

Appendix 1. Updates to the Particle-Tracking Program MODPATH to Improve Efficiency for Use in Computing Transient-State Contributing Areas for Wells that Act as Weak Sinks

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The following 11 changes were made to version 5.0 of the particle-tracking program, MODPATH (Pollock, 1994), so that the weak sink program would run correctly and efficiently for the transient case:

1. The checking process for IFACE was changed, because some compilers treat the empty spaces differently. A character variable with length 5 is used to do the check rather than CTMP, which is length 16.

In file BUDGETRD.FOR:

After line 131 in subroutine RDBDNM, add variable declaration.

```
CHARACTER*16 TXTSAV
```

C added to improve IFACE check

```
character*5 ifchk
```

```
SAVE IOLD,KS,KP,TXTSV,NC,NR,NLCODE
```

At line 177 in subroutine RDBDNM, change the check for IFACE.

```
DO 10 I=1,NVAL-1
```

```
ifchk = ctmp(i)
```

C original IF(CTMP(I).EQ.'IFACE') NIFACE=I+1

```
IF(ifchk.EQ.'IFACE') NIFACE=I+1
```

10

```
CONTINUE
```

2. A loop was added to the particle-tracking code to determine which particles already have been released at the beginning of each time step. This limits the number of times that hydraulic-head values are read from the MODPATH CBF file. In the modified code it is assumed that the particles are sorted by release time in the starting locations file. The sorting is done in the weak sink program.

In file MPDRIVE.FOR:

In subroutine DRIVER, change line 265

C original GO TO 69

```
GO TO 701
```

In subroutine DRIVER, add a line number at line 339

```
701 if(mode.eq.2 .and. iend.eq.0 .and. iunit(18).gt.0) then
```

3. The code was changed to allow for particles to be released at multiple times for backward tracking.

In file MPDATIN.FOR:

In subroutine DATIN, comment out line 537

C original IF(TRLEAS.NE.0.0 .AND. IREV.EQ.1) GO TO 150

In Subroutine DATIN, add after line 585

C add code to allow multiple release times in backward tracking

```
if (irev.eq.1) trleas = -1*trleas
```

C keep track of minimum release time

```

if((trleas.lt.trmin).or.(n.eq.1)) then
    trmin = trleas
end if

```

In file MPDRIVE.FOR:

In subroutine DRIVER, change line 48

```

C original 5TIMX,IBSTRT,ZLC,HDRY,HNOFLO,TOT,ICMPCT,TBGABS,LAYCBD,ISSFLG)
    5TIMX,IBSTRT,ZLC,HDRY,HNOFLO,TOT,ICMPCT,TBGABS,LAYCBD,ISSFLG
+stlcomment,trmin,tbegin)

```

In subroutine DRIVER, add after line 138

```

if(irev.eq.1) then
    timrel = tbgabs-trmin
else
    timrel = trmin + tbgabs
end if
    told = trmin
call getps (PERLEN,NUMTS,TIMX,NPER,TIMREL,TBEGIN,KKPER,
1          KKSTP,IERR)

```

In subroutine DRIVER, add after line 161

```

if(irev.eq.1) then
    told = told-(1.0-TIMREL)*DTSTP
else
    told = told - TIMREL*DTSTP
end if
    timstp = dtstp + told

```

In subroutine DRIVER, comment out lines 245 and 252

```

C original IF(IREV.EQ.0) THEN
C original END IF

```

4. The code was compiled in double precision to allow for more accuracy in computing times and position coordinates.

In file FLOWDATA.FOR:

In subroutine HQDATA, change line 103

```

C original LREC= 4*(NCOL+1)
    LREC= 8*(NCOL+1)

```

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In subroutine MAKEHQ, change line 279

```
C original          DBYTES=4.D0*(DBLE(NCOL)+1.D0)*DBLE(NCHECK)
                    DBYTES=8.D0*(DBLE(NCOL)+1.D0)*DBLE(NCHECK)
```

In subroutine CBFSIZ, change line 932

```
C original DBYTES= 4.D0*(DBLE(NCOL)+1.D0)*DBLE(NREC)
                    DBYTES= 8.D0*(DBLE(NCOL)+1.D0)*DBLE(NREC)
```

5. The code was changed to allow for the IEVTTP variable to be used for ET SEGMENTS package and for the Stream Leakage to be assigned to Face 6 because there is no allowance for setting IFACE.

In file FLOWDATA.FOR

In subroutine FLOWS, add new lines after line 599.

```
IF(TEXT.EQ.'      ET SEGMENTS') ITOP=IEVTTP
IF(TEXT.EQ.'  STREAM LEAKAGE') ITOP=1
```

6. The code was changed to allow a comment to be added to the starting locations files that would be added to the endpoint file.

In File MPATH5.FOR:

In the Main Program, add after line 75

```
character*256,dimension(:), allocatable:: STLCOMMENT
```

In the Main Program, add after line 247

```
allocate (stlcomment(MAXPTS))
```

In file MPDATIN.FOR:

In Subroutine DATIN, change line 18

```
5TIMX,IBSTRT,ZLC,HDRY,HNOFLO,TOT,ICMPCT,TBGABS,LAYCBD,ISSFLG,
```

```
6 stlcomment,trmin,tbegin)
```

In Subroutine DATIN, add after line 25

```
character*256 STLCOMMENT,comment
```

In Subroutine DATIN, add after line 40

```
+,STLCOMMENT(NPART)
```

In file WRITEPTS.FOR:

In subroutine WRITEP, add after line 46

```
character*256 stlcomment
```

```
1
```

In subroutine WRITEP, change line 54

```
C original          1          1X,E12.5,a256)
                    1          1X,E12.5,a256)
```

7. The code was changed to allow for the maximum line length in the starting locations file to be more than 81.

In file MPDATIN.FOR:

In subroutine DATIN, change line 25

```
C original CHARACTER*81 LINE2
      CHARACTER*256 LINE2
```

In subroutine DATIN, add after line 536

```
comment = line2(iwlast+1:256)
```

In subroutine DATIN, add after line 569

```
stlcomment(n) = comment
```

In file MPDRIVE.FOR:

In subroutine DRIVER, change line 16

```
C original 5HNOFLO,VER,LAYCBD,ISSFLG)
      5HNOFLO,VER,LAYCBD,ISSFLG,STLCOMMENT)
```

In subroutine DRIVER, add after line 21

```
character*256 STLCOMMENT
```

In subroutine DRIVER, add after line 33

```
+,STLCOMMENT(NPART)
```

In subroutine DRIVER, change line 48

```
C original 5TIMX,IBSTRT,ZLC,HDRY,HNOFLO,TOT,ICMPCT,TBGABS,LAYCBD,ISSFLG)
      5TIMX,IBSTRT,ZLC,HDRY,HNOFLO,TOT,ICMPCT,TBGABS,LAYCBD,ISSFLG
      +stlcomment,trmin,tbegin)
```

In subroutine DRIVER, changes lines 522 and 537

```
C original 2 KFRST,IZONE2,NSFRST,IPCODE,TRLEAS,NROW,NCOL,stlcomment(N))
      2 KFRST,IZONE2,NSFRST,IPCODE,TRLEAS,NROW,NCOL,stlcomment(N))
```

```
C original 2 KFRST,IZONE2,NSFRST,IPCODE,TRLEAS,NROW,NCOL,stlcomment(N))
      2 KFRST,IZONE2,NSFRST,IPCODE,TRLEAS,NROW,NCOL,stlcomment(N))
```

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In file WRITEPTS.FOR

In subroutine WRITEP, change line 46

```
C original 2 NROW,NCOL)
      2 NROW,NCOL, stlcomment)
```

In subroutine WRITEP, change line 52

```
C original 1          NDFRST, IZONE2, NSFRST, IPCODE, TRLEAS
      1          NDFRST, IZONE2, NSFRST, IPCODE, TRLEAS, stlcomment
      2
```

In subroutine WRITEP, change line 54

```
C original 1          1          1X, E12.5, a256)
      1          1X, E12.5, a256)
```

In subroutine WRITEP, change line 65

```
C original 1          JFRST, IFRST, KFRST, IZONE2, NSFRST, IPCODE, TRLEAS
      1          JFRST, IFRST, KFRST, IZONE2, NSFRST, IPCODE, TRLEAS, stlcomment
```

In subroutine WRITEP, change line 67

```
C original 1          1X, I6, 1X, E12.5, a256)
      1          1X, I6, 1X, E12.5, a256)
```

8. The code was changed to allow the endpoint file to be written with free format.

In file MPDATIN.FOR:

In Subroutine DATIN, add after line 320

```
IF(INDEX(LINE, 'FREE').ne.0) ICOMPCT = ICOMPCT - 2
```

In file WRITEPTS.FOR:

In subroutine WRITEP, add after line 55

```
ELSE IF(ICOMPCT.EQ.-1) THEN
      ND= (K-1)*NROW*NCOL + (I-1)*NCOL + J
      NDFRST= (KFRST-1)*NROW*NCOL + (IFRST-1)*NCOL + JFRST
      WRITE(IU, *) IZONE, ND, X, Y, ZL, TOT, XSTRT, YSTRT, ZLSTRT,
      1          NDFRST, IZONE2, NSFRST, IPCODE, TRLEAS, stlcomment
```

In subroutine WRITEP, add after line 60

```

ELSE IF(ICMPCT.EQ.-2) THEN

    inquire (iu, recl=ir)

    WRITE(IU,*) IZONE,J,I,K,X,Y,Z,ZL,TOT,XSTRT,YSTRT,ZLSTRT,
1      JFRST,IFRST,KFRST,IZONE2,NSFRST,IPCODE,TRLEAS, stlcomment

```

9. The code was changed to use the zone codes specified in the MODPATH input for determining whether or not a particle stops.

In file MPDRIVE.FOR:

In subroutine DRIVER, change lines 500 and 503

```

C original      IZONE=IBOUND(JLC(N),ILC(N),KLC(N))

      IZONE=IBSTRT(JLC(N),ILC(N),KLC(N))

C original      IZONE2=IBOUND(JFRST,IFRST,KFRST)

      IZONE2=IBSTRT(JFRST,IFRST,KFRST)

```

10. The code was changed to allow the layer index to be specified as 0, which is specified in the MODPATH documentation when a particle is to be placed in the top active layer.

In file STARTLOC.FOR:

In Subroutine GETIJK, change line 152

```

C original IF(K.LT.1 .OR. K.GT.NLAY) THEN

      IF(K.LT.0 .OR. K.GT.NLAY) THEN

```

11. The code was changed to increase the default record length.

In file UTILMP.FOR:

In subroutine OPNFIL, change lines 311 and 320

```

C original OPEN (IU,FILE=FNAME,STATUS='OLD',FORM=FMT,ACCESS=ACS,IOSTAT=IERR)

      OPEN (IU,FILE=FNAME,STATUS='OLD',FORM=FMT,ACCESS=ACS,IOSTAT=IERR,
+ recl=5000)

C original OPEN (IU,FILE=FNAME,STATUS='NEW',FORM=FMT,ACCESS=ACS,IOSTAT=IERR)

      OPEN (IU,FILE=FNAME,STATUS='NEW',FORM=FMT,ACCESS=ACS,IOSTAT=IERR,
+ recl=5000)

```

References Cited

Pollock, D.W., 1994, User's guide for MODPATH/MODPATH-PLOT, version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 94-464 [variously paged]. (Also available at <http://pubs.er.usgs.gov/publication/ofr94464>.)

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