440
      TBAR=A+C+E+F                                                            C 450
      TMK=TBAR*PARAM                                                          C 460
      BLH=-A-C-RHO-COEF-TMK                                                   C 470
      BRH=E+F-TMK                                                             C 480
      DR=BRH*HC(IX,IY)+BRK*HK(IX,IY)-E*HC(IX,IY-1)-F*HC(IX,IY+1)+QL+RECH      C 490
     1(IX,IY)+REC(IX,IY)*ARINV                                                C 500
      W(IX)=BLH-A*B(IX-1)                                                     C 510
      B(IX)=C/W(IX)                                                           C 520
      G(IX)=(DR-A*G(IX-1))/W(IX)                                              C 530
   30 CONTINUE                                                                C 540
C                                                                             C 550
C        ---BACK SUBSTITUTION---                                              C 560
      DO 40 J=2,NX                                                            C 570
      IJ=J-1                                                                  C 580
      IS=NX-IJ                                                                C 590
   40 HR(IS,IY)=G(IS)-B(IS)*HR(IS+1,IY)                                       C 600
   50 CONTINUE                                                                C 610
C     ************************************************************************C 620
C     ---COLUMN COMPUTATIONS---                                               C 630
      DO 90 IX=1,NX                                                           C 640
      DO 60 M=1,NY                                                            C 650
      W(M)=0.0                                                                C 660
      B(M)=0.0                                                                C 670
   60 G(M)=0.0                                                                C 680
      DO 70 IY=1,NY                                                           C 690
      IF (THCK(IX,IY).EQ.0.0) GO TO 70                                        C 700
      COEF=VPRM(IX,IY)                                                        C 710
      QL=-COEF*WT(IX,IY)                                                      C 720
      A=TMRX(IX,IY-1,2)*DYINV                                                 C 730
      C=TMRX(IX,IY,2)*DYINV                                                   C 740
      E=TMRX(IX-1,IY,1)*DXINV                                                 C 750
      F=TMRX(IX,IY,1)*DXINV                                                   C 760
      TBAR=A+C+E+F                                                            C 770
      TMK=TBAR*PARAM                                                          C 780
      BLH=-A-C-RHO-COEF-TMK                                                   C 790
      BRH=E+F-TMK                                                             C 800
      DC=BRH*HR(IX,IY)+BRK*HK(IX,IY)-E*HR(IX-1,IY)-F*HR(IX+1,IY)+QL+RECH      C 810
     1(IX,IY)+REC(IX,IY)*ARINV                                                C 820
      W(IY)=BLH-A*B(IY-1)                                                     C 830
      B(IY)=C/W(IY)                                                           C 840
      G(IY)=(DC-A*G(IY-1))/W(IY)                                              C 850
   70 CONTINUE                                                                C 860
C                                                                             C 870
C        ---BACK SUBSTITUTION---                                              C 880
      DO 80 J=2,NY                                                            C 890
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FORTRAN IV program listing—Continued

```
      IJ=J-1                                                                C 900
      IB=NY-IJ                                                              C 910
      HC(IX,IB)=G(IB)-B(IB)*HC(IX,IB+1)                                     C 920
      IF (THCK(IX,IB).EQ.0.0) GO TO 80                                      C 930
      CHK=DABS(HC(IX,IB)-HR(IX,IB))                                         C 940
      IF (CHK.GT.TOL) TEST=1.0                                              C 950
   80 CONTINUE                                                              C 960
   90 CONTINUE                                                              C 970
C     ******************************************************************    C 980
      KOUNT=KOUNT+1                                                         C 990
      IF (TEST.EQ.0.0) GO TO 120                                            C1000
      IF (KOUNT.GE.ITMAX) GO TO 100                                         C1010
      GO TO 10                                                              C1020
C     ******************************************************************    C1030
C     ---TERMINATE PROGRAM -- ITMAX EXCEEDED---                             C1040
  100 WRITE (6,160)                                                         C1050
      DO 110 IX=1,NX                                                        C1060
      DO 110 IY=1,NY                                                        C1070
  110 HK(IX,IY)=HC(IX,IY)                                                   C1080
      CALL OUTPT                                                            C1090
      STOP                                                                  C1100
C     ******************************************************************    C1110
C     ---SET NEW HEAD (HK)---                                               C1120
  120 DO 130 IY=1,NY                                                        C1130
      DO 130 IX=1,NX                                                        C1140
      IF (THCK(IX,IY).EQ.0.0) GO TO 130                                     C1150
      HR(IX,IY)=HK(IX,IY)                                                   C1160
      HK(IX,IY)=HC(IX,IY)                                                   C1170
C                                                                           C1180
C     ---COMPUTE LEAKAGE FOR MASS BALANCE---                                C1190
      IF (VPRM(IX,IY).EQ.0.0) GO TO 130                                     C1200
      DELQ=VPRM(IX,IY)*AREA*(WT(IX,IY)-HK(IX,IY))                           C1210
      TOTLQ=TOTLQ+DELQ*TIM(N)                                               C1220
  130 CONTINUE                                                              C1230
C                                                                           C1240
      WRITE (6,140) N                                                       C1250
      WRITE (6,150) KOUNT                                                   C1260
C     ******************************************************************    C1270
      RETURN                                                                C1280
C     ******************************************************************    C1290
C                                                                           C1300
C                                                                           C1310
C                                                                           C1320
  140 FORMAT (1HC//3X,4HN = ,I14)                                           C1330
  150 FORMAT (1H ,2X,23HNUMBER OF ITERATIONS = ,I14)                        C1340
  160 FORMAT (1HO,5X,64H***   EXECUTION TERMINATED -- MAX. NO. ITERATION    C1350
     1S EXCEEDED   ***/26X,21HFINAL OUTPUT FOLLOWS:)                        C1360
      END                                                                   C1370-
      SUBROUTINE GENPT                                                      D  10
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE               D  20
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR         D  30
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO    D  40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N    D  50
     2PNCHV,NPDELC                                                          D  60
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB    D  70
     1S(5)                                                                  D  80
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR     D  90
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,    D 100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T    D 110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       D 120
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,    D 130
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM    D 140
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FORTRAN IV program listing—Continued

```
      2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM                D 150
       DIMENSION RP(8), RN(8), IPT(8)                                       D 160
C      ********************************************************************  D 170
       F1=0.30                                                              D 180
       F2=1.0/3.0                                                           D 190
       IF (NPTPND.EQ.4) F1=0.25                                             D 200
       IF (NPTPND.EQ.9) F1=1.0/3.0                                          D 210
       IF (NPTPND.EQ.8) F2=0.25                                             D 220
       NCHK=NPTPND                                                          D 230
       IF (NPTPND.EQ.5.OR.NPTPND.EQ.9) NCHK=NPTPND-1                        D 240
       IF (TEST.GT.98.) GO TO 10                                            D 250
C      ********************************************************************  D 260
C      ---INITIALIZE VALUES---                                              D 270
       STORM=0.0                                                            D 280
       CMSIN=0.0                                                            D 290
       CMSOUT=0.0                                                           D 300
       FLMIN=0.0                                                            D 310
       FLMOT=0.0                                                            D 320
       SUMIO=0.0                                                            D 330
C      ********************************************************************  D 340
   10  DO 20 ID=1,3                                                         D 350
       DO 20 IN=1,NPMAX                                                     D 360
   20  PART(ID,IN)=0.0                                                      D 370
       DO 30 IA=1,8                                                         D 380
       RP(IA)=0.0                                                           D 390
       RN(IA)=0.0                                                           D 400
   30  IPT(IA)=0                                                            D 410
C      ---SET UP LIMBO ARRAY---                                             D 420
       DO 40 IN=1,500                                                       D 430
   40  LIMBO(IN)=0.0                                                        D 440
       IND=1                                                                D 450
       DO 50 IL=1,500,2                                                     D 460
       LIMBO(IL)=IND                                                        D 470
   50  IND=IND+1                                                            D 480
C      ********************************************************************  D 490
C      ---INSERT PARTICLES---                                               D 500
       DO 410 IX=1,NX                                                       D 510
       DO 410 IY=1,NY                                                       D 520
       IF (THCK(IX,IY).EQ.0.0) GO TO 410                                    D 530
       KR=0                                                                 D 540
       TEST2=0.0                                                            D 550
       METH=1                                                               D 560
       NPCELL(IX,IY)=0                                                      D 570
       C1=CONC(IX,IY)                                                       D 580
       IF (C1.LE.1.0E-05) TEST2=1.0                                         D 590
       IF (VPRM(IX,IY).GT.0.09) TEST2=1.0                                   D 600
       IF (REC(IX,IY).NE.0.0) TEST2=1.0                                     D 610
       IF (THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX+1,IY-1).EQ.0.0.OR.THCK(IX-1,   D 620
      1IY+1).EQ.0.0.OR.THCK(IX-1,IY-1).EQ.0.0) TEST2=1.0                    D 630
       IF ((THCK(IX,IY+1).EQ.0.0.OR.THCK(IX,IY-1).EQ.0.0.OR.THCK(IX+1,IY)   D 640
      1.EQ.0.0.OR.THCK(IX-1,IY).EQ.0.0).AND.NPTPND.GT.5) TEST2=1.0          D 650
       CNODE=C1*(1.0-F1)                                                    D 660
       IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 70                           D 670
       SUMC=CONC(IX+1,IY)+CONC(IX-1,IY)+CONC(IX,IY+1)+CONC(IX,IY-1)         D 680
       IF (NCHK.EQ.4) GO TO 60                                              D 690
       SUMC=SUMC+CONC(IX+1,IY+1)+CONC(IX+1,IY-1)+CONC(IX-1,IY+1)+CONC(IX-   D 700
      11,IY-1)                                                              D 710
   60  AVC=SUMC/NCHK                                                        D 720
       IF (AVC.GT.C1) METH=2                                                D 730
C                                                                           D 740
C         ---PUT 4 PARTICLES ON CELL DIAGONALS---                           D 750
   70  DO 140 IT=1,2                                                        D 760
```

FORTRAN IV program listing—Continued

```
      EVET=(-1.0)**IT                                                    D 770
      DO 140 IS=1,2                                                      D 780
      EVES=(-1.0)**IS                                                    D 790
      PART(1,IND)=IX+F1*EVET                                             D 800
      PART(2,IND)=IY+F1*EVES                                             D 810
      PART(2,IND)=-PART(2,IND)                                           D 820
      PART(3,IND)=C1                                                     D 830
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 130                        D 840
      IXD=IX+EVET                                                        D 850
      IYD=IY+EVES                                                        D 860
      KR=KR+1                                                            D 870
      IPT(KR)=IND                                                        D 880
      IF (METH.EQ.2) GO TO 80                                            D 890
      PART(3,IND)=CNODE+CONC(IXD,IYD)*F1                                 D 900
      GO TO 90                                                           D 910
   80 PART(3,IND)=2.0*C1*CONC(IXD,IYD)/(C1+CONC(IXD,IYD))                D 920
   90 IF (C1-CONC(IXD,IYD)) 100,110,120                                  D 930
  100 RP(KR)=CONC(IXD,IYD)-PART(3,IND)                                   D 940
      RN(KR)=C1-PART(3,IND)                                              D 950
      GO TO 130                                                          D 960
  110 RP(KR)=0.0                                                         D 970
      RN(KR)=0.0                                                         D 980
      GO TO 130                                                          D 990
  120 RP(KR)=C1-PART(3,IND)                                              D1000
      RN(KR)=CONC(IXD,IYD)-PART(3,IND)                                   D1010
  130 IND=IND+1                                                          D1020
  140 CONTINUE                                                           D1030
C                                                                        D1040
      IF (NPTPND.EQ.5.OR.NPTPND.EQ.9) GO TO 150                          D1050
      GO TO 160                                                          D1060
C        ---PUT ONE PARTICLE AT CENTER OF CELL---                        D1070
  150 PART(1,IND)=-IX                                                    D1080
      PART(2,IND)=-IY                                                    D1090
      PART(3,IND)=C1                                                     D1100
      IND=IND+1                                                          D1110
C        ---PLACE NORTH, SOUTH, EAST, AND WEST PARTICLES---              D1120
  160 IF (NPTPND.LT.8) GO TO 290                                         D1130
      CNODE=C1*(1.0-F2)                                                  D1140
      DO 280 IT=1,2                                                      D1150
      EVET=(-1.0)**IT                                                    D1160
      PART(1,IND)=IX+F2*EVET                                             D1170
      PART(2,IND)=-IY                                                    D1180
      PART(3,IND)=C1                                                     D1190
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 220                        D1200
      IXD=IX+EVET                                                        D1210
      KR=KR+1                                                            D1220
      IPT(KR)=IND                                                        D1230
      IF (METH.EQ.2) GO TO 170                                           D1240
      PART(3,IND)=CNODE+CONC(IXD,IY)*F2                                  D1250
      GO TO 180                                                          D1260
  170 PART(3,IND)=2.0*C1*CONC(IXD,IY)/(C1+CONC(IXD,IY))                  D1270
  180 IF (C1-CONC(IXD,IY)) 190,200,210                                   D1280
  190 RP(KR)=CONC(IXD,IY)-PART(3,IND)                                    D1290
      RN(KR)=C1-PART(3,IND)                                              D1300
      GO TO 220                                                          D1310
  200 RP(KR)=0.0                                                         D1320
      RN(KR)=0.0                                                         D1330
      GO TO 220                                                          D1340
  210 RP(KR)=C1-PART(3,IND)                                              D1350
      RN(KR)=CONC(IXD,IY)-PART(3,IND)                                    D1360
  220 IND=IND+1                                                          D1370
      PART(1,IND)=IX                                                     D1380
```

FORTRAN IV program listing—Continued

```
      PART(2,IND)=IY+F2*EVET                                          D1390
      PART(2,IND)=-PART(2,IND)                                        D1400
      PART(3,IND)=C1                                                  D1410
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 280                     D1420
      IYD=IY+EVET                                                     D1430
      KR=KR+1                                                         D1440
      IPT(KR)=IND                                                     D1450
      IF (METH.EQ.2) GO TO 230                                        D1460
      PART(3,IND)=CNODE+CONC(IX,IYD)*F2                               D1470
      GO TO 240                                                       D1480
  230 PART(3,IND)=2.0*C1*CONC(IX,IYD)/(C1+CONC(IX,IYD))               D1490
  240 IF (C1-CONC(IX,IYD)) 250,260,270                                D1500
  250 RP(KR)=CONC(IX,IYD)-PART(3,IND)                                 D1510
      RN(KR)=C1-PART(3,IND)                                           D1520
      GO TO 280                                                       D1530
  260 RP(KR)=0.0                                                      D1540
      RN(KR)=0.0                                                      D1550
      GO TO 280                                                       D1560
  270 RP(KR)=C1-PART(3,IND)                                           D1570
      RN(KR)=CONC(IX,IYD)-PART(3,IND)                                 D1580
  280 IND=IND+1                                                       D1590
C                                                                     D1600
  290 IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 410                     D1610
      SUMPT=0.0                                                       D1620
C        ---COMPUTE CONC. GRADIENT WITHIN CELL---                     D1630
      DO 300 KPT=1,NCHK                                               D1640
      IK=IPT(KPT)                                                     D1650
  300 SUMPT=PART(3,IK)+SUMPT                                          D1660
      CBAR=SUMPT/NCHK                                                 D1670
C        ---CHECK MASS BALANCE WITHIN CELL AND ADJUST PT. CONCS.---   D1680
      SUMPT=0.0                                                       D1690
      IF (CBAR-C1) 310,410,330                                        D1700
  310 CRCT=1.0-(CBAR/C1)                                              D1710
      IF (METH.EQ.1) CRCT=CBAR/C1                                     D1720
      DO 320 KPT=1,NCHK                                               D1730
      IK=IPT(KPT)                                                     D1740
      PART(3,IK)=PART(3,IK)+RP(KPT)*CRCT                              D1750
  320 SUMPT=SUMPT+PART(3,IK)                                          D1760
      CBARN=SUMPT/NCHK                                                D1770
      GO TO 350                                                       D1780
  330 CRCT=1.0-(C1/CBAR)                                              D1790
      IF (METH.EQ.1) CRCT=C1/CBAR                                     D1800
      DO 340 KPT=1,NCHK                                               D1810
      IK=IPT(KPT)                                                     D1820
      PART(3,IK)=PART(3,IK)+RN(KPT)*CRCT                              D1830
  340 SUMPT=SUMPT+PART(3,IK)                                          D1840
      CBARN=SUMPT/NCHK                                                D1850
  350 IF (CBARN.EQ.C1) GO TO 410                                      D1860
C        ---CORRECT FOR OVERCOMPENSATION---                           D1870
      CRCT=C1/CBARN                                                   D1880
      DO 380 KPT=1,NCHK                                               D1890
      IK=IPT(KPT)                                                     D1900
      PART(3,IK)=PART(3,IK)*CRCT                                      D1910
C        ---CHECK CONSTRAINTS---                                      D1920
      IF (PART(3,IK)-C1) 360,380,370                                  D1930
  360 CLIM=C1-RP(KPT)+RN(KPT)                                         D1940
      IF (PART(3,IK).LT.CLIM) GO TO 390                               D1950
      GO TO 380                                                       D1960
  370 CLIM=C1+RP(KPT)-RN(KPT)                                         D1970
      IF (PART(3,IK).GT.CLIM) GO TO 390                               D1980
  380 CONTINUE                                                        D1990
      GO TO 410                                                       D2000
```

FORTRAN IV program listing—Continued

```
  390 TEST2=1.0                                                                  D2010
      DO 400 KPT=1,NCHK                                                          D2020
      IK=IPT(KPT)                                                                D2030
  400 PART(3,IK)=C1                                                              D2040
  410 CONTINUE                                                                   D2050
      NP=IND                                                                     D2060
      IF (INT.EQ.0) CALL CHMOT                                                   D2070
C     ******************************************************************       D2080
      RETURN                                                                     D2090
C     ******************************************************************       D2100
      END                                                                        D2110-
      SUBROUTINE VELO                                                            E  10
      DOUBLE PRECISION DMIN1,DEXP,DLOG,DABS                                      E  20
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE                    E  30
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR              E  40
      REAL *8RATE,SLEAK,DIV                                                      E  50
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO         E  60
     1BS,NMOV,IMCV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N         E  70
     2PNCHV,NPDELC                                                               E  80
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB         E  90
     1S(5)                                                                       E 100
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR          E 110
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,         E 120
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T         E 130
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR            E 140
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                                     E 150
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,         E 160
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM         E 170
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM                      E 180
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)                        E 190
      COMMON /DIFUS/ DISP(20,20,4)                                               E 200
C     ******************************************************************       E 210
C     ---COMPUTE VELOCITIES AND STORE---                                         E 220
      VMAX=1.0E-10                                                               E 230
      VMAY=1.0E-10                                                               E 240
      VMXBD=1.0E-10                                                              E 250
      VMYBD=1.0E-10                                                              E 260
      TMV=TIM(N)                                                                 E 270
      LIM=0                                                                      E 280
C                                                                                E 290
      DO 20 IX=1,NX                                                              E 300
      DO 20 IY=1,NY                                                              E 310
      DO 10 IZ=1,4                                                               E 320
   10 DISP(IX,IY,IZ)=0.0                                                         E 330
C                                                                                E 340
      IF (THCK(IX,IY).EQ.0.0) GO TO 20                                           E 350
      RATE=REC(IX,IY)/AREA                                                       E 360
      SLEAK=(HK(IX,IY)-WT(IX,IY))*VPRM(IX,IY)                                    E 370
      DIV=RATE+SLEAK+RECH(IX,IY)                                                 E 380
C                                                                                E 390
C        ---VELOCITIES AT NODES---                                               E 400
C           ---X-DIRECTION---                                                    E 410
      GRDX=(HK(IX-1,IY)-HK(IX+1,IY))*DXINV*0.50                                  E 420
      IF (THCK(IX-1,IY).EQ.0.0) GRDX=(HK(IX,IY)-HK(IX+1,IY))*DXINV               E 430
      IF (THCK(IX+1,IY).EQ.0.0) GRDX=(HK(IX-1,IY)-HK(IX,IY))*DXINV               E 440
      IF (THCK(IX-1,IY).EQ.0.0.AND.THCK(IX+1,IY).EQ.0.0) GRDX=0.0                E 450
      VX(IX,IY)=PERM(IX,IY)*GRDX*PORINV                                          E 460
      ABVX=ABS(VX(IX,IY))                                                        E 470
      IF (ABVX.GT.VMAX) VMAX=ABVX                                                E 480
C           ---Y-DIRECTION---                                                    E 490
      GRDY=(HK(IX,IY-1)-HK(IX,IY+1))*DYINV*0.50                                  E 500
      IF (THCK(IX,IY-1).EQ.0.0) GRDY=(HK(IX,IY)-HK(IX,IY+1))*DYINV               E 510
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FORTRAN IV program listing—Continued

```
      IF (THCK(IX,IY+1).EQ.0.0) GRDY=(HK(IX,IY-1)-HK(IX,IY))*DYINV          E 520
      IF (THCK(IX,IY-1).EQ.0.0.AND.THCK(IX,IY+1).EQ.0.0) GRDY=0.0           E 530
      VY(IX,IY)=PERM(IX,IY)*GRDY*PORINV*ANFCTR                              E 540
      ABVY=ABS(VY(IX,IY))                                                   E 550
      IF (ABVY.GT.VMAY) VMAY=ABVY                                           E 560
C                                                                           E 570
C        ---VELOCITIES AT CELL BOUNDARIES---                                E 580
      GRDX=(HK(IX,IY)-HK(IX+1,IY))*DXINV                                    E 590
      PERMX=2.0*PERM(IX,IY)*PERM(IX+1,IY)/(PERM(IX,IY)+PERM(IX+1,IY))       E 600
      VXBDY(IX,IY)=PERMX*GRDX*PORINV                                        E 610
      GRDY=(HK(IX,IY)-HK(IX,IY+1))*DYINV                                    E 620
      PERMY=2.0*PERM(IX,IY)*PERM(IX,IY+1)/(PERM(IX,IY)+PERM(IX,IY+1))       E 630
      VYBDY(IX,IY)=PERMY*GRDY*PORINV*ANFCTR                                 E 640
      ABVX=ABS(VXBDY(IX,IY))                                                E 650
      ABVY=ABS(VYBDY(IX,IY))                                                E 660
      IF (ABVX.GT.VMXBD) VMXBD=ABVX                                         E 670
      IF (ABVY.GT.VMYBD) VMYBD=ABVY                                         E 680
C                                                                           E 690
      IF (DIV.GE.0.0) GO TO 20                                              E 700
      TDIV=(POROS*THCK(IX,IY))/DABS(DIV)                                    E 710
      IF (TDIV.LT.TMV) TMV=TDIV                                             E 720
   20 CONTINUE                                                              E 730
C     ***************************************************************       E 740
C     ---PRINT VELOCITIES---                                                E 750
      IF (NPNTVL.EQ.0) GO TO 80                                             E 760
      IF (NPNTVL.EQ.2) GO TO 30                                             E 770
      IF (NPNTVL.EQ.1.AND.N.EQ.1) GO TO 30                                  E 780
      GO TO 80                                                              E 790
   30 WRITE (6,320)                                                         E 800
      WRITE (6,330)                                                         E 810
      DO 40 IY=1,NY                                                         E 820
   40 WRITE (6,350) (VX(IX,IY),IX=1,NX)                                     E 830
      WRITE (6,340)                                                         E 840
      DO 50 IY=1,NY                                                         E 850
   50 WRITE (6,350) (VXBDY(IX,IY),IX=1,NX)                                  E 860
      WRITE (6,360)                                                         E 870
      WRITE (6,330)                                                         E 880
      DO 60 IY=1,NY                                                         E 890
   60 WRITE (6,350) (VY(IX,IY),IX=1,NX)                                     E 900
      WRITE (6,340)                                                         E 910
      DO 70 IY=1,NY                                                         E 920
   70 WRITE (6,350) (VYBDY(IX,IY),IX=1,NX)                                  E 930
C     ---PUNCH VELOCITIES---                                                E 940
   80 IF (NPNCHV.EQ.0) GO TO 110                                            E 950
      IF (NPNCHV.EQ.2) GO TO 90                                             E 960
      IF (NPNCHV.EQ.1.AND.N.EQ.1) GO TO 90                                  E 970
      GO TO 110                                                             E 980
   90 WRITE (7,510) NX,NY,XDEL,YDEL,VMAX,VMAY                               E 990
      DO 100 IY=1,NY                                                       E1000
      WRITE (7,520) (VX(IX,IY),IX=1,NX)                                    E1010
  100 WRITE (7,520) (VY(IX,IY),IX=1,NX)                                    E1020
C     ***************************************************************      E1030
C     ---COMPUTE NEXT TIME STEP---                                         E1040
  110 WRITE (6,390)                                                        E1050
      WRITE (6,400) VMAX,VMAY                                              E1060
      WRITE (6,410) VMXBD,VMYBD                                            E1070
      TDELX=CELDIS*XDEL/VMAX                                               E1080
      TDELY=CELDIS*YDEL/VMAY                                               E1090
      TDELXB=CELDIS*XDEL/VMXBD                                             E1100
      TDELYB=CELDIS*YDEL/VMYBD                                             E1110
      TIMV=AMIN1(TDELX,TDELY,TDELXB,TDELYB)                                E1120
      WRITE (6,310) TMV,TIMV                                               E1130
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FORTRAN IV program listing—Continued

```
      IF (TMV.LT.TIMV) GO TO 120                                          E1140
      LIM=-1                                                              E1150
      GO TO 130                                                           E1160
  120 TIMV=TMV                                                            E1170
      LIM=1                                                               E1180
  130 NTIMV=TIM(N)/TIMV                                                   E1190
      NMOV=NTIMV+1                                                        E1200
      WRITE (6,420) TIMV,NTIMV,NMOV                                       E1210
      TIMV=TIM(N)/NMOV                                                    E1220
      WRITE (6,370) TIM(N)                                                E1230
      WRITE (6,380) TIMV                                                  E1240
C                                                                         E1250
      IF (BETA.EQ.0.0) GO TO 200                                          E1260
C     ******************************************************************  E1270
C     ---COMPUTE DISPERSION COEFFICIENTS---                               E1280
      ALPHA=BETA                                                          E1290
      ALNG=ALPHA                                                          E1300
      TRAN=DLTRAT*ALPHA                                                   E1310
      XX2=XDEL*XDEL                                                       E1320
      YY2=YDEL*YDEL                                                       E1330
      XY2=4.0*XDEL*YDEL                                                   E1340
      DO 150 IX=2,NNX                                                     E1350
      DO 150 IY=2,NNY                                                     E1360
      IF (THCK(IX,IY).EQ.0.0) GO TO 150                                   E1370
      VXE=VXBDY(IX,IY)                                                    E1380
      VYS=VYBDY(IX,IY)                                                    E1390
      IF (THCK(IX+1,IY).EQ.0.0) GO TO 140                                 E1400
C        ---FORWARD COEFFICIENTS: X-DIRECTION---                          E1410
      VYE=(VYBDY(IX,IY-1)+VYBDY(IX+1,IY-1)+VYS+VYBDY(IX+1,IY))/4.0        E1420
      VXE2=VXE*VXE                                                        E1430
      VYE2=VYE*VYE                                                        E1440
      VMGE=SQRT(VXE2+VYE2)                                                E1450
      IF (VMGE.LT.1.0E-20) GO TO 140                                      E1460
      DALN=ALNG*VMGE                                                      E1470
      DTRN=TRAN*VMGE                                                      E1480
      VMGE2=VMGE*VMGE                                                     E1490
C           ---XX COEFFICIENT---                                          E1500
      DISP(IX,IY,1)=(DALN*VXE2+DTRN*VYE2)/(VMGE2*XX2)                     E1510
C           ---XY COEFFICIENT---                                          E1520
      DISP(IX,IY,3)=(DALN-DTRN)*VXE*VYE/(VMGE2*XY2)                       E1530
C        ---FORWARD COEFFICIENTS: Y-DIRECTION---                          E1540
  140 IF (THCK(IX,IY+1).EQ.0.0) GO TO 150                                 E1550
      VXS=(VXBDY(IX-1,IY)+VXE+VXBDY(IX-1,IY+1)+VXBDY(IX,IY+1))/4.0        E1560
      VYS2=VYS*VYS                                                        E1570
      VXS2=VXS*VXS                                                        E1580
      VMGS=SQRT(VXS2+VYS2)                                                E1590
      IF (VMGS.LT.1.0E-20) GO TO 150                                      E1600
      DALN=ALNG*VMGS                                                      E1610
      DTRN=TRAN*VMGS                                                      E1620
      VMGS2=VMGS*VMGS                                                     E1630
C           ---YY COEFFICIENT---                                          E1640
      DISP(IX,IY,2)=(DALN*VYS2+DTRN*VXS2)/(VMGS2*YY2)                     E1650
C           ---YX COEFFICIENT---                                          E1660
      DISP(IX,IY,4)=(DALN-DTRN)*VXS*VYS/(VMGS2*XY2)                       E1670
  150 CONTINUE                                                            E1680
C     ******************************************************************  E1690
C     ---ADJUST CROSS-PRODUCT TERMS FOR ZERO THICKNESS---                 E1700
      DO 160 IX=2,NNX                                                     E1710
      DO 160 IY=2,NNY                                                     E1720
      IF (THCK(IX,IY+1).EQ.0.0.OR.THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX,IY-1  E1730
     1).EQ.0.0.OR.THCK(IX+1,IY-1).EQ.0.0) DISP(IX,IY,3)=0.0               E1740
      IF (THCK(IX+1,IY).EQ.0.0.OR.THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX-1,IY  E1750
```

FORTRAN IV program listing—Continued

```
     1).EQ.0.0.OR.THCK(IX-1,IY+1).EQ.0.0) DISP(IX,IY,4)=0.0                E1760
  160 CONTINUE                                                             E1770
C     ******************************************************************  E1780
C     ---CHECK FOR STABILITY OF EXPLICIT METHOD---                        E1790
      TIMDIS=0.0                                                           E1800
      DO 170 IX=2,NNX                                                      E1810
      DO 170 IY=2,NNY                                                      E1820
      TDCO=DISP(IX,IY,1)+DISP(IX,IY,2)                                     E1830
  170 IF (TDCO.GT.TIMDIS) TIMDIS=TDCO                                      E1840
      TIMDC=0.5/TIMDIS                                                     E1850
      WRITE (6,440) TIMDC                                                  E1860
      NTIMD=TIM(N)/TIMDC                                                   E1870
      NDISP=NTIMD+1                                                        E1880
      IF (NDISP.LE.NMOV) GO TO 180                                         E1890
      NMOV=NDISP                                                           E1900
      TIMV=TIM(N)/NMOV                                                     E1910
      LIM=0                                                                E1920
  180 WRITE (6,430) TIMV,NTIMD,NMOV                                        E1930
C     ******************************************************************  E1940
C     ---ADJUST DISP. EQUATION COEFFICIENTS FOR SATURATED THICKNESS---     E1950
      DO 190 IX=2,NNX                                                      E1960
      DO 190 IY=2,NNY                                                      E1970
      BAVX=0.5*(THCK(IX,IY)+THCK(IX+1,IY))                                 E1980
      BAVY=0.5*(THCK(IX,IY)+THCK(IX,IY+1))                                 E1990
      DISP(IX,IY,1)=DISP(IX,IY,1)*BAVX                                     E2000
      DISP(IX,IY,2)=DISP(IX,IY,2)*BAVY                                     E2010
      DISP(IX,IY,3)=DISP(IX,IY,3)*BAVX                                     E2020
  190 DISP(IX,IY,4)=DISP(IX,IY,4)*BAVY                                     E2030
C     ******************************************************************  E2040
  200 IF (LIM) 210,220,230                                                 E2050
  210 WRITE (6,530)                                                        E2060
      GO TO 240                                                            E2070
  220 WRITE (6,540)                                                        E2080
      GO TO 240                                                            E2090
  230 WRITE (6,550)                                                        E2100
C     ******************************************************************  E2110
C     ---PRINT DISPERSION EQUATION COEFFICIENTS---                        E2120
  240 IF (NPNTD.EQ.0) GO TO 300                                            E2130
      IF (NPNTD.EQ.2) GO TO 250                                            E2140
      IF (NPNTD.EQ.1.AND.N.EQ.1) GO TO 250                                 E2150
      GO TO 300                                                            E2160
  250 WRITE (6,450)                                                        E2170
      WRITE (6,460)                                                        E2180
      DO 260 IY=1,NY                                                       E2190
  260 WRITE (6,500) (DISP(IX,IY,1),IX=1,NX)                                E2200
      WRITE (6,470)                                                        E2210
      DO 270 IY=1,NY                                                       E2220
  270 WRITE (6,500) (DISP(IX,IY,2),IX=1,NX)                                E2230
      WRITE (6,480)                                                        E2240
      DO 280 IY=1,NY                                                       E2250
  280 WRITE (6,500) (DISP(IX,IY,3),IX=1,NX)                                E2260
      WRITE (6,490)                                                        E2270
      DO 290 IY=1,NY                                                       E2280
  290 WRITE (6,500) (DISP(IX,IY,4),IX=1,NX)                                E2290
C     ******************************************************************  E2300
  300 RETURN                                                               E2310
C     ******************************************************************  E2320
C                                                                          E2330
C                                                                          E2340
C                                                                          E2350
  310 FORMAT (1H ,19H TMV (MAX. INJ.) = ,G12.5/20H  TIMV (CELDIS)    = ,G  E2360
     112.5)                                                                E2370
```

FORTRAN IV program listing—Continued

```
  320 FORMAT (1H1,12HX VELOCITIES)                                          E2380
  330 FORMAT (1H ,25X,8HAT NODES/)                                          E2390
  340 FORMAT (1HO,25X,13HON BOUNDARIES/)                                    E2400
  350 FORMAT (1H ,10G12.3)                                                  E2410
  360 FORMAT (1H1,12HY VELOCITIES)                                          E2420
  370 FORMAT (3H   ,11HTIM (N)  = ,1G12.5)                                  E2430
  380 FORMAT (3H   ,11HTIMEVELO = ,1G12.5)                                  E2440
  390 FORMAT (1H1,10X,29HSTABILITY CRITERIA --- M.O.C.//)                    E2450
  400 FORMAT (1HO,8H VMAX = ,1PE9.2,5X,7HVMAY = ,1PE9.2)                    E2460
  410 FORMAT (1H ,8H VMXBD= ,1PE9.2,5X,7HVMYBD= ,1PE9.2)                    E2470
  420 FORMAT (1HO,8H TIMV = ,1PE9.2,5X,8HNTIMV = ,I5,5X,7HNMOV = ,I5/)      E2480
  430 FORMAT (1HO,8H TIMV = ,1PE9.2,5X,8HNTIMD = ,I5,5X,7HNMOV = ,I5)       E2490
  440 FORMAT (3H   ,11HTIMEDISP = ,1E12.5)                                  E2500
  450 FORMAT (1H1,32HDISPERSION EQUATION COEFFICIENTS,10X,25H=(D-IJ)*(B)    E2510
     1/(GRID FACTOR))                                                       E2520
  460 FORMAT (1H ,35X,14HXX COEFFICIENT/)                                   E2530
  470 FORMAT (1H ,35X,14HYY COEFFICIENT/)                                   E2540
  480 FORMAT (1H ,35X,14HXY COEFFICIENT/)                                   E2550
  490 FORMAT (1H ,35X,14HYX COEFFICIENT/)                                   E2560
  500 FORMAT (1H ,1P10E8.1)                                                 E2570
  510 FORMAT (2I4,2F10.1,2F10.7)                                            E2580
  520 FORMAT (8F10.7)                                                       E2590
  530 FORMAT (1HO,10X,42HTHE LIMITING STABILITY CRITERION IS CELDIS)        E2600
  540 FORMAT (1HC,10X,40HTHE LIMITING STABILITY CRITERION IS BETA)          E2610
  550 FORMAT (1HO,10X,58HTHE LIMITING STABILITY CRITERION IS MAXIMUM INJ    E2620
     1ECTION RATE)                                                          E2630
      END                                                                   E2640-
      SUBROUTINE MOVE                                                       F  10
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE               F  20
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR         F  30
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO    F  40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N    F  50
     2PNCHV,NPDELC                                                          F  60
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB    F  70
     1S(5)                                                                  F  80
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR     F  90
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,    F 100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T    F 110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       F 120
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                                F 130
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,    F 140
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM    F 150
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM                 F 160
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)                   F 170
      DIMENSION XNEW(4), YNEW(4), DIST(4)                                   F 180
C     ****************************************************************    F 190
      WRITE (6,680) NMOV                                                    F 200
      SUMTCH=SUMT-TIM(N)                                                    F 210
      F1=0.249                                                              F 220
      IF (NPTPND.EQ.5) F1=0.299                                             F 230
      IF (NPTPND.EQ.9) F1=0.333                                             F 240
      CONST1=TIMV*DXINV                                                     F 250
      CONST2=TIMV*DYINV                                                     F 260
C     ---MOVE PARTICLES 'NMOV' TIMES---                                     F 270
      DO 650 IMOV=1,NMOV                                                    F 280
   10 NPTM=NP                                                               F 290
C        ---MOVE EACH PARTICLE---                                           F 300
      DO 590 IN=1,NP                                                        F 310
      IF (PART(1,IN).EQ.0.0) GO TO 590                                      F 320
      KFLAG=0                                                               F 330
C     ****************************************************************    F 340
C           ---COMPUTE OLD LOCATION---                                      F 350
```

FORTRAN IV program listing—Continued

```
      JFLAG=1                                                                F 360
      IF (PART(1,IN).GT.0.0) GO TO 20                                        F 370
      JFLAG=-1                                                               F 380
      PART(1,IN)=-PART(1,IN)                                                 F 390
   20 XOLD=PART(1,IN)                                                        F 400
      IX=XOLD+0.5                                                            F 410
      IFLAG=1                                                                F 420
      IF (PART(2,IN).GE.0.0) GO TO 30                                        F 430
      IFLAG=-1                                                               F 440
      PART(2,IN)=-PART(2,IN)                                                 F 450
   30 YOLD=PART(2,IN)                                                        F 460
      IY=YOLD+0.5                                                            F 470
      IF (THCK(IX,IY).EQ.0.0) GO TO 560                                      F 480
C     ***************************************************************      F 490
C           ---COMPUTE NEW LOCATION AND LOCATE CLOSEST NODE---               F 500
C           ---LOCATE NORTHWEST CORNER---                                    F 510
      IVX=XOLD                                                               F 520
      IVY=YOLD                                                               F 530
      IXE=IVX+1                                                              F 540
      IYS=IVY+1                                                              F 550
C     ***************************************************************      F 560
C        ---LOCATE QUADRANT, VEL. AT 4 CORNERS, CHECK FOR BOUNDARIES---      F 570
      CELDX=XOLD-IX                                                          F 580
      CELDY=YOLD-IY                                                          F 590
      IF (CELDX.EQ.0.0.AND.CELDY.EQ.0.0) GO TO 280                           F 600
      IF (CELDX.GE.0.0.OR.CELDY.GE.0.0) GO TO 70                             F 610
C              ---PT. IN NW QUADRANT---                                      F 620
      VXNW=VXBDY(IVX,IVY)                                                    F 630
      VXNE=VX(IXE,IVY)                                                       F 640
      VXSW=VXBDY(IVX,IYS)                                                    F 650
      VXSE=VX(IXE,IYS)                                                       F 660
      VYNW=VYBDY(IVX,IVY)                                                    F 670
      VYNE=VYBDY(IXE,IVY)                                                    F 680
      VYSW=VY(IVX,IYS)                                                       F 690
      VYSE=VY(IXE,IYS)                                                       F 700
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 50                                     F 710
      IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LT.0.09) GO TO 40            F 720
      VXNE=VXNW                                                              F 730
   40 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LT.0.09) GO TO 50            F 740
      VYSW=VYNW                                                              F 750
   50 IF (REC(IXE,IYS).EQ.0.0.AND.VPRM(IXE,IYS).LT.0.09) GO TO 270           F 760
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 60                                     F 770
      VXSE=VXSW                                                              F 780
   60 IF (THCK(IXE,IVY).EQ.0.0) GO TO 270                                    F 790
      VYSE=VYNE                                                              F 800
      GO TO 270                                                              F 810
C                                                                            F 820
   70 IF (CELDX.LE.0.0.OR.CELDY.GE.0.0) GO TO 130                            F 830
C              ---PT. IN NE QUADRANT---                                      F 840
   80 VXNW=VX(IVX,IVY)                                                       F 850
      VXNE=VXBDY(IVX,IVY)                                                    F 860
      VXSW=VX(IVX,IYS)                                                       F 870
      VXSE=VXBDY(IVX,IYS)                                                    F 880
      VYNW=VYBDY(IVX,IVY)                                                    F 890
      VYNE=VYBDY(IXE,IVY)                                                    F 900
      VYSW=VY(IVX,IYS)                                                       F 910
      VYSE=VY(IXE,IYS)                                                       F 920
      IF (CELDX.EQ.0.0) GO TO 120                                            F 930
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 100                                    F 940
      IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LT.0.09) GO TO 90            F 950
      VXNW=VXNE                                                              F 960
   90 IF (REC(IXE,IYS).EQ.0.0.AND.VPRM(IXE,IYS).LT.0.09) GO TO 100           F 970
```

FORTRAN IV program listing—Continued

```
      VYSE=VYNE                                                          F 980
  100 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LT.0.09) GO TO 270       F 990
      IF (THCK(IXE,IYS).EQ.0.0) GO TO 110                                F1000
      VXSW=VXSE                                                          F1010
  110 IF (THCK(IVX,IVY).EQ.0.0) GO TO 270                                F1020
      VYSW=VYNW                                                          F1030
      GO TO 270                                                          F1040
  120 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LE.0.09) GO TO 270       F1050
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 270                                F1060
      VYSW=VYNW                                                          F1070
      GO TO 270                                                          F1080
C                                                                        F1090
  130 IF (CELDY.LE.0.0.OR.CELDX.GE.0.0) GO TO 190                        F1100
C               ---PT. IN SW QUADRANT---                                 F1110
  140 VXNW=VXBDY(IVX,IVY)                                                F1120
      VXNE=VX(IXE,IVY)                                                   F1130
      VXSW=VXBDY(IVX,IYS)                                                F1140
      VXSE=VX(IXE,IYS)                                                   F1150
      VYNW=VY(IVX,IVY)                                                   F1160
      VYNE=VY(IXE,IVY)                                                   F1170
      VYSW=VYBDY(IVX,IVY)                                                F1180
      VYSE=VYBDY(IXE,IVY)                                                F1190
      IF (CELDY.EQ.0.0) GO TO 180                                        F1200
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 160                                F1210
      IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LT.0.09) GO TO 150       F1220
      VYNW=VYSW                                                          F1230
  150 IF (REC(IXE,IYS).EQ.0.0.AND.VPRM(IXE,IYS).LT.0.09) GO TO 160       F1240
      VXSE=VXSW                                                          F1250
  160 IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LT.0.09) GO TO 270       F1260
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 170                                F1270
      VXNE=VXNW                                                          F1280
  170 IF (THCK(IXE,IYS).EQ.0.0) GO TO 270                                F1290
      VYNE=VYSE                                                          F1300
      GO TO 270                                                          F1310
  180 IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LE.0.09) GO TO 270       F1320
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 270                                F1330
      VXNE=VXNW                                                          F1340
      GO TO 270                                                          F1350
C                                                                        F1360
  190 IF (CELDY.LE.0.0.OR.CELDX.LE.0.0) GO TO 260                        F1370
C               ---PT. IN SE QUADRANT---                                 F1380
  200 VXNW=VX(IVX,IVY)                                                   F1390
      VXNE=VXBDY(IVX,IVY)                                                F1400
      VXSW=VX(IVX,IYS)                                                   F1410
      VXSE=VXBDY(IVX,IYS)                                                F1420
      VYNW=VY(IVX,IVY)                                                   F1430
      VYNE=VY(IXE,IVY)                                                   F1440
      VYSW=VYBDY(IVX,IVY)                                                F1450
      VYSE=VYBDY(IXE,IVY)                                                F1460
      IF (CELDY.EQ.0.0) GO TO 240                                        F1470
      IF (CELDX.EQ.0.0) GO TO 250                                        F1480
      IF (THCK(IXE,IYS).EQ.0.0) GO TO 220                                F1490
      IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LT.0.09) GO TO 210       F1500
      VYNE=VYSE                                                          F1510
  210 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LT.0.09) GO TO 220       F1520
      VXSW=VXSE                                                          F1530
  220 IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LT.0.09) GO TO 270       F1540
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 230                                F1550
      VXNW=VXNE                                                          F1560
  230 IF (THCK(IVX,IYS).EQ.0.0) GO TO 270                                F1570
      VYNW=VYSW                                                          F1580
      GO TO 270                                                          F1590
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FORTRAN IV program listing—Continued

```
  240 IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LE.0.09) GO TO 270        F1600
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 270                                 F1610
      VXNW=VXNE                                                           F1620
      GO TO 270                                                           F1630
  250 IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LE.0.09) GO TO 270        F1640
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 270                                 F1650
      VYNW=VYSW                                                           F1660
      GO TO 270                                                           F1670
C                                                                         F1680
  260 IF (CELDX.EQ.0.0.AND.CELDY.LT.0.0) GO TO 80                         F1690
      IF (CELDX.LT.0.0.AND.CELDY.EQ.0.0) GO TO 140                        F1700
      IF (CELDX.GT.0.0.AND.CELDY.EQ.0.0) GO TO 200                        F1710
      IF (CELDX.EQ.0.0.AND.CELDY.GT.0.0) GO TO 200                        F1720
      WRITE (6,690) IN,IX,IY                                              F1730
  270 CONTINUE                                                            F1740
C     ******************************************************************  F1750
C        ---BILINEAR INTERPOLATION---                                     F1760
      CELXD=XOLD-IVX                                                      F1770
      CELDXH=AMOD(CELXD,0.5)                                              F1780
      CELDX=CELDXH*2.0                                                    F1790
      CELDY=YOLD-IVY                                                      F1800
C     ******************************************************************  F1810
C           ---X VELOCITY---                                              F1820
      VXN=VXNW*(1.0-CELDX)+VXNE*CELDX                                     F1830
      IF (THCK(IVX,IVY).EQ.0.0.OR.THCK(IXE,IVY).EQ.0.0) VXN=VXNW+VXNE     F1840
      VXS=VXSW*(1.0-CELDX)+VXSE*CELDX                                     F1850
      IF (THCK(IVX,IYS).EQ.0.0.OR.THCK(IXE,IYS).EQ.0.0) VXS=VXSW+VXSE     F1860
      XVEL=VXN*(1.0-CELDY)+VXS*CELDY                                      F1870
      IF (THCK(IVX,IVY).EQ.0.0.AND.THCK(IXE,IVY).EQ.0.0) XVEL=VXS         F1880
      IF (THCK(IVX,IYS).EQ.0.0.AND.THCK(IXE,IYS).EQ.0.0) XVEL=VXN         F1890
C           ---Y VELOCITY---                                              F1900
      CELDYH=AMOD(CELDY,0.5)                                              F1910
      CELDY=CELDYH*2.0                                                    F1920
      VYW=VYNW*(1.0-CELDY)+VYSW*CELDY                                     F1930
      IF (THCK(IVX,IVY).EQ.0.0.OR.THCK(IVX,IYS).EQ.0.0) VYW=VYNW+VYSW     F1940
      VYE=VYNE*(1.0-CELDY)+VYSE*CELDY                                     F1950
      IF (THCK(IXE,IVY).EQ.0.0.OR.THCK(IXE,IYS).EQ.0.0) VYE=VYNE+VYSE     F1960
      YVEL=VYW*(1.0-CELXD)+VYE*CELXD                                      F1970
      IF (THCK(IVX,IVY).EQ.0.0.AND.THCK(IVX,IYS).EQ.0.0) YVEL=VYE         F1980
      IF (THCK(IXE,IVY).EQ.0.0.AND.THCK(IXE,IYS).EQ.0.0) YVEL=VYW         F1990
C                                                                         F2000
      GO TO 290                                                           F2010
  280 XVEL=VX(IX,IY)                                                      F2020
      YVEL=VY(IX,IY)                                                      F2030
  290 DISTX=XVEL*CONST1                                                   F2040
      DISTY=YVEL*CONST2                                                   F2050
C     ******************************************************************  F2060
C        ---BOUNDARY CONDITIONS---                                        F2070
      TEMPX=XOLD+DISTX                                                    F2080
      TEMPY=YOLD+DISTY                                                    F2090
      INX=TEMPX+0.5                                                       F2100
      INY=TEMPY+0.5                                                       F2110
      IF (THCK(INX,INY).GT.0.0) GO TO 330                                 F2120
C     ******************************************************************  F2130
C           ---X BOUNDARY---                                              F2140
      IF (THCK(INX,IY).EQ.0.0) GO TO 300                                  F2150
      PART(1,IN)=TEMPX                                                    F2160
      GO TO 310                                                           F2170
  300 BEYON=TEMPX-IX                                                      F2180
      IF (BEYON.LT.0.0) BEYON=BEYON+0.5                                   F2190
      IF (BEYON.GT.0.0) BEYON=BEYON-0.5                                   F2200
      PART(1,IN)=TEMPX-2.0*BEYON                                          F2210
```

FORTRAN IV program listing—Continued

```
      INX=PART(1,IN)+0.5                                                F2220
      TEMPX=PART(1,IN)                                                  F2230
C     ******************************************************************F2240
C           ---Y BOUNDARY---                                            F2250
  310 IF (THCK(INX,INY).EQ.0.0) GO TO 320                               F2260
      PART(2,IN)=TEMPY                                                  F2270
      GO TO 340                                                         F2280
C     ******************************************************************F2290
  320 BEYON=TEMPY-IY                                                    F2300
      IF (BEYON.LT.0.0) BEYON=BEYON+0.5                                 F2310
      IF (BEYON.GT.0.0) BEYON=BEYON-0.5                                 F2320
      PART(2,IN)=TEMPY-2.0*BEYON                                        F2330
      INY=PART(2,IN)+0.5                                                F2340
      TEMPY=PART(2,IN)                                                  F2350
      GO TO 340                                                         F2360
  330 PART(1,IN)=TEMPX                                                  F2370
      PART(2,IN)=TEMPY                                                  F2380
  340 CONTINUE                                                          F2390
C     ******************************************************************F2400
C        ---SUM CONCENTRATIONS AND COUNT PARTICLES---                   F2410
      SUMC(INX,INY)=SUMC(INX,INY)+PART(3,IN)                            F2420
      NPCELL(INX,INY)=NPCELL(INX,INY)+1                                 F2430
C     ******************************************************************F2440
C        ---CHECK FOR CHANGE IN CELL LOCATION---                        F2450
      IF (IX.EQ.INX.AND.IY.EQ.INY) GO TO 580                            F2460
C           ---CHECK FOR CONST.-HEAD BDY. OR SOURCE AT OLD LOCATION---  F2470
      IF (REC(IX,IY).LT.0.0) GO TO 350                                  F2480
      IF (REC(IX,IY).GT.0.0) GO TO 360                                  F2490
      IF (VPRM(IX,IY).LT.0.09) GO TO 540                                F2500
      IF (WT(IX,IY).GT.HK(IX,IY)) GO TO 350                             F2510
      IF (WT(IX,IY).LT.HK(IX,IY)) GO TO 360                             F2520
      GO TO 540                                                         F2530
C     ******************************************************************F2540
C           ---CREATE NEW PARTICLES AT BOUNDARIES---                    F2550
  350 IF (IFLAG.GT.0) GO TO 550                                         F2560
      KFLAG=1                                                           F2570
  360 DO 370 IL=1,500                                                   F2580
      IF (LIMBO(IL).EQ.0) GO TO 370                                     F2590
      IP=LIMBO(IL)                                                      F2600
      IF (IP.LT.IN) GO TO 380                                           F2610
  370 CONTINUE                                                          F2620
C     ******************************************************************F2630
C           ---GENERATE NEW PARTICLE---                                 F2640
      IF (NPTM.EQ.NPMAX) GO TO 600                                      F2650
      NPTM=NPTM+1                                                       F2660
      IP=NPTM                                                           F2670
      GO TO 390                                                         F2680
  380 LIMBO(IL)=0                                                       F2690
C                                                                       F2700
  390 IF (KFLAG.EQ.0) GO TO 520                                         F2710
      IF (THCK(IX+1,IY).EQ.0.0.OR.THCK(IX-1,IY).EQ.0.0.OR.THCK(IX,IY+1).  F2720
     1EQ.0.0.OR.THCK(IX,IY-1).EQ.0.0) GO TO 520                         F2730
      IF (THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX+1,IY-1).EQ.0.0.OR.THCK(IX-1,  F2740
     1IY+1).EQ.0.0.OR.THCK(IX-1,IY-1).EQ.0.0) GO TO 520                 F2750
C              ---IF CENTER SOURCE---                                   F2760
      IF (JFLAG.LT.0) GO TO 500                                         F2770
      JJ=4                                                              F2780
      AN=TEMPY-YOLD                                                     F2790
      AD=TEMPX-XOLD                                                     F2800
      DISTMV=SQRT((AD*AD)+(AN*AN))                                      F2810
      IF (AD.EQ.0.0) GO TO 410                                          F2820
      SLOPE=AN/AD                                                       F2830
```

FORTRAN IV program listing—Continued

```
      BI=YOLD-SLOPE*XOLD                                                    F2840
      XC1=IX-F1                                                             F2850
      XC2=IX+F1                                                             F2860
      YC1=IY-F1                                                             F2870
      YC2=IY+F1                                                             F2880
C               ---COMPUTE NEW COORDINATES AND VERIFY---                    F2890
      DO 400 IK=1,4                                                         F2900
      YNEW(IK)=0.0                                                          F2910
      XNEW(IK)=0.0                                                          F2920
  400 DIST(IK)=0.0                                                          F2930
      YNEW(1)=(SLOPE*XC1)+BI                                                F2940
      XNEW(1)=XC1                                                           F2950
      YNEW(2)=(SLOPE*XC2)+BI                                                F2960
      XNEW(2)=XC2                                                           F2970
      IF (SLOPE.EQ.0.0) GO TO 420                                           F2980
      YNEW(3)=YC1                                                           F2990
      XNEW(3)=(YC1-BI)/SLOPE                                                F3000
      YNEW(4)=YC2                                                           F3010
      XNEW(4)=(YC2-BI)/SLOPE                                                F3020
      GO TO 430                                                             F3030
  410 YNEW(1)=IY-F1                                                         F3040
      XNEW(1)=XOLD                                                          F3050
      YNEW(2)=IY+F1                                                         F3060
      XNEW(2)=XOLD                                                          F3070
  420 JJ=2                                                                  F3080
  430 DO 440 II=1,JJ                                                        F3090
  440 DIST(II)=SQRT((XNEW(II)-TEMPX)**2+(YNEW(II)-TEMPY)**2)*1.00001        F3100
      IACC=0                                                                F3110
      DISTCK=2.0                                                            F3120
      DO 460 IG=1,JJ                                                        F3130
      IF (DIST(IG).GE.DISTMV.AND.DIST(IG).LT.DISTCK) GO TO 450              F3140
      GO TO 460                                                             F3150
  450 IXC=XNEW(IG)+0.50                                                     F3160
      IYC=YNEW(IG)+0.50                                                     F3170
      IF (IXC.NE.IX.OR.IYC.NE.IY) GO TO 460                                 F3180
      IACC=IG                                                               F3190
      DISTCK=DIST(IG)                                                       F3200
  460 CONTINUE                                                              F3210
      IF (IACC.LT.1.OR.IACC.GT.4) GO TO 510                                 F3220
      IF (XNEW(IACC).EQ.XC1.OR.XNEW(IACC).EQ.XC2) GO TO 470                 F3230
      IF (YNEW(IACC).EQ.YC1.OR.YNEW(IACC).EQ.YC2) GO TO 480                 F3240
      GO TO 510                                                             F3250
  470 IF (YNEW(IACC).LT.YC1) YNEW(IACC)=YC1                                 F3260
      IF (YNEW(IACC).GT.YC2) YNEW(IACC)=YC2                                 F3270
      GO TO 490                                                             F3280
  480 IF (XNEW(IACC).LT.XC1) XNEW(IACC)=XC1                                 F3290
      IF (XNEW(IACC).GT.XC2) XNEW(IACC)=XC2                                 F3300
  490 PART(1,IP)=XNEW(IACC)                                                 F3310
      PART(2,IP)=YNEW(IACC)                                                 F3320
      GO TO 530                                                             F3330
  500 PART(1,IP)=-IX                                                        F3340
      PART(2,IP)=IY                                                         F3350
      GO TO 530                                                             F3360
  510 PART(1,IP)=XOLD                                                       F3370
      PART(2,IP)=YOLD                                                       F3380
      GO TO 530                                                             F3390
C               ---IF EDGE SOURCE OR SINK---                                F3400
C                  ---X POSITION---                                         F3410
  520 DLX=INX-IX                                                            F3420
      PART(1,IP)=TEMPX-DLX                                                  F3430
C                  ---Y POSITION---                                         F3440
      DLY=INY-IY                                                            F3450
```

FORTRAN IV program listing—Continued

```
      PART(2,IP)=TEMPY-DLY                                                F3460
      IF (KFLAG.GT.0) GO TO 530                                           F3470
C               ---IF SINK---                                             F3480
      SUMC(IX,IY)=SUMC(IX,IY)+CONC(IX,IY)                                 F3490
      NPCELL(IX,IY)=NPCELL(IX,IY)+1                                       F3500
C                                                                         F3510
  530 PART(2,IP)=-PART(2,IP)                                              F3520
      PART(3,IP)=CONC(IX,IY)                                              F3530
      IF (REC(IX,IY).EQ.0.0) GO TO 540                                    F3540
C     ******************************************************************  F3550
C           ---CHECK FOR DISCHARGE BOUNDARY AT NEW LOCATION---            F3560
  540 IFLAG=1.0                                                           F3570
  550 IF (VPRM(INX,INY).GT.0.09.AND.WT(INX,INY).LT.HK(INX,INY)) GO TO 56  F3580
     10                                                                   F3590
      IF (REC(INX,INY).GT.0.0) GO TO 560                                  F3600
      GO TO 590                                                           F3610
C     ******************************************************************  F3620
C           ---PUT PT. IN LIMBO---                                        F3630
  560 PART(1,IN)=0.0                                                      F3640
      PART(2,IN)=0.0                                                      F3650
      PART(3,IN)=0.0                                                      F3660
      DO 570 ID=1,500                                                     F3670
      IF (LIMBO(ID).GT.0) GO TO 570                                       F3680
      LIMBO(ID)=IN                                                        F3690
      GO TO 590                                                           F3700
  570 CONTINUE                                                            F3710
C                                                                         F3720
  580 IF (IFLAG.LT.0) PART(2,IN)=-TEMPY                                   F3730
      IF (JFLAG.LT.0) PART(1,IN)=-TEMPX                                   F3740
  590 CONTINUE                                                            F3750
C     ---END OF LOOP---                                                   F3760
C     ******************************************************************  F3770
      GO TO 620                                                           F3780
C        ---RESTART MOVE IF PT. LIMIT EXCEEDED---                         F3790
  600 WRITE (6,700) IMOV,IN                                               F3800
      TEST=100.0                                                          F3810
      CALL GENPT                                                          F3820
      DO 610 IX=1,NX                                                      F3830
      DO 610 IY=1,NY                                                      F3840
      SUMC(IX,IY)=0.0                                                     F3850
  610 NPCELL(IX,IY)=0                                                     F3860
      TEST=0.0                                                            F3870
      GO TO 10                                                            F3880
C     ******************************************************************  F3890
  620 SUMTCH=SUMTCH+TIMV                                                  F3900
C        ---ADJUST NUMBER OF PARTICLES---                                 F3910
      NP=NPTM                                                             F3920
      WRITE (6,670) NP,IMOV                                               F3930
C     ******************************************************************  F3940
      CALL CNCON                                                          F3950
C     ******************************************************************  F3960
C        ---STORE OBS. WELL DATA FOR STEADY FLOW PROBLEMS---              F3970
      IF (S.GT.0.0) GO TO 640                                             F3980
      IF (NUMOBS.LE.0) GO TO 640                                          F3990
      J=MOD(IMOV,50)                                                      F4000
      IF (J.EQ.0) J=50                                                    F4010
      TMOBS(J)=SUMTCH                                                     F4020
      DO 630 I=1,NUMOBS                                                   F4030
      TMWL(I,J)=HK(IXOBS(I),IYOBS(I))                                     F4040
  630 TMCN(I,J)=CONC(IXOBS(I),IYOBS(I))                                   F4050
C        ---PRINT CHEMICAL OUTPUT---                                      F4060
  640 IF (IMOV.GE.NMOV) GO TO 660                                         F4070
```

FORTRAN IV program listing—Continued

```
  650 IF (MOD(IMOV,NPNTMV).EQ.0.OR.MOD(IMOV,50).EQ.0) CALL CHMOT          F4080
C     ******************************************************************  F4090
  660 RETURN                                                              F4100
C     ******************************************************************  F4110
C                                                                         F4120
C                                                                         F4130
C                                                                         F4140
  670 FORMAT (1HC,2X,2HNP,7X,2H= ,8X,I4,10X,11HIMOV      = ,8X,I4)        F4150
  680 FORMAT (1HO,10X,61HNO. OF PARTICLE MOVES REQUIRED TO COMPLETE THIS  F4160
     1 TIME STEP  = ,I4//)                                                F4170
  690 FORMAT (1HO,5X,53H*** WARNING ***     QUADRANT NOT LOCATED FOR PT.  F4180
     1 NO. ,I5,11H , IN CELL ,2I4)                                        F4190
  700 FORMAT (1HO,5X,17H ***   NOTE   ***,10X,23HNPTM.EQ.NPMAX --- IMOV=   F4200
     1,I4,5X,8HPT. NO.=,I4,5X,10HCALL GENPT/)                             F4210
      END                                                                 F4220-
      SUBROUTINE CNCON                                                    G  10
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE             G  20
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       G  30
      REAL *8FLW                                                          G  40
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO  G  50
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N  G  60
     2PNCHV,NPDELC                                                        G  70
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB  G  80
     1S(5)                                                                G  90
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR   G 100
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,  G 110
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T  G 120
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     G 130
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                              G 140
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,  G 150
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM  G 160
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM               G 170
      COMMON /DIFUS/ DISP(20,20,4)                                        G 180
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)                 G 190
      DIMENSION CNCNC(20,20), CNOLD(20,20)                                G 200
C     ******************************************************************  G 210
      ITEST=0                                                             G 220
      DO 10 IX=1,NX                                                       G 230
      DO 10 IY=1,NY                                                       G 240
      CNOLD(IX,IY)=CONC(IX,IY)                                            G 250
   10 CNCNC(IX,IY)=0.0                                                    G 260
      APC=0.0                                                             G 270
      NZERO=0                                                             G 280
      TVA=AREA*TIMV                                                       G 290
      ARPOR=AREA*POROS                                                    G 300
C     ******************************************************************  G 310
C     ---CONC. CHANGE FOR 0.5*TIMV DUE TO:                                G 320
C           RECHARGE, PUMPING, LEAKAGE, DIVERGENCE OF VELOCITY...         G 330
      CONST=0.5*TIMV                                                      G 340
   20 DO 60 IX=1,NX                                                       G 350
      DO 60 IY=1,NY                                                       G 360
      IF (THCK(IX,IY).EQ.0.0) GO TO 60                                    G 370
      EQFCT1=CONST/THCK(IX,IY)                                            G 380
      EQFCT2=EQFCT1/POROS                                                 G 390
      C1=CONC(IX,IY)                                                      G 400
      CLKCN=0.0                                                           G 410
      SLEAK=(HK(IX,IY)-WT(IX,IY))*VPRM(IX,IY)                            G 420
      IF (SLEAK.LT.0.0) CLKCN=CNRECH(IX,IY)                               G 430
      IF (SLEAK.GT.0.0) CLKCN=C1                                          G 440
      CNREC=C1                                                            G 450
      RATE=REC(IX,IY)*ARINV                                               G 460
      IF (RATE.LT.0.0) CNREC=CNRECH(IX,IY)                                G 470
```

FORTRAN IV program listing—Continued

```
      DIV=RATE+SLEAK+RECH(IX,IY)                                          G 480
      IF (S.EQ.0.0) GO TO 30                                              G 490
      DERH=(HK(IX,IY)-HR(IX,IY))/TIM(N)                                   G 500
      DIV=DIV+S*DERH                                                      G 510
      IF (S.LT.0.005) GO TO 30                                            G 520
C     ...NOTE: ABOVE STATEMENT ASSUMES THAT S=0.005 SEPARATES CONFINED    G 530
C              FROM UNCONFINED CONDITIONS; THIS CRITERION SHOULD BE       G 540
C              CHANGED IF FIELD CONDITIONS ARE DIFFERENT.                 G 550
      DELC=EQFCT2*(C1*(DIV-POROS*DERH)-RATE*CNREC-SLEAK*CLKCN-RECH(IX,IY  G 560
     1)*CNRECH(IX,IY))                                                    G 570
      GO TO 40                                                            G 580
   30 DELC=EQFCT2*(C1*DIV-RATE*CNREC-SLEAK*CLKCN-RECH(IX,IY)*CNRECH(IX,I  G 590
     1Y))                                                                 G 600
   40 CNCNC(IX,IY)=CNCNC(IX,IY)+DELC                                      G 610
C     ---CONC. CHANGE DUE TO DISPERSION FOR 0.5*TIMV---                   G 620
C        ---DISPERSION WITH TENSOR COEFFICIENTS---                        G 630
      IF (BETA.EQ.0.0) GO TO 50                                           G 640
      X1=DISP(IX,IY,1)*(CONC(IX+1,IY)-C1)                                 G 650
      X2=DISP(IX-1,IY,1)*(CONC(IX-1,IY)-C1)                               G 660
      Y1=DISP(IX,IY,2)*(CONC(IX,IY+1)-C1)                                 G 670
      Y2=DISP(IX,IY-1,2)*(CONC(IX,IY-1)-C1)                               G 680
      XX1=DISP(IX,IY,3)*(CONC(IX,IY+1)+CONC(IX+1,IY+1)-CONC(IX,IY-1)-CON  G 690
     1C(IX+1,IY-1))                                                       G 700
      XX2=DISP(IX-1,IY,3)*(CONC(IX,IY+1)+CONC(IX-1,IY+1)-CONC(IX,IY-1)-C  G 710
     1ONC(IX-1,IY-1))                                                     G 720
      YY1=DISP(IX,IY,4)*(CONC(IX+1,IY)+CONC(IX+1,IY+1)-CONC(IX-1,IY)-CON  G 730
     1C(IX-1,IY+1))                                                       G 740
      YY2=DISP(IX,IY-1,4)*(CONC(IX+1,IY)+CONC(IX+1,IY-1)-CONC(IX-1,IY)-C  G 750
     1ONC(IX-1,IY-1))                                                     G 760
   50 CNCNC(IX,IY)=CNCNC(IX,IY)+EQFCT1*(X1+X2+Y1+Y2+XX1-XX2+YY1-YY2)      G 770
   60 CONTINUE                                                            G 780
C     ***************************************************************   G 790
      ITEST=ITEST+1                                                       G 800
      IF (ITEST.EQ.1) GO TO 70                                            G 810
      GO TO 110                                                           G 820
C     ***************************************************************   G 830
C     ---CONC. CHANGE AT NODES DUE TO CONVECTION---                       G 840
   70 DO 90 IX=1,NX                                                       G 850
      DO 90 IY=1,NY                                                       G 860
      IF (THCK(IX,IY).EQ.0.0) GO TO 90                                    G 870
      APC=NPCELL(IX,IY)                                                   G 880
      IF (APC.GT.0.0) GO TO 80                                            G 890
      IF (REC(IX,IY).NE.0.0.OR.VPRM(IX,IY).GT.0.09) GO TO 90              G 900
      NZERO=NZERO+1                                                       G 910
      GO TO 90                                                            G 920
   80 CONC(IX,IY)=SUMC(IX,IY)/APC                                         G 930
   90 CONTINUE                                                            G 940
C        ---CHECK NUMBER OF CELLS VOID OF PTS.---                         G 950
      IF (NZERO.GT.0) WRITE (6,290) NZERO,IMOV                            G 960
      IF (NZERO.LE.NZCRIT) GO TO 20                                       G 970
      TEST=99.0                                                           G 980
      WRITE (6,300)                                                       G 990
      WRITE (6,320)                                                      G1000
      DO 100 IY=1,NY                                                     G1010
  100 WRITE (6,330) (NPCELL(IX,IY),IX=1,NX)                              G1020
      GO TO 20                                                           G1030
C     ***************************************************************   G1040
C     ---CHANGE CONCENTRATIONS AT NODES---                               G1050
  110 DO 130 IX=1,NX                                                     G1060
      DO 130 IY=1,NY                                                     G1070
      IF (THCK(IX,IY).EQ.0.0) GO TO 120                                  G1080
      CONC(IX,IY)=CONC(IX,IY)+CNCNC(IX,IY)                               G1090
```

FORTRAN IV program listing—Continued

```
      NPCELL(IX,IY)=0                                                    G1100
      SUMC(IX,IY)=0.0                                                    G1110
      IF (CONC(IX,IY).LE.0.0) GO TO 130                                  G1120
      CNCPCT=CNCNC(IX,IY)/CONC(IX,IY)                                    G1130
      SUMC(IX,IY)=CNCPCT                                                 G1140
      GO TO 130                                                          G1150
  120 IF (CONC(IX,IY).GT.0.0) WRITE (6,310) IX,IY,CONC(IX,IY)            G1160
      CONC(IX,IY)=0.0                                                    G1170
  130 CONTINUE                                                           G1180
C     ******************************************************************G1190
C     ---CHANGE CONCENTRATION OF PARTICLES---                            G1200
      DO 180 IN=1,NP                                                     G1210
      IF (PART(1,IN).EQ.0.0) GO TO 180                                   G1220
      INX=ABS(PART(1,IN))+0.5                                            G1230
      INY=ABS(PART(2,IN))+0.5                                            G1240
C     ---UPDATE CONC. OF PTS. IN SINK/SOURCE CELLS---                    G1250
      IF (REC(INX,INY).NE.0.0) GO TO 140                                 G1260
      IF (VPRM(INX,INY).LE.0.09) GO TO 150                               G1270
  140 PART(3,IN)=CONC(INX,INY)                                           G1280
      GO TO 180                                                          G1290
  150 IF (CNCNC(INX,INY).LT.0.0) GO TO 170                               G1300
  160 PART(3,IN)=PART(3,IN)+CNCNC(INX,INY)                               G1310
      GO TO 180                                                          G1320
  170 IF (CONC(INX,INY).LE.0.0) GO TO 160                                G1330
      IF (SUMC(INX,INY).LT.-1.0) GO TO 160                               G1340
      PART(3,IN)=PART(3,IN)+PART(3,IN)*SUMC(INX,INY)                     G1350
  180 CONTINUE                                                           G1360
      WRITE (6,280) TIM(N),TIMV,SUMTCH                                   G1370
C     ******************************************************************G1380
C     ---COMPUTE MASS BALANCE FOR SOLUTE---                              G1390
      CSTORM=0.0                                                         G1400
      STORM=0.0                                                          G1410
      DO 270 IX=1,NX                                                     G1420
      DO 270 IY=1,NY                                                     G1430
      IF (THCK(IX,IY).EQ.0.0) GO TO 270                                  G1440
      SUMC(IX,IY)=0.0                                                    G1450
C        ---COMPUTE MASS OF SOLUTE IN STORAGE---                         G1460
      STORM=STORM+CONC(IX,IY)*THCK(IX,IY)*ARPOR                          G1470
C        ---ACCOUNT FOR MASS PUMPED IN, OUT, RECHARGED, & DISCHARGED---  G1480
      IF (REC(IX,IY)) 200,210,190                                        G1490
  190 CMSOUT=CMSOUT+REC(IX,IY)*CNOLD(IX,IY)*TIMV                         G1500
      GO TO 210                                                          G1510
  200 CMSIN=CMSIN+REC(IX,IY)*CNRECH(IX,IY)*TIMV                          G1520
  210 IF (RECH(IX,IY)) 230,240,220                                       G1530
  220 CMSOUT=CMSOUT+RECH(IX,IY)*CNOLD(IX,IY)*TVA                         G1540
      GO TO 240                                                          G1550
  230 CMSIN=CMSIN+RECH(IX,IY)*CNRECH(IX,IY)*TVA                          G1560
C     ******************************************************************G1570
C        ---ACCOUNT FOR BOUNDARY FLOW---                                 G1580
  240 IF (VPRM(IX,IY).EQ.0.0) GO TO 270                                  G1590
      FLW=VPRM(IX,IY)*(WT(IX,IY)-HK(IX,IY))                              G1600
      IF (FLW.GT.0.0) GO TO 250                                          G1610
      IF (FLW.LT.0.0) GO TO 260                                          G1620
      GO TO 270                                                          G1630
C           ---MASS IN BOUNDARY DURING TIME STEP---                      G1640
  250 FLMIN=FLMIN+FLW*CNRECH(IX,IY)*TVA                                  G1650
      GO TO 270                                                          G1660
C           ---MASS OUT DURING TIME STEP---                              G1670
  260 FLMOT=FLMOT+FLW*CNOLD(IX,IY)*TVA                                   G1680
  270 CONTINUE                                                           G1690
C     ******************************************************************G1700
C        ---COMPUTE CHANGE IN MASS OF SOLUTE STORED---                   G1710
```

FORTRAN IV program listing—Continued

```
      CSTORM=STORM-STORMI                                                    G1720
      SUMIO=FLMIN+FLMOT-CMSIN-CMSOUT                                         G1730
C     ***************************************************************      G1740
C     ---REGENERATE PARTICLES IF 'NZCRIT' EXCEEDED---                        G1750
      IF (TEST.GT.98.0) CALL GENPT                                           G1760
      TEST=0.0                                                               G1770
C     ***************************************************************      G1780
      RETURN                                                                 G1790
C     ***************************************************************      G1800
C                                                                            G1810
C                                                                            G1820
C                                                                            G1830
  280 FORMAT (3H   ,11HTIM(N)   = ,1G12.5,10X,11HTIMV     = ,1G12.5,10X,    G1840
     19HSUMTCH = ,G12.5)                                                     G1850
  290 FORMAT (1HO,5X,40HNUMBER OF CELLS WITH ZERO PARTICLES  =  ,I4,5X,9     G1860
     1HIMOV  =  ,I4/)                                                        G1870
  300 FORMAT (1HO,5X,44H***   NZCRIT EXCEEDED  ---  CALL GENPT   ***/)      G1880
  310 FORMAT (1H ,5X,37H***CONC.GT.0.AND.THCK.EQ.0 AT NODE = ,2I4,4X,7HC     G1890
     1ONC = ,G10.4,4H ***)                                                   G1900
  320 FORMAT (1HO,2X,6HNPCELL/)                                              G1910
  330 FORMAT (1H ,4X,20I3)                                                   G1920
      END                                                                    G1930-
      SUBROUTINE OUTPT                                                       H  10
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE                H  20
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR          H  30
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO     H  40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N     H  50
     2PNCHV,NPDELC                                                           H  60
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB     H  70
     1S(5)                                                                   H  80
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR      H  90
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,     H 100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T     H 110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR        H 120
      COMMON /BALM/ TOTLQ                                                    H 130
      DIMENSION IH(20)                                                       H 140
C     ***************************************************************      H 150
      TIMD=SUMT/86400.                                                       H 160
      TIMY=SUMT/(86400.0*365.25)                                             H 170
C     ---PRINT HEAD VALUES---                                                H 180
      WRITE (6,120)                                                          H 190
      WRITE (6,130) N                                                        H 200
      WRITE (6,140) SUMT                                                     H 210
      WRITE (6,150) TIMD                                                     H 220
      WRITE (6,160) TIMY                                                     H 230
      WRITE (6,170)                                                          H 240
      DO 10 IY=1,NY                                                          H 250
   10 WRITE (6,180) (HK(IX,IY),IX=1,NX)                                      H 260
      IF (N.EQ.0) GO TO 110                                                  H 270
C     ***************************************************************      H 280
C     ---PRINT HEAD MAP---                                                   H 290
      WRITE (6,120)                                                          H 300
      WRITE (6,130) N                                                        H 310
      WRITE (6,140) SUMT                                                     H 320
      WRITE (6,150) TIMD                                                     H 330
      WRITE (6,160) TIMY                                                     H 340
      WRITE (6,170)                                                          H 350
      DO 30 IY=1,NY                                                          H 360
      DO 20 IX=1,NX                                                          H 370
   20 IH(IX)=HK(IX,IY)+0.5                                                   H 380
   30 WRITE (6,190) (IH(ID),ID=1,NX)                                         H 390
C     ***************************************************************      H 400
```

FORTRAN IV program listing—Continued

```
C     ---COMPUTE WATER BALANCE AND DRAWDOWN---                          H 410
      QSTR=0.0                                                          H 420
      PUMP=0.0                                                          H 430
      TPUM=0.0                                                          H 440
      QIN=0.0                                                           H 450
      QOUT=0.0                                                          H 460
      QNET=0.0                                                          H 470
      DELQ=0.0                                                          H 480
      JCK=0                                                             H 490
      PCTERR=0.0                                                        H 500
      WRITE (6,290)                                                     H 510
C                                                                       H 520
      DO 80 IY=1,NY                                                     H 530
      DO 70 IX=1,NX                                                     H 540
      IH(IX)=0.0                                                        H 550
      IF (THCK(IX,IY).EQ.0.0) GO TO 70                                  H 560
      TPUM=REC(IX,IY)+RECH(IX,IY)*AREA+TPUM                             H 570
      IF (VPRM(IX,IY).EQ.0.0) GO TO 60                                  H 580
      DELQ=VPRM(IX,IY)*AREA*(WT(IX,IY)-HK(IX,IY))                       H 590
      IF (DELQ.GT.0.0) GO TO 40                                         H 600
      QOUT=QOUT+DELQ                                                    H 610
      GO TO 50                                                          H 620
   40 QIN=QIN+DELQ                                                      H 630
   50 QNET=QNET+DELQ                                                    H 640
   60 DDRW=HI(IX,IY)-HK(IX,IY)                                          H 650
      IH(IX)=DDRW+0.5                                                   H 660
      QSTR=QSTR+DDRW*AREA*S                                             H 670
   70 CONTINUE                                                          H 680
C        ---PRINT DRAWDOWN MAP---                                       H 690
      WRITE (6,300) (IH(IX),IX=1,NX)                                    H 700
   80 CONTINUE                                                          H 710
      PUMP=TPUM*SUMT                                                    H 720
      DELS=-QSTR/SUMT                                                   H 730
      ERRMB=PUMP-TOTLQ-QSTR                                             H 740
      DEN=PUMP+TOTLQ                                                    H 750
      IF (ABS(DEN).EQ.ABS(ERRMB)) JCK=1                                 H 760
      IF (DEN.EQ.0.0) GO TO 100                                         H 770
      IF (JCK.EQ.1) GO TO 90                                            H 780
      PCTERR=ERRMB*200.0/DEN                                            H 790
      GO TO 100                                                         H 800
   90 IF (QIN.EQ.0.0) GO TO 100                                         H 810
      PCTERR=100.0*QNET/QIN                                             H 820
C        ---PRINT MASS BALANCE DATA FOR FLOW MODEL---                   H 830
  100 WRITE (6,240)                                                     H 840
      WRITE (6,250) PUMP                                                H 850
      WRITE (6,230) QSTR                                                H 860
      WRITE (6,260) TOTLQ                                               H 870
      WRITE (6,270) ERRMB                                               H 880
      IF (JCK.EQ.0) WRITE (6,280) PCTERR                                H 890
      WRITE (6,200) QIN,QOUT,QNET                                       H 900
      WRITE (6,210) TPUM                                                H 910
      WRITE (6,220) DELS                                                H 920
      IF (JCK.EQ.1) WRITE (6,280) PCTERR                                H 930
C     ******************************************************************H 940
  110 RETURN                                                            H 950
C     ******************************************************************H 960
C                                                                       H 970
C                                                                       H 980
C                                                                       H 990
  120 FORMAT (1H1,23HHEAD DISTRIBUTION - ROW)                           H1000
  130 FORMAT (1X,23HNUMBER OF TIME STEPS = ,I5)                         H1010
  140 FORMAT (8X,16HTIME(SECONDS) = ,1G12.5)                            H1020
```

FORTRAN IV program listing—Continued

```
  150 FORMAT (8X,16HTIME(DAYS)     = ,1E12.5)                                  H1030
  160 FORMAT (8X,16HTIME(YEARS)    = ,1E12.5)                                  H1040
  170 FORMAT (1H )                                                             H1050
  180 FORMAT (1H0,10F12.7/10F12.7)                                             H1060
  190 FORMAT (1H0,20I4)                                                        H1070
  200 FORMAT (1H0,2X,33HRATE MASS BALANCE -- (IN C.F.S.) //10X,8HQIN  =        H1080
     1 ,G12.5/10X,8HQOUT =  ,G12.5/10X,8HQNET =  ,G12.5/)                      H1090
  210 FORMAT (1H ,17X,8HTPUM =  ,G12.5)                                        H1100
  220 FORMAT (1H ,17X,8HDELS =  ,G12.5/)                                       H1110
  230 FORMAT (4X,29HWATER RELEASE FROM STORAGE = ,1E12.5)                       H1120
  240 FORMAT (1H0,2X,23HCUMULATIVE MASS BALANCE//)                             H1130
  250 FORMAT (4X,29HCUMULATIVE  NET  PUMPAGE   = ,1E12.5)                      H1140
  260 FORMAT (4X,29HCUMULATIVE  NET  LEAKAGE   = ,1E12.5)                      H1150
  270 FORMAT (1H0,7X,25HMASS BALANCE RESIDUAL  = ,G12.5)                       H1160
  280 FORMAT (1H ,7X,25HERROR  (AS PERCENT)    = ,G12.5/)                      H1170
  290 FORMAT (1H1,8HDRAWDOWN)                                                  H1180
  300 FORMAT (3H   ,20I5)                                                      H1190
      END                                                                      H1200-
      SUBROUTINE CHMOT                                                         I  10
      REAL *8TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT,TITLE                  I  20
      REAL *8XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR            I  30
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO       I  40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N       I  50
     2PNCHV,NPDELC                                                            I  60
      COMMON /PRMK/ NODEID(20,20),NPCELL(20,20),LIMBO(500),IXOBS(5),IYOB       I  70
     1S(5)                                                                    I  80
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR        I  90
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,       I 100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T       I 110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR          I 120
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,       I 130
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM       I 140
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM                   I 150
      DIMENSION IC(20)                                                         I 160
C     ****************************************************************       I 170
      TMFY=86400.0*365.25                                                      I 180
      TMYR=SUMT/TMFY                                                           I 190
      TCHD=SUMTCH/86400.0                                                      I 200
      TCHYR=SUMTCH/TMFY                                                        I 210
      IF (IPRNT.GT.0) GO TO 100                                                I 220
C     ****************************************************************       I 230
C     ---PRINT CONCENTRATIONS---                                               I 240
      WRITE (6,160)                                                            I 250
      WRITE (6,170) N                                                          I 260
      IF (N.GT.0) WRITE (6,180) TIM(N)                                         I 270
      WRITE (6,190) SUMT                                                       I 280
      WRITE (6,450) SUMTCH                                                     I 290
      WRITE (6,200) TCHD                                                       I 300
      WRITE (6,210) TMYR                                                       I 310
      WRITE (6,460) TCHYR                                                      I 320
      WRITE (6,380) IMOV                                                       I 330
      WRITE (6,220)                                                            I 340
      DO 20 IY=1,NY                                                            I 350
      DO 10 IX=1,NX                                                            I 360
   10 IC(IX)=CONC(IX,IY)+0.5                                                   I 370
   20 WRITE (6,240) (IC(IX),IX=1,NX)                                           I 380
C     ****************************************************************       I 390
      IF (N.EQ.0) GO TO 150                                                    I 400
      IF (NPDELC.EQ.0) GO TO 50                                                I 410
C                                                                              I 420
C     ---PRINT CHANGES IN CONCENTRATION---                                     I 430
      WRITE (6,230)                                                            I 440
```

FORTRAN IV program listing—Continued

```
      WRITE (6,170) N                                                    I 450
      WRITE (6,180) TIM(N)                                               I 460
      WRITE (6,190) SUMT                                                 I 470
      WRITE (6,450) SUMTCH                                               I 480
      WRITE (6,200) TCHD                                                 I 490
      WRITE (6,210) TMYR                                                 I 500
      WRITE (6,460) TCHYR                                                I 510
      WRITE (6,380) IMOV                                                 I 520
      WRITE (6,220)                                                      I 530
      DO 40 IY=1,NY                                                      I 540
      DO 30 IX=1,NX                                                      I 550
      CNG=CONC(IX,IY)-CONINT(IX,IY)                                      I 560
   30 IC(IX)=CNG                                                         I 570
   40 WRITE (6,240) (IC(IX),IX=1,NX)                                     I 580
C     ******************************************************************I 590
C     ---PRINT MASS BALANCE DATA FOR SOLUTE---                           I 600
   50 RESID=SUMIO-CSTORM                                                 I 610
      IF (SUMIO.EQ.0.0) GO TO 60                                         I 620
      RESID=SUMIO-CSTORM                                                 I 630
      ERR1=RESID*200.0/(SUMIO+CSTORM)                                    I 640
   60 IF (STORMI.EQ.0.0) GO TO 70                                        I 650
      ERR3=-100.0*RESID/(STORMI-SUMIO)                                   I 660
   70 WRITE (6,220)                                                      I 670
      WRITE (6,250)                                                      I 680
      WRITE (6,220)                                                      I 690
      WRITE (6,260) FLMIN                                                I 700
      WRITE (6,270) FLMOT                                                I 710
      RECIN=-CMSIN                                                       I 720
      RECOUT=-CMSOUT                                                     I 730
      WRITE (6,290) RECIN                                                I 740
      WRITE (6,280) RECOUT                                               I 750
      WRITE (6,300) SUMIO                                                I 760
      WRITE (6,310) STORMI                                               I 770
      WRITE (6,320) STORM                                                I 780
      WRITE (6,330) CSTORM                                               I 790
      IF (SUMIO.EQ.0.0) GO TO 80                                         I 800
      WRITE (6,340)                                                      I 810
      WRITE (6,350) RESID                                                I 820
      WRITE (6,360) ERR1                                                 I 830
   80 IF (STORMI.EQ.0.0) GO TO 90                                        I 840
      WRITE (6,370)                                                      I 850
      WRITE (6,360) ERR3                                                 I 860
C     ******************************************************************I 870
C     ---PRINT HYDROGRAPHS AFTER 50 STEPS OR END OF SIMULATION---        I 880
   90 IF (MOD(IMOV,50).EQ.0.AND.S.EQ.0.0) GO TO 100                      I 890
      IF (MOD(N,50).EQ.0.AND.S.GT.0.0) GO TO 100                         I 900
      GO TO 150                                                          I 910
  100 WRITE (6,390) TITLE                                                I 920
      IF (NUMOBS.LE.0) GO TO 150                                         I 930
      WRITE (6,400) INT                                                  I 940
      IF (S.GT.0.0) WRITE (6,410)                                        I 950
      IF (S.EQ.0.0) WRITE (6,420)                                        I 960
C        ---TABULATE HYDROGRAPH DATA---                                  I 970
      MOZ=0                                                              I 980
      IF (S.GT.0.0) GO TO 110                                            I 990
      NTO=NMOV                                                           I1000
      IF (NMOV.GT.50) NTO=MOD(IMOV,50)                                   I1010
      GO TO 120                                                          I1020
  110 NTO=NTIM                                                           I1030
      IF (NTIM.GT.50) NTO=MOD(N,50)                                      I1040
  120 IF (NTO.EQ.0) NTO=50                                               I1050
      DO 140 J=1,NUMOBS                                                  I1060
```

FORTRAN IV program listing—Continued

```
      TMYR=0.0                                                          I1070
      WRITE (6,430) J,IXOBS(J),IYOBS(J)                                 I1080
      WRITE (6,440) MOZ,WT(IXOBS(J),IYOBS(J)),CONINT(IXOBS(J),IYOBS(J)), I1090
     1TMYR                                                              I1100
      DO 130 M=1,NTO                                                    I1110
      TMYR=TMOBS(M)/TMFY                                                I1120
  130 WRITE (6,440) M,TMWL(J,M),TMCN(J,M),TMYR                          I1130
  140 CONTINUE                                                          I1140
C     ******************************************************************I1150
  150 RETURN                                                            I1160
C     ******************************************************************I1170
C                                                                       I1180
C                                                                       I1190
C                                                                       I1200
  160 FORMAT (1H1,13HCONCENTRATION/)                                    I1210
  170 FORMAT (1X,23HNUMBER OF TIME STEPS = ,1I5)                        I1220
  180 FORMAT (8X,16HDELTA T        = ,1G12.5)                           I1230
  190 FORMAT (8X,16HTIME(SECONDS) = ,1G12.5)                            I1240
  200 FORMAT (3X,21HCHEM.TIME(DAYS)     = ,1E12.5)                      I1250
  210 FORMAT (8X,16HTIME(YEARS)    = ,1E12.5)                           I1260
  220 FORMAT (1H )                                                      I1270
  230 FORMAT (1H1,23HCHANGE IN CONCENTRATION/)                          I1280
  240 FORMAT (1HO,20I5)                                                 I1290
  250 FORMAT (1H ,21HCHEMICAL MASS BALANCE)                             I1300
  260 FORMAT (8X,25HMASS IN BOUNDARIES      = ,1E12.5)                  I1310
  270 FORMAT (8X,25HMASS OUT BOUNDARIES     = ,1E12.5)                  I1320
  280 FORMAT (8X,25HMASS PUMPED OUT         = ,1E12.5)                  I1330
  290 FORMAT (8X,25HMASS PUMPED IN          = ,1E12.5)                  I1340
  300 FORMAT (8X,25HINFLOW MINUS OUTFLOW    = ,1E12.5)                  I1350
  310 FORMAT (8X,25HINITIAL MASS STORED     = ,1E12.5)                  I1360
  320 FORMAT (8X,25HPRESENT MASS STORED     = ,1E12.5)                  I1370
  330 FORMAT (8X,25HCHANGE MASS STORED      = ,1E12.5)                  I1380
  340 FORMAT (1H ,5X,53HCOMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULA I1390
     1TION:)                                                            I1400
  350 FORMAT (8X,25HMASS BALANCE RESIDUAL   = ,1E12.5)                  I1410
  360 FORMAT (8X,25HERROR  (AS PERCENT)     = ,1E12.5)                  I1420
  370 FORMAT (1H ,5X,55HCOMPARE INITIAL MASS STORED WITH CHANGE IN MASS I1430
     1STORED:)                                                          I1440
  380 FORMAT (1X,23H NO. MOVES COMPLETED = ,1I5)                        I1450
  390 FORMAT (1H1,10A8//)                                               I1460
  400 FORMAT (1HO,5X,65HTIME VERSUS HEAD AND CONCENTRATION AT SELECTED O I1470
     1BSERVATION POINTS//15X,19HPUMPING PERIOD NO. ,I4////)             I1480
  410 FORMAT (1HO,16X,19HTRANSIENT  SOLUTION////)                       I1490
  420 FORMAT (1HO,15X,21HSTEADY-STATE SOLUTION////)                     I1500
  430 FORMAT (1HO,20X,22HOBS.WELL NO.     X     Y,17X,1HN,6X,4OHHEAD (FT)  I1510
     1   CONC.(MG/L)     TIME (YEARS)//24X,I3,9X,I2,3X,I2//)          I1520
  440 FORMAT (1H ,58X,I2,6X,F7.1,8X,F7.1,8X,F7.2)                       I1530
  450 FORMAT (1H ,2X,21HCHEM.TIME(SECONDS) = ,E12.5)                    I1540
  460 FORMAT (1H ,2X,21HCHEM.TIME(YEARS)   = ,E12.5)                    I1550
      END                                                               I1560-
```

Attachment II

Definition of Selected Program Variables

AAQ	area of aquifer in model
ALNG	BETA
ANFCTR	anisotropy factor (ratio of T_{yy} to T_{xx})
AOPT	iteration parameters
AREA	area of one cell in finite-difference grid
BETA	longitudinal dispersivity of porous medium
CELDIS	maximum distance across one cell that a particle is permitted to move in one step (as fraction of width of cell)
CLKCN	concentration of leakage through confining layer or streambed
CMSIN	mass of solute recharged into aquifer
CMSOUT	mass of solute discharged from aquifer
CNCNC	change in concentration due to dispersion and sources
CNCPCT	change in concentration as percentage of concentration at node
CNOLD	concentration at node at end of previous time increment
CNREC	concentration of well withdrawal or injection
CNRECH	concentration in fluid source
CONC	concentration in aquifer at node
CONINT	concentration in aquifer at start of simulation
C1	CONC at node (IX,IY)
DALN	longitudinal dispersion coefficient
DDRW	drawdown
DELQ	volumetric rate of leakage across a confining layer or streambed
DELS	rate of change in ground-water storage
DERH	change in head with respect to time
DISP	dispersion equation coefficients
DISTX	distance particle moves in x-direction during time increment
DISTY	distance particle moves in y-direction during time increment
DLTRAT	ratio of transverse to longitudinal dispersivity
DTRN	transverse dispersion coefficient
FCTR	multiplication or conversion factor
FLMIN	solute mass entering modeled area during time step
FLMOT	solute mass leaving modeled area during time step
GRDX	hydraulic gradient in x-direction
GRDY	hydraulic gradient in y-direction
HC	head from column computation
HI	initial head in aquifer
HK	computed head at end of time step
HMIN	minimum iteration parameter
HR	head from row computation in subroutine ITERAT; elsewhere HR represents head from previous time step
IMOV	particle movement step number
INT	pumping period number
IPRNT	print control index for hydrographs
ITMAX	maximum permitted number of iterations
IXOBS	x-coordinate of observation point
IYOBS	y-coordinate of observation point
KOUNT	iteration number for ADIP
LIMBO	array for temporary storage of particles
N	time step number
NCA	number of aquifer nodes in model
NCODES	number of node identification codes
NITP	number of iteration parameters
NMOV	number of particle movements (or time increments) required to complete time step
NODEID	node identification code
NP	total number of active particles in grid
NPCELL	number of particles in a cell during time increment
NPMAX	maximum number of available particles
NPMP	number of pumping periods or simulation periods
NPNT	number of time steps between printouts
NPTPND	initial number of particles per node
NREC	number of pumping wells
NTIM	number of time steps
NUMOBS	number of observation wells
NX	number of nodes in x-direction
NY	number of nodes in y-direction
NZCRIT	maximum number of cells that can be void of particles
NZERO	number of cells that are void of particles at the end of a time increment
PARAM	iteration parameter for current iteration
PART	1. x-coordinate of particle; 2. y-coordinate of particle; 3. concentration of particle. Also note that the signs of coordinates are used as flags to store information on original location of particle.
PERM	hydraulic conductivity (in LT^{-1})
PINT	pumping period in years
POROS	effective porosity
PUMP	cumulative net pumpage
PYR	total duration of pumping period (in seconds)
QNET	net water flux (in L^3T^{-1})

Definition of selected program variables—Continued

QSTR	cumulative change in volume of water in storage
REC	point source or sink; negative for injection, positive for withdrawal (in L^3T^{-1})
RECH	diffuse recharge or discharge; negative for recharge, positive for discharge (in LT^{-1})
RN	range in concentration between regenerated particle and adjacent node having lower concentration
RP	range in concentration between regenerated particle and adjacent node having higher concentration
S	storage coefficient (or specific yield)
SLEAK	rate of leakage through confining layer or streambed
STORM	change in total solute mass in storage (by summation)
STORMI	initial mass of solute in storage
SUMC	summation of concentrations of all particles in a cell
SUMIO	change in total solute mass in storage (from inflows—outflows)
SUMT	total elapsed time (in seconds)
SUMTCH	cumulative elapsed time during particle moves (in seconds)
THCK	saturated thickness of aquifer
TIM	length of specific time step (in seconds)
TIMD	elapsed time in days
TIMY	elapsed time in years
TIMV	length of time increment for particle movement (in seconds)
TIMX	time step multiplier for transient flow problems
TINIT	size of initial time step for transient flow problems (in seconds)
TITLE	problem description
TMCN	computed concentrations at observation points
TMOBS	elapsed times for observation point records
TMRX	transmissivity coefficients (harmonic means on cell boundaries; forward values are stored)
TMWL	computed heads at observation points
TOL	convergence criteria (ADIP)
TOTLQ	cumulative net leakage through confining layer or streambed
TRAN	transverse dispersivity of porous medium
VMAX	maximum value of VX
VMAY	maximum value of VY
VMGE	magnitude of velocity vector
VMXBD	maximum value of VXBDY
VMYBD	maximum value of VYBDY
VPRM	initially used to read transmissivity values at nodes; then after line B2270, VPRM equals leakance factor for confining layer or streambed (vertical hydraulic conductivity/thickness). If VPRM≧0.09, then the program assumes that the node is a constant-head boundary and is flagged for subsequent special treatment in calculating convective transport.
VX	velocity in x-direction at a node
VXBDY	velocity in x-direction on a boundary between nodes
VY	velocity in y-direction at a node
VYBDY	velocity in y-direction on a boundary between nodes
WT	initial water-table or potentiometric elevation, or constant head in stream or source bed
XDEL	grid spacing in x-direction
XOLD	x-coordinate of particle at end of previous time increment
XVEL	velocity of particle in x-direction
YDEL	grid spacing in y-direction
YOLD	y-coordinate of particle at end of previous time increment
YVEL	velocity of particle in y-direction

Attachment III
Data Input Formats

Card	Column	Format	Variable	Definition
1	1–80	10A8	TITLE	Description of problem
2	1– 4	I4	NTIM	Maximum number of time steps in a pumping period (limit=100)*.
	5– 8	I4	NPMP	Number of pumping periods. Note that if NPMP>1, then data set 10 must be completed.
	9–12	I4	NX	Number of nodes in x direction (limit=20)*.
	13–16	I4	NY	Number of nodes in y direction (limit=20)*.
	17–20	I4	NPMAX	Maximum number of particles (limit=3200)*. (See eq 71.)
	21–24	I4	NPNT	Time-step interval for printing hydraulic and chemical output data.
	25–28	I4	NITP	Number of iteration parameters (usually $4 \leq NITP \leq 7$).
	29–32	I4	NUMOBS	Number of observation points to be specified in a following data set (limit=5)*.
	33–36	I4	ITMAX	Maximum allowable number of iterations in ADIP (usually $100 \leq ITMAX \leq 200$).
	37–40	I4	NREC	Number of pumping or injection wells to be specified in a following data set.
	41–44	I4	NPTPND	Initial number of particles per node (options=4, 5, 8, 9).
	45–48	I4	NCODES	Number of node identification codes to be specified in a following data set (limit=10)*.
	49–52	I4	NPNTMV	Particle movement interval (IMOV) for printing chemical output data. (Specify 0 to print only at end of time steps.)
	53–56	I4	NPNTVL	Option for printing computed velocities (0=do not print; 1=print for first time step; 2=print for all time steps).
	57–60	I4	NPNTD	Option for printing computed dispersion equation coefficients (option definition same as for NPNTVL).
	61–64	I4	NPDELC	Option for printing computed changes in concentration (0=do not print; 1=print).
	65–68	I4	NPNCHV	Option to punch velocity data (option definition same as for NPNTVL). When specified, program will punch on unit 7 the velocities at nodes.

See footnotes at end of table.

Data input formats—Continued

Card	Column	Format	Variable	Definition
3	1– 5	G5.0	PINT	Pumping period in years.
	6–10	G5.0	TOL	Convergence criteria in ADIP (usually TOL≤0.01).
	11–15	G5.0	POROS	Effective porosity.
	16–20	G5.0	BETA	Characteristic length, in feet (=longitudinal dispersivity).
	21–25	G5.0	S	Storage coefficient (set S=0 for steady flow problems).
	26–30	G5.0	TIMX	Time increment multiplier for transient flow problems. TIMX is disregarded if S=0 .
	31–35	G5.0	TINIT	Size of initial time step in seconds. TINIT is disregarded if S=0.
	36–40	G5.0	XDEL	Width of finite-difference cell in x direction, in feet.
	41–45	G5.0	YDEL	Width in finite-difference cell in y direction, in feet.
	46–50	G5.0	DLTRAT	Ratio of transverse to longitudinal dispersivity.
	51–55	G5.0	CELDIS	Maximum cell distance per particle move (value between 0 and 1.0).
	56–60	G5.0	ANFCTR	Ratio of T_{yy} to T_{xx}.

Data set	Number of cards	Format	Variable	Definition
1	Value of NUMOBS (limit=5)*	2I2	IXOBS, IYOBS	x and y coordinates of observation points. This data set is eliminated if NUMOBS is specified as =0.
2	Value of NREC	2I2, 2G8.2	IX, IY, REC, CNRECH	x and y coordinates of pumping (+) or injection (−) wells, rate in ft^3/s, and if an injection well, the concentration of injected water. This data set is eliminated if NREC=0.
3	a. 1	I1, G10.0	INPUT, FCTR	Parameter card † for transmissivity.
	b. Value of NY (limit=20)*	20G4.1	VPRM	Array for temporary storage of transmissivity data, in ft^3/s. For an anisotropic aquifer, read in values of T_{xx} and the program will adjust for anisotropy by multiplying T_{yy} by ANFCTR.
4	a. 1	I1, G10.0	INPUT, FCTR	Parameter card† for THCK.
	b. Value of NY (limit=20)*	20G3.0	THCK	Saturated thickness of aquifer, in feet.
5	a. 1	I1, G10.0	INPUT, FCTR	Parameter card† for RECH.
	b. Value of NY (limit=20)*	20G4.1	RECH	Diffuse recharge (−) or discharge (+), in ft/s.
6	a. 1	I1, G10.0	INPUT, FCTR	Parameter card† for NODEID.
	b. Value of NY (limit=20)*	20I1	NODEID	Node identification matrix (used to define constant-head nodes or other boundary conditions and stresses).

See footnotes at end of table.

Data input formats—Continued

Data set	Number of cards	Format	Variable	Definition
7	Value of NCODES (limit=10)*	I2, 3G10.2, I2	ICODE, FCTR1, FCTR2, FCTR3, OVERRD	Instructions for using NODEID array. When NODEID=ICODE, program sets leakance=FCTR1, CNRECH=FCTR2, and if OVERRD is nonzero, RECH =FCTR3. Set OVERRD=0 to preserve values of RECH specified in data set 5.
8	a. 1	I1, G10.0	INPUT, FCTR	Parameter card† for WT.
	b. Value of NY (limit=20)*	20G4.0	WT	Initial water-table or potentiometric elevation, or constant head in stream or source bed, in feet.
9	a. 1	I1, G10.0	INPUT, FCTR	Parameter card† for CONC.
	b. Value of NY (limit=20)*	20G4.0	CONC	Initial concentration in aquifer.
10				This data set allows time step parameters, print options, and pumpage data to be revised for each pumping period of the simulation. Data set 10 is only used if NPMP >1. The sequence of cards in data set 10 must be repeated (NPMP −1) times (that is, data set 10 is required for each pumping period after the first).
	a. 1	I1	ICHK	Parameter to check whether any revisions are desired. Set ICHK=1 if data are to be revised, and then complete data set 10b and c. Set ICHK=0 if data are not to be revised for the next pumping period, and skip rest of data set 10.
	b. 1	10I4,3G5.0	NTIM, NPNT, NITP, ITMAX, NREC, NPNTMV, NPNTVL, NPNTD, NPDELC, NPNCHV, PINT, TIMX, TINIT	Thirteen parameters to be revised for next pumping period; the parameters were previously defined in the description of data cards 2 and 3. Only include this card if ICHK=1 in previous part a.
	c. Value of NREC	2I2, 2G8.2	IX, IY, REC, CNRECH	Revision of previously defined data set 2. Include part c only if ICHK=1 in previous part a and if NREC>0 in previous part b.

* These limits can be modified if necessary by changing the corresponding array dimensions in the COMMON statements of the program.

† The parameter card must be the first card of the indicated data sets. It is used to specify whether the parameter is constant and uniform, and can be defined by one value, or whether it varies in space and must be defined at each node. If INPUT=0, the data set has a constant value, which is defined by FCTR. If INPUT=1, the data set is read from cards as described by part b. Then FCTR is a multiplication factor for the values read in the data set.

Attachment IV
Input Data for Test Problem 3

```
Card 1   TEST PROBLEM NO. 3 (STEADY FLOW, 1 WELL, CONSTANT-HEAD BOUNDARIES)
Card 2      1    1    9  103200    1    7    2 100    1    9    2  10    1    0    0    0
Card 3    2.5.0001 0.30 100.  0.0  0.0  0.0 900. 900.  0.3 0.50  1.0
Data Set 1  5 4
            5 7
Data Set 2  4 7    1.0
Data Set 3  0  0.1
Data Set 4  0  20.0
Data Set 5  0  0.0
Data Set 6  1  1.0
            000000000
            022111220
            000000000
            000000000
            000000000
            000000000
            000000000
            000000000
            022222220
            000000000
Data Set 7  2    1.0         0.0         0.0       0
            1    1.0       100.0         0.0       0
Data Set 8  1  1.0

            0.0100.100.100.100.100.100.100. 0.0




            0.0 75. 75. 75. 75. 75. 75. 75. 0.0
Data Set 9  0  0.0
```

Attachment V
Selected Output for Test Problem 3

```
U.S.G.S. METHOD-OF-CHARACTERISTICS MODEL FOR SOLUTE TRANSPORT IN GROUND WATER

TEST PROBLEM NO. 3 (STEADY FLOW, 1 WELL, CONSTANT-HEAD BOUNDARIES)

                    I N P U T     D A T A

                      GRID DESCRIPTORS

NX     (NUMBER OF COLUMNS)   =      9
NY     (NUMBER OF ROWS)      =     10
XDEL   (X-DISTANCE IN FEET)  =  900.0
YDEL   (Y-DISTANCE IN FEET)  =  900.0

                      TIME  PARAMETERS

NTIM   (MAX. NO. OF TIME STEPS)          =       1
NPMP   (NO. OF PUMPING PERIODS)          =       1
PINT   (PUMPING PERIOD IN YEARS)         =    2.50
TIMX   (TIME INCREMENT MULTIPLIER)       =    0.00
TINIT  (INITIAL TIME STEP IN SEC.)       =      0.

  HYDROLOGIC AND CHEMICAL PARAMETERS

S       (STORAGE COEFFICIENT)            =   0.000000
POROS   (EFFECTIVE POROSITY)             =    0.30
BETA    (CHARACTERISTIC LENGTH)          =   100.0
DLTRAT  (RATIO OF TRANSVERSE TO
        LONGITUDINAL DISPERSIVITY)       =    0.30
ANFCTR  (RATIO OF T-YY TO T-XX)          =   1.000000

                    EXECUTION PARAMETERS

NITP   (NO. OF ITERATION PARAMETERS) =     7
TOL    (CONVERGENCE CRITERIA - ADIP) =     0.0001
ITMAX  (MAX.NO.OF ITERATIONS - ADIP) =   100
CELDIS (MAX.CELL DISTANCE PER MOVE
           OF PARTICLES - M.O.C.)    =     0.500
NPMAX  (MAX. NO. OF PARTICLES)       =  3200
NPTPND (NO. PARTICLES PER NODE)      =     9

                      PROGRAM OPTIONS

NPNT   (TIME STEP INTERVAL FOR
        COMPLETE PRINTOUT)       =     1
NPNTMV (MOVE INTERVAL FOR CHEM.
        CONCENTRATION PRINTOUT)  =    10
NPNTVL (PRINT OPTION-VELOCITY
        0=NO; 1=FIRST TIME STEP;
        2=ALL TIME STEPS)        =     1
NPNTD  (PRINT OPTION-DISP.COEF.
        0=NO; 1=FIRST TIME STEP;
        2=ALL TIME STEPS)        =     0
NUMOBS (NO. OF OBSERVATION WELLS
        FOR HYDROGRAPH PRINTOUT) =     2
NREC   (NO. OF PUMPING WELLS)    =     1
NCODES (FOR NODE IDENT.)         =     2
NPNCHV (PUNCH VELOCITIES)        =     0
NPDELC (PRINT OPT.-CONC. CHANGE) =     0
```

Selected output for test problem 3—Continued

```
            STEADY-STATE FLOW

TIME INTERVAL (IN SEC) FOR SOLUTE-TRANSPORT SIMULATION =  0.78894d+08

      LOCATION OF OBSERVATION WELLS

            NO.      X      Y

             1       5      4
             2       5      7

      LOCATION  OF  PUMPING  WELLS

      X    Y    RATE(IN CFS)    CONC.

      4    7        1.00          0.0

      AREA OF ONE CELL =    0.8100d+06

      X-Y SPACING:
          900.00
          900.00



TRANSMISSIVITY MAP (FT*FT/SEC)
   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.00
   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00



AQUIFER THICKNESS (FT)
    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

Selected output for test problem 3—Continued

```
DIFFUSE RECHARGE AND DISCHARGE (FT/SEC)
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00
  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00  0.00d+00


PERMEABILTY MAP (FT/SEC)
  0.0000.0000.0000.0000.0000.0000.0000.0000.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0050.0050.0050.0050.0050.0050.0050.000
  0.0000.0000.0000.0000.0000.0000.0000.0000.000


          NO. OF FINITE-DIFFERENCE CELLS IN AQUIFER =   56

          AREA OF AQUIFER IN MODEL  =  0.45360e+08   SQ. FT.


          NZCRIT   (MAX. NO. OF CELLS THAT CAN BE VOID OF
                    PARTICLES; IF EXCEEDED, PARTICLES ARE REGENERATED)  =   1
```

Selected output for test problem 3—Continued

```
NODE IDENTIFICATION MAP

    0    0    0    0    0    0    0    0    0
    0    2    2    1    1    1    2    2    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    2    2    2    2    2    2    2    0
    0    0    0    0    0    0    0    0    0

 NO. OF NODE IDENT. CODES SPECIFIED =  2

      THE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:
 CODE NO.      LEAKANCE      SOURCE CONC.      RECHARGE

     2         0.100e+01          0.00

     1         0.100e+01        100.00


VERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC))
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  0.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.00
  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00


WATER TABLE
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0. 100. 100. 100. 100. 100. 100. 100.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.  75.  75.  75.  75.  75.  75.  75.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.
```

Selected output for test problem 3—Continued

```
ITERATION PARAMETERS
          0.246740d-01
          0.457299d-01
          0.847539d-01
           .157080
           .291125
           .539560
           1.00000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000
          0.000000

CONCENTRATION

NUMBER OF TIME STEPS =      0
      TIME(SECONDS) =  0.00000
  CHEM.TIME(SECONDS) =  0.00000e+00
  CHEM.TIME(DAYS)    =  0.00000e+00
      TIME(YEARS)    =  0.00000e+00
  CHEM.TIME(YEARS)   =  0.00000e+00
 NO. MOVES COMPLETED =      0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

 N =    1
 NUMBER OF ITERATIONS =   20
```

Selected output for test problem 3—Continued

```
HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS =      1
       TIME(SECONDS) =  0.78894d+08
       TIME(DAYS)    =  0.91313e+03
       TIME(YEARS)   =  0.25000e+01

   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000
   0.0000000  99.9999995  99.9999995  99.9999995  99.9999995  99.9999995  99.9999995  99.9999995   0.0000000
   0.0000000  95.9387858  95.9346978  95.9468712  95.9958792  96.0611455  96.1171357  96.1482887   0.0000000
   0.0000000  91.8816815  91.8531641  91.8569301  91.9755221  92.1315893  92.2591385  92.3277521   0.0000000
   0.0000000  87.8530674  87.7393101  87.6521342  87.9176617  88.2305223  88.4600398  88.5758019   0.0000000
   0.0000000  83.9382225  83.5988909  83.0946482  83.8124811  84.4128118  84.7747129  84.9396259   0.0000000
   0.0000000  80.3627221  79.6233998  77.3151005  79.8248158  80.8335448  81.2863911  81.4683757   0.0000000
   0.0000000  77.5265176  77.2168501  76.7175099  77.3381095  77.8101323  78.0688953  78.1790838   0.0000000
   0.0000000  75.0000003  75.0000003  75.0000002  75.0000003  75.0000003  75.0000004  75.0000004   0.0000000
   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS =      1
       TIME(SECONDS) =  0.78894d+08
       TIME(DAYS)    =  0.91313e+03
       TIME(YEARS)   =  0.25000e+01

   0   0   0   0   0   0   0   0   0
   0 100 100 100 100 100 100 100   0
   0  96  96  96  96  96  96  96   0
   0  92  92  92  92  92  92  92   0
   0  88  88  88  88  88  88  89   0
   0  84  84  83  84  84  85  85   0
   0  80  80  77  80  81  81  81   0
   0  78  77  77  77  78  78  78   0
   0  75  75  75  75  75  75  75   0
   0   0   0   0   0   0   0   0   0
```

Selected output for test problem 3—Continued

```
DRAWDOWN
      0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0
      0   -95   -95   -95   -95   -95   -95   -95     0
      0   -91   -91   -91   -91   -91   -91   -91     0
      0   -87   -87   -87   -87   -87   -87   -88     0
      0   -83   -83   -82   -83   -83   -84   -84     0
      0   -79   -79   -76   -79   -80   -80   -80     0
      0   -77   -76   -76   -76   -77   -77   -77     0
      0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0

  CUMULATIVE MASS BALANCE

   CUMULATIVE  NET  PUMPAGE    =  0.78894e+08
   WATER RELEASE FROM STORAGE =  0.00000e+00
   CUMULATIVE  NET  LEAKAGE    =  0.78895e+08

       MASS BALANCE RESIDUAL   =  -767.00
       ERROR  (AS PERCENT)     = -0.97219e-03

  RATE MASS BALANCE -- (IN C.F.S.)
         QIN  =    2.7857
         QOUT =   -1.7857
         QNET =    1.0000

                TPUM =    1.0000
                DELS =   0.00000

X VELOCITIES
                          AT NODES

   0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000
   0.000       0.935e-14  -0.924e-14  -0.699e-13  -0.131e-12  -0.139e-12  -0.996e-13  -0.712e-13   0.000
   0.000       0.757e-07  -0.749e-07  -0.566e-06  -0.106e-05  -0.112e-05  -0.807e-06  -0.577e-06   0.000
   0.000       0.528e-06   0.229e-06  -0.113e-05  -0.254e-05  -0.263e-05  -0.182e-05  -0.127e-05   0.000
   0.000       0.211e-05   0.186e-05  -0.165e-05  -0.536e-05  -0.502e-05  -0.320e-05  -0.214e-05   0.000
   0.000       0.628e-05   0.781e-05  -0.198e-05  -0.122e-04  -0.891e-05  -0.488e-05  -0.305e-05   0.000
   0.000       0.137e-04   0.282e-04  -0.186e-05  -0.326e-04  -0.135e-04  -0.588e-05  -0.337e-05   0.000
   0.000       0.573e-05   0.749e-05  -0.112e-05  -0.101e-04  -0.677e-05  -0.342e-05  -0.204e-05   0.000
   0.000       0.708e-12   0.925e-12  -0.139e-12  -0.125e-11  -0.835e-12  -0.422e-12  -0.252e-12   0.000
   0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000

                          ON BOUNDARIES

   0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000
   0.000       0.935e-14  -0.278e-13  -0.112e-12  -0.149e-12  -0.128e-12  -0.712e-13   0.000       0.000
   0.000       0.757e-07  -0.225e-06  -0.908e-06  -0.121e-05  -0.104e-05  -0.577e-06   0.000       0.000
   0.000       0.528e-06  -0.697e-07  -0.220e-05  -0.289e-05  -0.236e-05  -0.127e-05   0.000       0.000
   0.000       0.211e-05   0.161e-05  -0.492e-05  -0.579e-05  -0.425e-05  -0.214e-05   0.000       0.000
   0.000       0.628e-05   0.934e-05  -0.133e-04  -0.111e-04  -0.670e-05  -0.305e-05   0.000       0.000
   0.000       0.137e-04   0.427e-04  -0.465e-04  -0.187e-04  -0.839e-05  -0.337e-05   0.000       0.000
   0.000       0.573e-05   0.925e-05  -0.115e-04  -0.874e-05  -0.479e-05  -0.204e-05   0.000       0.000
   0.000       0.708e-12   0.114e-11  -0.142e-11  -0.108e-11  -0.592e-12  -0.252e-12   0.000       0.000
   0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000
```

Selected output for test problem 3—Continued

```
Y VELOCITIES
                        AT NODES
   0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000
   0.000        0.752e-04    0.753e-04    0.751e-04    0.742e-04    0.729e-04    0.719e-04    0.713e-04    0.000
   0.000        0.752e-04    0.754e-04    0.754e-04    0.743e-04    0.729e-04    0.717e-04    0.710e-04    0.000
   0.000        0.749e-04    0.759e-04    0.768e-04    0.748e-04    0.725e-04    0.709e-04    0.701e-04    0.000
   0.000        0.736e-04    0.764e-04    0.811e-04    0.756e-04    0.715e-04    0.693e-04    0.684e-04    0.000
   0.000        0.694e-04    0.751e-04    0.957e-04    0.749e-04    0.685e-04    0.664e-04    0.658e-04    0.000
   0.000        0.594e-04    0.591e-04    0.590e-04    0.599e-04    0.611e-04    0.621e-04    0.626e-04    0.000
   0.000        0.497e-04    0.428e-04    0.214e-04    0.447e-04    0.540e-04    0.582e-04    0.599e-04    0.000
   0.000        0.468e-04    0.411e-04    0.318e-04    0.433e-04    0.520e-04    0.568e-04    0.589e-04    0.000
   0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000
                        ON BOUNDARIES
   0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000
   0.000        0.752e-04    0.753e-04    0.751e-04    0.742e-04    0.729e-04    0.719e-04    0.713e-04    0.000
   0.000        0.751e-04    0.756e-04    0.757e-04    0.745e-04    0.728e-04    0.714e-04    0.708e-04    0.000
   0.000        0.746e-04    0.762e-04    0.779e-04    0.751e-04    0.722e-04    0.704e-04    0.695e-04    0.000
   0.000        0.725e-04    0.767e-04    0.844e-04    0.760e-04    0.707e-04    0.682e-04    0.673e-04    0.000
   0.000        0.662e-04    0.736e-04    0.107e-03    0.738e-04    0.663e-04    0.646e-04    0.643e-04    0.000
   0.000        0.525e-04    0.446e-04    0.111e-04    0.461e-04    0.560e-04    0.596e-04    0.609e-04    0.000
   0.000        0.468e-04    0.411e-04    0.318e-04    0.433e-04    0.520e-04    0.568e-04    0.589e-04    0.000
   0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000
   0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000


         STABILITY CRITERIA --- M.O.C.


VMAX =  3.26e-05     VMAY =  9.57e-05
VMXBD=  4.65e-05     VMYBD=  1.07e-04
TMV (MAX. INJ.) =  0.11955e+08
TIMV (CELDIS)   =  0.42045e+07

TIMV =  4.20e+06     NTIMV =    18     NMOV =    19

 TIM (N)  =  0.78894d+08
 TIMEVELO =  0.41523e+07
 TIMEDISP =  0.30143e+08

TIMV =  4.15e+06     NTIMD =     2     NMOV =    19

         THE LIMITING STABILITY CRITERION IS CELDIS

         NO. OF PARTICLE MOVES REQUIRED TO COMPLETE THIS TIME STEP  =   19
```

Selected output for test problem 3—Continued

```
CONCENTRATION

NUMBER OF TIME STEPS =      1
       DELTA T       =  0.78894d+08
       TIME(SECONDS) =  0.78894d+08
  CHEM.TIME(SECONDS) =  0.78894e+08
  CHEM.TIME(DAYS)    =  0.91313e+03
       TIME(YEARS)   =  0.25000e+01
  CHEM.TIME(YEARS)   =  0.25000e+01
 NO. MOVES COMPLETED =     19

    0    0    0    0    0    0    0    0    0

    0    0    2   98  100   98    2    0    0

    0    0    4   96  100   96    4    0    0

    0    0    7   92   99   93    7    0    0

    0    0    9   89   96   88    9    0    0

    0    1   10   81   89   80   10    1    0

    0    1    8   56   73   46    8    1    0

    0    0    2   20   35   19    3    0    0

    0    0    0    1    5    3    0    0    0

    0    0    0    0    0    0    0    0    0

CHEMICAL MASS BALANCE

       MASS IN BOUNDARIES      =  0.94642e+10
       MASS OUT BOUNDARIES     = -0.13340e+08
       MASS PUMPED IN          =  0.00000e+00
       MASS PUMPED OUT         = -0.96281e+09
       INFLOW MINUS OUTFLOW    =  0.84881e+10
       INITIAL MASS STORED     =  0.00000e+00
       PRESENT MASS STORED     =  0.84631e+10
       CHANGE MASS STORED      =  0.84631e+10
     COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
       MASS BALANCE RESIDUAL   =  0.24910e+08
       ERROR  (AS PERCENT)     =  0.29390e+00
```

Selected output for test problem 3—Continued

TEST PROBLEM NO. 3 (STEADY FLOW, 1 WELL, CONSTANT-HEAD BOUNDARIES)

TIME VERSUS HEAD AND CONCENTRATION AT SELECTED OBSERVATION POINTS*

PUMPING PERIOD NO. 1

STEADY-STATE SOLUTION

OBS.WELL NO.	X	Y	N	HEAD (FT)	CONC.(MG/L)	TIME (YEARS)
1	5	4				
			0	0.0	0.0	0.00
			1	92.0	0.0	0.13
			2	92.0	0.2	0.26
			3	92.0	1.2	0.39
			4	92.0	2.9	0.53
			5	92.0	15.5	0.66
			6	92.0	33.0	0.79
			7	92.0	53.1	0.92
			8	92.0	64.6	1.05
			9	92.0	72.9	1.18
			10	92.0	79.8	1.32
			11	92.0	85.4	1.45
			12	92.0	89.4	1.58
			13	92.0	92.2	1.71
			14	92.0	94.3	1.84
			15	92.0	95.8	1.97
			16	92.0	97.0	2.11
			17	92.0	97.8	2.24
			18	92.0	98.4	2.37
			19	92.0	98.7	2.50

Selected output for test problem 3—Continued

OBS.WELL NO. X Y

2 5 7

N	HEAD (FT)	CONC.(MG/L)	TIME (YEARS)
0	0.0	0.0	0.00
1	79.8	0.0	0.13
2	79.8	0.0	0.26
3	79.8	0.0	0.39
4	79.8	0.0	0.53
5	79.8	0.0	0.66
6	79.8	0.0	0.79
7	79.8	0.1	0.92
8	79.8	0.2	1.05
9	79.8	0.6	1.18
10	79.8	1.7	1.32
11	79.8	4.8	1.45
12	79.8	8.2	1.58
13	79.8	14.3	1.71
14	79.8	27.0	1.84
15	79.8	38.2	1.97
16	79.8	49.4	2.11
17	79.8	51.1	2.24
18	79.8	67.2	2.37
19	79.8	73.0	2.50

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