APPENDIX
EXAMPLE SIMULATION

The example problem described in McDonald and Harbaugh (1988) and duplicated in Harbaugh and McDonald (1996a) and Harbaugh and others (2000) is used here to demonstrate the use of MODFLOW–2005. The example is implemented two ways—with and without parameters. For the implementation without parameters, the BCF Package is used as in McDonald and Harbaugh (1988). When the example is implemented using parameters, the LPF Package is used. The simulated system is shown in figure A–1.

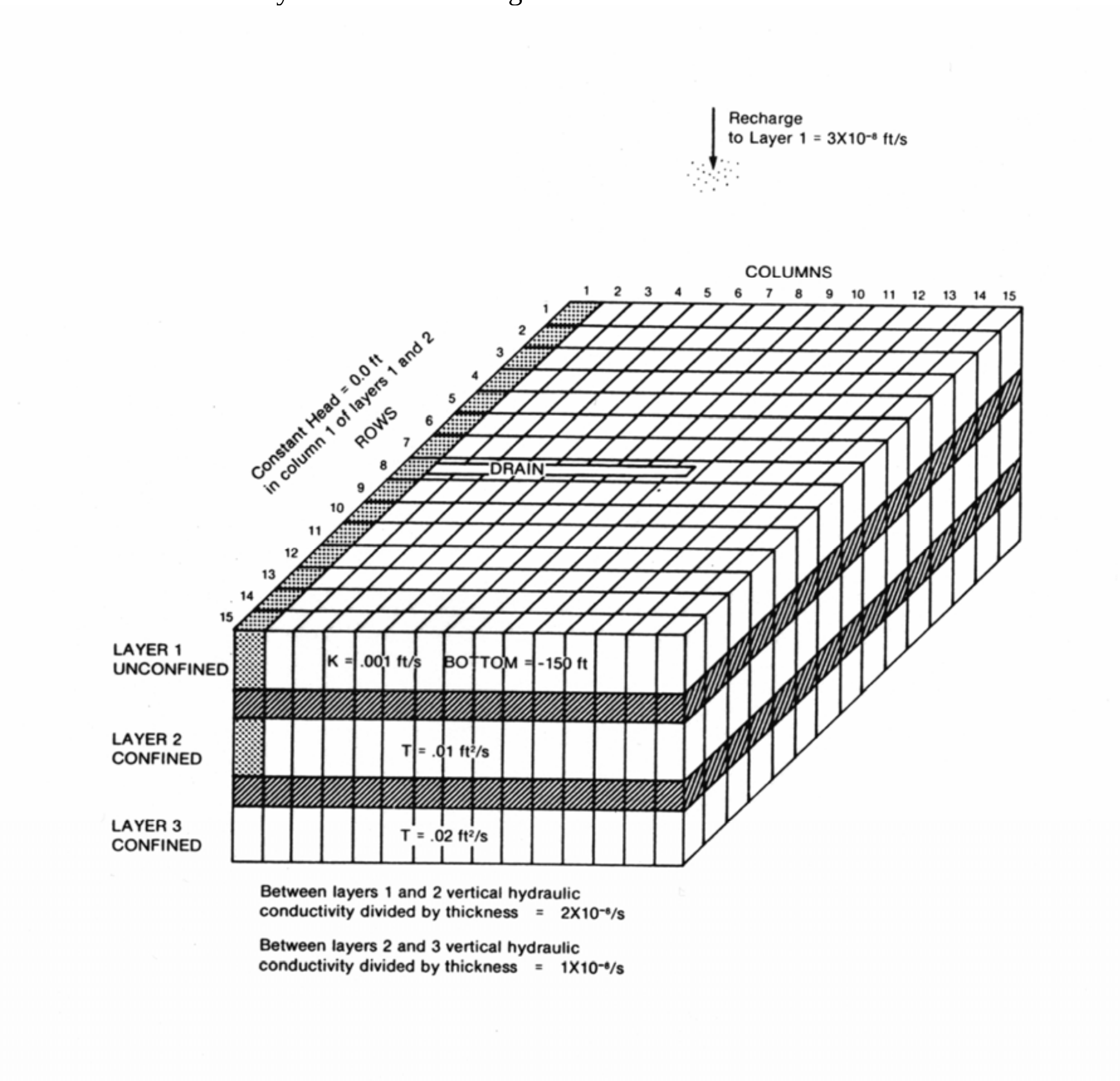

Figure A–1. Illustration of the system simulated in the example problem. (From McDonald and Harbaugh, 1988.)

Example Without Parameters

As shown in figure A–1, all of the layers are flat; the original problem definition did not specify the elevations except for the bottom of layer 1. The other elevations were not specified because they were not needed in earlier versions of MODFLOW. Layer thickness is incorporated into transmissivity and vertical hydraulic conductivity divided by thickness (VCONT) values. For MODFLOW–2005, however, all of the elevations must be specified. Any physically consistent elevations can be used if the only goal is to reproduce the heads calculated by MODFLOW–96. That is, each successive layer must have a lower elevation than the layer above, and the top elevation of layer 1 must be above the water table. Within these constraints, the following values were arbitrarily selected:

Elevation of the top of layer 1 = 200 ft,
Elevation of the bottom of the confining bed below layer 1 = -200 ft,
Elevation of the bottom of layer 2 = -300 ft,
Elevation of the bottom of the confining bed below layer 2 = -350 ft, and
Elevation of the bottom of layer 3 = -450 ft.

The following are the resulting input files:

Name File:

```
LIST  6 twri.lst
BAS6  5 twri.ba6
BCF6 11 twri.bc6
WEL  12 twri.wel
DRN  13 twri.drn
RCH  18 twri.rch
SIP  19 twri.sip
OC   22 twri.oc
DIS  10 twri.dis
```

Discretization (DIS) File

```
    3   15   15    1    1    0  NLAY,NROW,NCOL,NPER,ITMUNI,LENUNI
 1 1 0                    LAYCBD
CONSTANT   5.000000E+03  DELR
CONSTANT   5.000000E+03  DELC
CONSTANT   2.000000E+02  TOP of system
CONSTANT  -1.500000E+02  Layer BOTM layer   1
CONSTANT  -2.000000E+02  Confining bed BOTM layer   1
CONSTANT  -3.000000E+02  Layer BOTM layer   2
CONSTANT  -3.500000E+02  Confining bed BOTM layer   2
CONSTANT  -4.500000E+02  Layer BOTM layer   3
 8.640E+04         1 1.000E+00  SS  PERLEN,NSTP,TSMULT,Ss/tr
```

Basic Package (BAS6) File

```
#SAMPLE---3 LAYERS, 15 ROWS, 15 COLUMNS; STEADY STATE; CONSTANT HEADS IN
COLUMN 1
#LAYERS 1 AND 2; RECHARGE, WELLS AND DRAINS
NO OPTIONS
INTERNAL          1 (20I4)    3  IBOUND layer   1
  -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
```

```
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
INTERNAL          1 (20I4)    3  IBOUND layer   2
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
CONSTANT          1  IBOUND layer   3
    999.99  HNOFLO
CONSTANT   0.000000E+00  Initial Head layer   1
CONSTANT   0.000000E+00  Initial Head layer   2
CONSTANT   0.000000E+00  Initial Head layer   3
```

Output Control Option (OC) File—Default output control was used when this problem was run by McDonald and Harbaugh (1988), so no file was required. The Output Control Option is used here only for the purpose of changing the format for printing head. A format has been chosen that is less than page width.

```
HEAD PRINT FORMAT 20
PERIOD 1 STEP 1
PRINT HEAD
```

Block-Centered Flow Package (BCF6) File

```
         0  1.00E+30         0  0.00E+00         0         0
 1 0 0                    Ltype
CONSTANT   1.000000E+00  TRPY
CONSTANT   1.000000E-03  HY layer   1
CONSTANT   2.000000E-08  VCONT layer   1
CONSTANT   1.000000E-02  TRAN layer   2
CONSTANT   1.000000E-08  VCONT layer   2
CONSTANT   2.000000E-02  TRAN layer   3
```

Recharge Package (RCH) File

```
         1         0    NRCHOP,IRCHBD
         1              INRECH
         0     3.E-8                              RECH-1
```

Well Package (WEL) File

```
        15         0    MXACTW,IWELCB
        15              ITMP
         3         5        11       -5.
         2         4         6       -5.
         2         6        12       -5.
         1         9         8       -5.
         1         9        10       -5.
         1         9        12       -5.
         1         9        14       -5.
         1        11         8       -5.
         1        11        10       -5.
         1        11        12       -5.
         1        11        14       -5.
         1        13         8       -5.
         1        13        10       -5.
         1        13        12       -5.
         1        13        14       -5.
```

Drain Package (DRN) File

```
         9         0    MXACTD,IDRNCB
         9              ITMP
         1         8         2        0.     1.E00
         1         8         3        0.     1.E00
         1         8         4       10.     1.E00
         1         8         5       20.     1.E00
         1         8         6       30.     1.E00
         1         8         7       50.     1.E00
         1         8         8       70.     1.E00
         1         8         9       90.     1.E00
         1         8        10      100.     1.E00
```

Strongly Implicit Procedure Package (SIP) File

```
        50         5       MXITER,NPARM
        1.      .001         0      .001         1
```

This problem was run on a personal computer by using a runfile that was compiled with the Lahey Fortran 95 compiler. The Name File includes a file of type LIST, which is the Listing File. All of the “printed” output goes to this single file. The contents of the Listing File are shown in figure A–2.

```
                                  MODFLOW-2005
     U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER FLOW MODEL
                             VERSION 1.00 12/15/2005

 LIST FILE: twri.lst
                         UNIT    7

 OPENING twri.ba6
 FILE TYPE:BAS6   UNIT    8   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.bc6
 FILE TYPE:BCF6   UNIT   11   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.wel
 FILE TYPE:WEL   UNIT   12   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.drn
 FILE TYPE:DRN   UNIT   13   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.rch
 FILE TYPE:RCH   UNIT   18   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.sip
 FILE TYPE:SIP   UNIT   19   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.oc
 FILE TYPE:OC   UNIT   22   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twri.dis
 FILE TYPE:DIS   UNIT   10   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 BAS -- BASIC PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT    8

 DISCRETIZATION INPUT DATA READ FROM UNIT   10
    3 LAYERS        15 ROWS        15 COLUMNS
    1 STRESS PERIOD(S) IN SIMULATION
 MODEL TIME UNIT IS SECONDS
 MODEL LENGTH UNIT IS UNDEFINED
  Confining bed flag for each layer:
   1   1   0

                     DELR =   5000.00

                     DELC =   5000.00
```

Figure A–2. Listing File for example problem without parameters.

```
TOP ELEVATION OF LAYER 1 =   200.000
  MODEL LAYER BOTTOM EL. =  -150.000     FOR LAYER   1

BOT. EL. OF QUASI-3D BED =  -200.000     FOR LAYER   1

  MODEL LAYER BOTTOM EL. =  -300.000     FOR LAYER   2

BOT. EL. OF QUASI-3D BED =  -350.000     FOR LAYER   2

  MODEL LAYER BOTTOM EL. =  -450.000     FOR LAYER   3


STRESS PERIOD     LENGTH       TIME STEPS     MULTIPLIER FOR DELT    SS FLAG
----------------------------------------------------------------------------
       1         86400.00          1                    1.000         SS

STEADY-STATE SIMULATION




#SAMPLE----3 LAYERS, 15 ROWS, 15 COLUMNS; STEADY STATE; CONSTANT HEADS COLUMN 1
#LAYERS 1 AND 2; RECHARGE, WELLS AND DRAINS



                    BOUNDARY ARRAY FOR LAYER   1
READING ON UNIT    8 WITH FORMAT: (20I4)

       1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
................................................................
  1   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  2   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  3   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  4   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  5   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  6   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  7   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  8   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  9   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 10   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 11   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 12   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 13   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 14   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 15   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
                    BOUNDARY ARRAY FOR LAYER   2
READING ON UNIT    8 WITH FORMAT: (20I4)

       1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
................................................................
  1   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  2   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  3   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  4   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  5   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  6   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  7   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  8   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  9   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 10   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 11   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 12   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 13   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 14   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 15   -1   1   1   1   1   1   1   1   1   1   1   1   1   1   1

          BOUNDARY ARRAY =              1 FOR LAYER   3

AQUIFER HEAD WILL BE SET TO  999.99     AT ALL NO-FLOW NODES (IBOUND=0).

            INITIAL HEAD =   0.00000     FOR LAYER   1

            INITIAL HEAD =   0.00000     FOR LAYER   2

            INITIAL HEAD =   0.00000     FOR LAYER   3

OUTPUT CONTROL IS SPECIFIED ONLY AT TIME STEPS FOR WHICH OUTPUT IS DESIRED
HEAD PRINT FORMAT CODE IS  20    DRAWDOWN PRINT FORMAT CODE IS   0
HEADS WILL BE SAVED ON UNIT    0    DRAWDOWNS WILL BE SAVED ON UNIT    0

BCF -- BLOCK-CENTERED FLOW PACKAGE, VERSION 7, 5/2/2005
        INPUT READ FROM UNIT 11
STEADY-STATE SIMULATION
HEAD AT CELLS THAT CONVERT TO DRY=  0.10000E+31
WETTING CAPABILITY IS NOT ACTIVE
     LAYER  LAYER-TYPE CODE     INTERBLOCK T
     --------------------------------------------
        1            1          0 -- HARMONIC
        2            0          0 -- HARMONIC
        3            0          0 -- HARMONIC
```

Figure A–2. Listing File for example problem without parameters.—Continued

COLUMN TO ROW ANISOTROPY =   1.00000

```
    HYD. COND. ALONG ROWS =  1.000000E-03 FOR LAYER   1

 VERT HYD COND /THICKNESS =  2.000000E-08 FOR LAYER   1

     TRANSMIS. ALONG ROWS =  1.000000E-02 FOR LAYER   2

 VERT HYD COND /THICKNESS =  1.000000E-08 FOR LAYER   2

     TRANSMIS. ALONG ROWS =  2.000000E-02 FOR LAYER   3

 WEL -- WELL PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT   12
 No named parameters
 MAXIMUM OF     15 ACTIVE WELLS AT ONE TIME


     0 Well parameters

 DRN -- DRAIN PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT   13
 No named parameters
 MAXIMUM OF      9 ACTIVE DRAINS AT ONE TIME


     0 Drain parameters

 RCH -- RECHARGE PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT   18
 No named parameters
 OPTION 1 -- RECHARGE TO TOP LAYER


     0 Recharge parameters

 SIP -- STRONGLY-IMPLICIT PROCEDURE SOLUTION PACKAGE
                    VERSION 7, 5/2/2005 INPUT READ FROM UNIT   19
 MAXIMUM OF  50 ITERATIONS ALLOWED FOR CLOSURE
  5 ITERATION PARAMETERS

          SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
          -------------------------------------------
 MAXIMUM ITERATIONS ALLOWED FOR CLOSURE =       50
                 ACCELERATION PARAMETER =     1.0000
      HEAD CHANGE CRITERION FOR CLOSURE =    0.10000E-02
      SIP HEAD CHANGE PRINTOUT INTERVAL =        1

     5 ITERATION PARAMETERS CALCULATED FROM SPECIFIED WSEED = 0.00100000 :

  0.000000E+00 0.822172E+00 0.968377E+00 0.994377E+00 0.999000E+00
1
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
                                        STRESS PERIOD NO.    1, LENGTH =   86400.00
                                        ----------------------------------------------

                                          NUMBER OF TIME STEPS =     1

                                           MULTIPLIER FOR DELT =     1.000

                                        INITIAL TIME STEP SIZE =   86400.00

 WELL NO.  LAYER   ROW   COL   STRESS RATE
 --------------------------------------------------
      1      3      5     11      -5.000
      2      2      4      6      -5.000
      3      2      6     12      -5.000
      4      1      9      8      -5.000
      5      1      9     10      -5.000
      6      1      9     12      -5.000
      7      1      9     14      -5.000
      8      1     11      8      -5.000
      9      1     11     10      -5.000
     10      1     11     12      -5.000
     11      1     11     14      -5.000
     12      1     13      8      -5.000
     13      1     13     10      -5.000
     14      1     13     12      -5.000
     15      1     13     14      -5.000

     15 WELLS

 DRAIN NO.  LAYER   ROW   COL     DRAIN EL.  CONDUCTANCE
 ----------------------------------------------------------------
      1      1      8      2       0.000          1.000
      2      1      8      3       0.000          1.000
      3      1      8      4       10.00          1.000
      4      1      8      5       20.00          1.000
      5      1      8      6       30.00          1.000
      6      1      8      7       50.00          1.000
      7      1      8      8       70.00          1.000
      8      1      8      9       90.00          1.000
      9      1      8     10       100.0          1.000

      9 DRAINS

                 RECHARGE =  3.000000E-08

 SOLVING FOR HEAD

    31 ITERATIONS FOR TIME STEP   1 IN STRESS PERIOD    1
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
 MAXIMUM HEAD CHANGE FOR EACH ITERATION:

    HEAD CHANGE   HEAD CHANGE   HEAD CHANGE   HEAD CHANGE   HEAD CHANGE
  LAYER,ROW,COL LAYER,ROW,COL LAYER,ROW,COL LAYER,ROW,COL LAYER,ROW,COL
 ------------------------------------------------------------------------
     -22.41         12.48         13.39         48.21         35.91
  (  3,  5, 11) (  1,  1, 15) (  3,  1, 14) (  1,  1, 15) (  3,  1, 13)
      2.482         1.430         6.214         7.411         13.66
  (  1,  9, 14) (  3, 10, 13) (  1, 12, 14) (  3, 11, 14) (  1, 15, 15)
     0.5503        0.4821        0.4711         2.019         2.302
  (  3,  8,  7) (  2,  6,  9) (  3,  5, 10) (  1, 11, 14) (  3,  5, 13)
     0.1108        0.7059E-01    0.2819        0.3141        0.3320
  (  1, 13, 12) (  3, 12, 11) (  1, 14, 14) (  3, 13, 14) (  1, 15, 15)
     0.7853E-02    0.1586E-01    0.1777E-01    0.7910E-01    0.8500E-01
  (  1, 13, 12) (  2, 11, 11) (  3, 11, 10) (  1, 14, 14) (  3,  7, 14)
     0.4169E-02    0.2555E-02    0.9769E-02    0.1082E-01    0.1030E-01
  (  1, 13, 14) (  3, 14, 15) (  1, 14, 14) (  3, 13, 14) (  1, 15, 15)
     0.2430E-03
  (  1, 13, 12)


 OUTPUT CONTROL FOR STRESS PERIOD    1   TIME STEP   1
    PRINT HEAD FOR ALL LAYERS
1
             HEAD IN LAYER   1 AT END OF TIME STEP   1 IN STRESS PERIOD    1
  ---------------------------------------------------------------------------

            1           2           3           4           5           6
            7           8           9          10          11          12
           13          14          15
 ........................................................................
   1    0.000       24.94       44.01       59.26       71.82       82.52
        91.91       100.0       106.9       112.6       117.4       121.3
        124.3       126.4       127.4
   2    0.000       24.45       43.10       57.98       70.17       80.57
        90.12       98.40       105.3       111.0       115.7       119.6
        122.7       124.9       126.1
   3    0.000       23.45       41.30       55.43       66.78       76.21
        86.51       95.20       102.2       107.6       112.0       116.1
        119.6       122.1       123.4
   4    0.000       21.92       38.61       51.75       61.79       68.03
        81.34       90.75       97.64       102.5       106.1       110.7
        114.9       117.9       119.4
   5    0.000       19.73       34.92       47.32       57.69       66.74
        77.09       85.76       92.22       96.15       97.29       103.1
        108.8       112.5       114.3
   6    0.000       16.51       29.50       40.90       51.30       61.21
        71.19       79.85       86.47       90.82       93.03       94.23
        102.1       106.4       108.4
   7    0.000       11.55       21.10       31.21       41.40       51.84
        63.08       72.68       79.95       84.92       88.60       91.66
        96.43       99.82       101.8
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
   8    0.000        3.483        6.832        16.25        26.30        36.97
        52.59        64.31        72.52        77.25        81.99        85.00
        89.27        91.72        94.33
   9    0.000        10.54        19.11        28.12        36.92        45.27
        52.95        55.38        65.15        66.07        73.93        73.79
        80.84        80.17        86.49
  10    0.000        14.62        25.86        35.38        43.49        50.11
        54.93        57.55        62.95        65.55        70.39        72.44
        76.72        78.26        81.79
  11    0.000        17.11        29.96        40.01        47.78        53.24
        55.81        53.33        60.27        59.29        66.43        65.45
        72.22        71.04        77.62
  12    0.000        18.68        32.56        43.07        50.81        55.92
        58.33        58.47        61.93        63.18        67.12        68.50
        72.29        73.46        76.85
  13    0.000        19.67        34.24        45.14        53.01        58.04
        59.91        56.75        62.59        60.91        67.22        65.75
        71.90        70.35        76.48
  14    0.000        20.27        35.27        46.48        54.61        60.08
        63.17        64.52        67.25        68.79        71.64        73.18
        75.84        77.03        79.09
  15    0.000        20.56        35.78        47.16        55.48        61.26
        65.02        67.52        69.94        72.01        74.29        76.22
        78.22        79.66        80.82
1
              HEAD IN LAYER   2 AT END OF TIME STEP   1 IN STRESS PERIOD    1
  ---------------------------------------------------------------------------

            1            2            3            4            5            6
            7            8            9           10           11           12
           13           14           15
 ........................................................................
   1    0.000        24.66        43.73        59.02        71.61        82.32
        91.72        99.86        106.7        112.5        117.2        121.1
        124.1        126.2        127.3
   2    0.000        24.17        42.83        57.74        69.95        80.36
        89.93        98.22        105.1        110.8        115.5        119.4
        122.6        124.8        125.9
   3    0.000        23.17        41.03        55.19        66.53        75.77
        86.29        95.02        102.0        107.4        111.8        116.0
        119.5        121.9        123.2
   4    0.000        21.65        38.34        51.50        61.35        60.17
        80.90        90.55        97.45        102.3        105.4        110.4
        114.8        117.7        119.2
   5    0.000        19.48        34.65        47.07        57.44        66.30
        76.85        85.57        92.00        95.41        91.09        102.1
        108.6        112.4        114.2
   6    0.000        16.27        29.24        40.65        51.07        60.98
        70.98        79.65        86.28        90.54        92.06        86.23
        101.7        106.2        108.3
   7    0.000        11.38        20.95        31.05        41.25        51.70
        62.90        72.48        79.76        84.73        88.35        91.24
        96.22        99.65        101.6
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
  8     0.000       4.209       8.330       17.58       27.58       38.25
        52.94       64.19       72.34       77.12       81.81       84.86
        89.10       91.59       94.17
  9     0.000       10.38       18.96       27.98       36.79       45.16
        52.86       56.13       65.08       66.79       73.87       74.48
        80.77       80.84       86.38
 10     0.000       14.40       25.61       35.15       43.27       49.91
        54.76       57.48       62.79       65.49       70.24       72.37
        76.57       78.20       81.64
 11     0.000       16.87       29.70       39.78       47.56       53.05
        55.68       54.09       60.20       60.04       66.37       66.18
        72.16       71.75       77.51
 12     0.000       18.43       32.31       42.85       50.60       55.73
        58.16       58.41       61.78       63.12       66.98       68.44
        72.15       73.40       76.69
 13     0.000       19.42       33.98       44.91       52.80       57.85
        59.78       57.50       62.53       61.65       67.16       66.48
        71.84       71.06       76.37
 14     0.000       20.02       35.02       46.26       54.41       59.88
        62.99       64.39       67.08       68.66       71.48       73.06
        75.68       76.91       78.93
 15     0.000       20.30       35.52       46.94       55.28       61.07
        64.84       67.34       69.76       71.84       74.11       76.04
        78.04       79.49       80.65
1
              HEAD IN LAYER   3 AT END OF TIME STEP   1 IN STRESS PERIOD    1
  ---------------------------------------------------------------------------

            1           2           3           4           5           6
            7           8           9          10          11          12
           13          14          15
 ........................................................................
  1     1.800       24.34       43.36       58.70       71.33       82.06
        91.48       99.63       106.5       112.3       117.0       120.9
        123.9       126.0       127.1
  2     1.764       23.85       42.46       57.42       69.66       80.07
        89.68       97.99       104.9       110.6       115.3       119.2
        122.4       124.6       125.7
  3     1.691       22.86       40.67       54.87       66.20       75.28
        85.98       94.77       101.7       107.2       111.5       115.7
        119.3       121.7       123.0
  4     1.578       21.35       37.98       51.17       60.85       62.69
        80.41       90.28       97.19       101.9       104.1       110.0
        114.5       117.5       119.0
  5     1.415       19.18       34.30       46.75       57.10       65.80
        76.54       85.30       91.67       94.17       77.46       100.7
        108.2       112.1       114.0
  6     1.176       15.99       28.91       40.33       50.76       60.67
        70.70       79.38       86.01       90.12       90.60       88.55
        101.2       106.0       108.0
  7    0.8273       11.21       20.79       30.88       41.09       51.55
        62.67       72.22       79.50       84.46       87.98       90.77
        95.94       99.41       101.4
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
  8   0.4331       5.131       10.19       19.27       29.19       39.84
       53.40       64.07       72.11       76.95       81.58       84.68
       88.88       91.44       93.95
  9   0.7543       10.22       18.82       27.84       36.66       45.06
       52.78       57.03       65.02       67.64       73.81       75.31
       80.72       81.64       86.24
 10    1.039       14.13       25.29       34.85       42.99       49.65
       54.54       57.44       62.61       65.44       70.05       72.33
       76.39       78.15       81.43
 11    1.224       16.59       29.37       39.47       47.28       52.79
       55.53       55.01       60.16       60.94       66.33       67.06
       72.13       72.60       77.38
 12    1.341       18.15       31.97       42.54       50.32       55.47
       57.94       58.37       61.60       63.08       66.80       68.41
       71.97       73.36       76.49
 13    1.415       19.14       33.65       44.61       52.53       57.60
       59.63       58.39       62.48       62.54       67.12       67.35
       71.80       71.90       76.24
 14    1.460       19.73       34.68       45.96       54.13       59.63
       62.76       64.24       66.87       68.52       71.27       72.91
       75.47       76.77       78.71
 15    1.481       20.01       35.18       46.63       55.00       60.81
       64.59       67.11       69.52       71.61       73.87       75.82
       77.81       79.27       80.42
1
  VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP  1 IN STRESS PERIOD   1
  ------------------------------------------------------------------------------

     CUMULATIVE VOLUMES      L**3       RATES FOR THIS TIME STEP      L**3/T
     ------------------                 ------------------------

           IN:                                   IN:
           ---                                   ---
             STORAGE =           0.0000            STORAGE =           0.0000
       CONSTANT HEAD =           0.0000      CONSTANT HEAD =           0.0000
               WELLS =           0.0000              WELLS =           0.0000
              DRAINS =           0.0000             DRAINS =           0.0000
            RECHARGE =    13608000.0000           RECHARGE =         157.5000

            TOTAL IN =    13608000.0000           TOTAL IN =         157.5000

          OUT:                                  OUT:
          ----                                  ----
             STORAGE =           0.0000            STORAGE =           0.0000
       CONSTANT HEAD =     4326522.0000      CONSTANT HEAD =          50.0755
               WELLS =     6480000.0000              WELLS =          75.0000
              DRAINS =     2801081.2500             DRAINS =          32.4199
            RECHARGE =           0.0000           RECHARGE =           0.0000

           TOTAL OUT =    13607603.0000          TOTAL OUT =         157.4954
            IN - OUT =         397.0000           IN - OUT =       4.5929E-03

 PERCENT DISCREPANCY =           0.00     PERCENT DISCREPANCY =           0.00
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
          TIME SUMMARY AT END OF TIME STEP   1 IN STRESS PERIOD    1
                    SECONDS     MINUTES      HOURS       DAYS        YEARS
                    -----------------------------------------------------------
   TIME STEP LENGTH  86400.      1440.0      24.000      1.0000     2.73785E-03
 STRESS PERIOD TIME  86400.      1440.0      24.000      1.0000     2.73785E-03
         TOTAL TIME  86400.      1440.0      24.000      1.0000     2.73785E-03
1

 Run end date and time (yyyy/mm/dd hh:mm:ss): 2005/11/25  9:53:57
 Elapsed run time:  0.328 Seconds
```

Figure A–2. Listing File for example problem without parameters.

Example With Parameters

The same problem is run using the LPF Package. LPF does not have an option to enter transmissivity for confined layers; instead, horizontal hydraulic conductivity (HK) must be entered for all layers. HK values for layers 2 and 3 were not directly specified in the problem, but HK can be easily calculated from the specified values of transmissivity and the assumed layer thicknesses.

LPF also differs from BCF in the way that vertical hydraulic information is entered. LPF requires vertical hydraulic conductivity for each model layer and Quasi–3D confining bed, whereas BCF requires only the vertical leakance (VCONT) between nodes, which is the vertical hydraulic conductivity (including a Quasi–3D confining bed, if it exists) divided by the distance between nodes. In this problem, there are Quasi–3D confining layers separating the model layers, and VCONT would be calculated using equation 5–40. For example, for a cell in layer 1, VCONT would be calculated from the VCONT of half the thickness of layer 1, the full thickness of the confining bed, and half the thickness of layer 2. The problem, however, directly defines VCONT values rather than providing the component parts for computing VCONT, and the vertical hydraulic conductivity of each layer and the confining beds cannot be uniquely calculated from the BCF VCONT values alone. The approach used here is to assume that the confining beds dominate the VCONT calculation and that virtually no contribution comes from the actual model layers, which is consistent with the assumptions used in making the Quasi–3D approximation. If the model layers have no influence on VCONT, then the vertical hydraulic conductivity of the confining bed (VKCB) is VCONT times the confining-bed thickness. For layer 1, VKCB is 10^{-6} ft/s; for layer 2, $5x10^{-7}$ ft/s.

Although the assumption is that for the above calculation of VKCB there is no contribution to vertical conductance (CV) from the aquifer vertical hydraulic conductivity (VK), LPF requires VK to be specified as part of the input data. According to equation 5–26, VK should be infinite in order to have no impact on CV. There is no way to directly specify an infinite value for VK, but the effect of having an infinite value can be obtained by making the VK values large compared to VKCB. For this example problem, VK is set to 1.0 feet per second (ft/s) for all model layers, which is a million times larger than the largest VKCB. The low impact of this value on CV is demonstrated by the fact that the calculated head as shown in the Listing File when LPF is used (fig. A–3) is the same as the head in the BCF Listing File (fig. A–2).

Note that any combination of VK and CBVK that produces virtually the same CV that BCF calculates using the original VCONT values will produce the same heads in this problem. If the values of VK for layer 1 were relatively small compared to CBVK, then the VK values would have to be varied from cell to cell because the saturated thickness of layer 1 varies; that is, as indicated by equation 5–26, the conductance between cells depends on saturated thickness of the model cells. Thus, the choice to use a large VK in order to essentially eliminate the aquifer contribution to CV makes the LPF input simpler than it would be if a small VK were used.

Another difference in the input data for this problem is that parameters are used for defining some of the data in order to illustrate the use of parameters. Parameters are used for defining HK, VKCB, RECH, well recharge and drain conductance input variables. In the LPF Package, five parameters are used—three define HK, and two define VKCB. Each of these parameters is for a single layer, and each parameter has a uniform value for the entire layer. HK1, HK2, and HK3 are HK for layers 1, 2, and 3, respectively. These use “NONE” for the multiplier array, which means that a multiplier array is not used. Instead, the parameter value applies directly to all of the included cells. The zone array is "ALL," which means the values for all cells in the indicated layer are defined by the parameter. Parameter VKCB1 defines VKCB values for all of layer 1, and VKCB2 defines VKCB values for layer 2. Both of these parameters use the same multiplier array, which has a value of 1.0E-6 at all cells. The parameter value for VKCB1 is 1.0, and the value for VKCB2 is 0.5, which produces the required values of 1.0E-6 for layer 1 and 5.0E-7 for layer 2.

For the RCH Package, two parameters, RCH1 and RCH2, are used. RCH1 includes the left seven columns of the grid, and RCH2 includes the right 8 columns. These areas are specified using zone array RCHZONES, which contains "1" in columns 1–7, and "2" in columns 8–15. Accordingly, the zone value of 1 is specified in the definition of RCH1, and zone value 2 is specified for RCH2. The parameter values for RCH1 and RCH2 are both 3.0E-8, which results in all cells having the same recharge rate. Thus, having two parameters is not advantageous in this example; however, two zones were used to illustrate how this is done. The value of having two zones would become apparent if there were a need to change the recharge rate in the area of zone 1 without changing the zone 2 values. This could be done simply by changing the value of parameter RCH1.

The Well Package has one parameter, WELL1, and the Drain Package has one parameter, DRN1. Both of these parameters have a value of 1.0, so the multipliers in the lists for both parameters are simply the same as the data values that are used to define the input data without using parameters. Using parameters could be advantageous, however, if there were a need to change all of the input values associated with the parameters. All of the values could be changed by a constant factor simply by changing the parameter values. The parameters define only part of the wells and drains. Some of them are defined as separate nonparameter lists.

The input files that are different as a result of using LPF instead of BCF and adding parameters are shown below. The DIS, BAS, SIP, and OC files are not shown again because they are unchanged.

Name File

```
LIST   6 twri.lst
BAS6   5 twri.ba6
LPF   11 twri.lpf
WEL   12 twri.wel
DRN   13 twri.drn
RCH   18 twri.rch
SIP   19 twri.sip
OC    22 twri.oc
MULT   8 twri.mlt
ZONE   9 twri.zon
DIS   10 twri.dis
```

Multiplier File

```
1
MULT1
CONSTANT 1.0E-6
```

Figure A–2. Listing File for example problem without parameters.—Continued

Zone File

```
1
RCHZONES
INTERNAL 1 (15I2)   1
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
```

Layer-Property Flow Package (LPF) File

```
#  LPF Package input data for example problem
0  1.00E+30    5 ILPFCB,HDRY,NPLPF
 1 0 0           LAYTYP
 0 0 0           LAYAVG
 1. 1. 1.        CHANI
 0 0 0           LAYVKA
 0 0 0           LAYWET
HK1 HK  1.0E-3 1
1 NONE ALL
HK2 HK  1.0E-4 1
2 NONE ALL
HK3 HK  2.0E-4 1
3 NONE ALL
VKCB1 VKCB 1.0 1
1 MULT1 ALL
VKCB2 VKCB 0.5 1
2 MULT1 ALL
0                        HK layer   1
CONSTANT   1.0           VK layer   1
0                        VKCB layer 1
0                        HK layer   2
CONSTANT   1.0           VK layer   2
0                        VKCB layer 2
0                        HK  ayer   3
CONSTANT   1.0           VK layer   3
```

Figure A–2. Listing File for example problem without parameters.—Continued

Recharge Package (RCH) File

```
PARAMETER  2
         1         0    NRCHOP,IRCHBD
RCH1  RCH  3.0E-8  1
NONE  RCHZONES  1
RCH2  RCH  3.0E-8  1
NONE  RCHZONES  2
         2              INRECH
RCH1
RCH2
```

Well Package (WEL) File

```
PARAMETER 1 12
        15         0    MXACTW,IWELCB
WELL1 Q  1.0 12
         1         9         8       -5.
         1         9        10       -5.
         1         9        12       -5.
         1         9        14       -5.
         1        11         8       -5.
         1        11        10       -5.
         1        11        12       -5.
         1        11        14       -5.
         1        13         8       -5.
         1        13        10       -5.
         1        13        12       -5.
         1        13        14       -5.
         3         1                  ITMP,NP
         3         5        11       -5.
         2         4         6       -5.
         2         6        12       -5.
WELL1
```

Drain Package (DRN) File

```
PARAMETER  1  2
         9         0    MXACTD,IDRNCB
DRN1  DRN  1.0   2
         1         8         2        0.      1.E00
         1         8         3        0.      1.E00
         7         1     ITMP,NP
         1         8         4       10.      1.E00
         1         8         5       20.      1.E00
```

Figure A–2. Listing File for example problem without parameters.—Continued

```
         1         8         6        30.      1.E00
         1         8         7        50.      1.E00
         1         8         8        70.      1.E00
         1         8         9        90.      1.E00
         1         8        10       100.      1.E00
DRN1
```

The Listing File is shown in figure A–3.

```
                                  MODFLOW-2005
      U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER FLOW MODEL
                             VERSION 1.00 12/15/2005

 LIST FILE: twrip.lst
                         UNIT    2

 OPENING twrip.ba6
 FILE TYPE:BAS6   UNIT    3   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.lpf
 FILE TYPE:LPF   UNIT   11   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.wel
 FILE TYPE:WEL   UNIT   12   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.drn
 FILE TYPE:DRN   UNIT   13   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.rch
 FILE TYPE:RCH   UNIT   18   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.sip
 FILE TYPE:SIP   UNIT   19   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.oc
 FILE TYPE:OC   UNIT   22   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.mlt
 FILE TYPE:MULT   UNIT    8   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL
```

Figure A–3. Listing File for example problem with parameters.

```
OPENING twrip.zon
 FILE TYPE:ZONE   UNIT    9   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 OPENING twrip.dis
 FILE TYPE:DIS   UNIT   10   STATUS:OLD
 FORMAT:FORMATTED              ACCESS:SEQUENTIAL

 BAS -- BASIC PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT    3

 DISCRETIZATION INPUT DATA READ FROM UNIT   10
    3 LAYERS        15 ROWS        15 COLUMNS
    1 STRESS PERIOD(S) IN SIMULATION
 MODEL TIME UNIT IS SECONDS
 MODEL LENGTH UNIT IS UNDEFINED
  Confining bed flag for each layer:
   1   1   0

                     DELR =   5000.00

                     DELC =   5000.00

 TOP ELEVATION OF LAYER 1 =   200.000

   MODEL LAYER BOTTOM EL. =  -150.000     FOR LAYER   1

 BOT. EL. OF QUASI-3D BED =  -200.000     FOR LAYER   1

   MODEL LAYER BOTTOM EL. =  -300.000     FOR LAYER   2

 BOT. EL. OF QUASI-3D BED =  -350.000     FOR LAYER   2

   MODEL LAYER BOTTOM EL. =  -450.000     FOR LAYER   3


 STRESS PERIOD     LENGTH       TIME STEPS     MULTIPLIER FOR DELT    SS FLAG
 ----------------------------------------------------------------------------
        1         86400.00          1                    1.000         SS

 STEADY-STATE SIMULATION




 #SAMPLE----3 LAYERS, 15 ROWS, 15 COLUMNS; STEADY STATE; CONSTANT HEADS COLUMN 1
 #LAYERS 1 AND 2; RECHARGE, WELLS AND DRAINS
```

Figure A-3. Listing File for example problem with parameters.—Continued

BOUNDARY ARRAY FOR LAYER 1

READING ON UNIT 3 WITH FORMAT: (20I4)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

BOUNDARY ARRAY FOR LAYER 2

READING ON UNIT 3 WITH FORMAT: (20I4)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

BOUNDARY ARRAY = 1 FOR LAYER 3

AQUIFER HEAD WILL BE SET TO 999.99 AT ALL NO-FLOW NODES (IBOUND=0).

INITIAL HEAD = 0.00000 FOR LAYER 1

INITIAL HEAD = 0.00000 FOR LAYER 2

INITIAL HEAD = 0.00000 FOR LAYER 3

Figure A–3. Listing File for example problem with parameters.—Continued

```
OUTPUT CONTROL IS SPECIFIED ONLY AT TIME STEPS FOR WHICH OUTPUT IS DESIRED
 HEAD PRINT FORMAT CODE IS  20    DRAWDOWN PRINT FORMAT CODE IS   0
 HEADS WILL BE SAVED ON UNIT    0    DRAWDOWNS WILL BE SAVED ON UNIT    0

 ZONE OPTION, INPUT READ FROM UNIT    9
     1 ZONE ARRAYS

 MULTIPLIER OPTION, INPUT READ FROM UNIT    8
   1 MULTIPLIER ARRAYS

  MULT. ARRAY: MULT1      =  1.000000E-06



              ZONE ARRAY: RCHZONES
 READING ON UNIT    9 WITH FORMAT: (15I2)

      1 2 3 4 5 6 7 8 9101112131415
 ..................................
   1  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   2  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   3  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   4  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   5  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   6  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   7  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   8  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
   9  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
  10  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
  11  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
  12  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
  13  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
  14  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
  15  1 1 1 1 1 1 1 2 2 2 2 2 2 2 2

 LPF -- LAYER-PROPERTY FLOW PACKAGE, VERSION 7, 5/2/2005
         INPUT READ FROM UNIT   11
 #  LPF Package input data for example problem
 HEAD AT CELLS THAT CONVERT TO DRY=  1.00000E+30
     5 Named Parameters

   LAYER FLAGS:
 LAYER       LAYTYP        LAYAVG         CHANI        LAYVKA        LAYWET
 ---------------------------------------------------------------------------
    1             1             0     1.000E+00             0             0
    2             0             0     1.000E+00             0             0
    3             0             0     1.000E+00             0             0
```

Figure A–3. Listing File for example problem with parameters.—Continued

```
  INTERPRETATION OF LAYER FLAGS:
                       INTERBLOCK     HORIZONTAL    DATA IN
        LAYER TYPE   TRANSMISSIVITY   ANISOTROPY   ARRAY VKA   WETTABILITY
LAYER      (LAYTYP)      (LAYAVG)       (CHANI)      (LAYVKA)      (LAYWET)
---------------------------------------------------------------------------
   1   CONVERTIBLE      HARMONIC     1.000E+00    VERTICAL K  NON-WETTABLE
   2      CONFINED      HARMONIC     1.000E+00    VERTICAL K  NON-WETTABLE
   3      CONFINED      HARMONIC     1.000E+00    VERTICAL K  NON-WETTABLE

WETTING CAPABILITY IS NOT ACTIVE IN ANY LAYER

PARAMETERS DEFINED IN THE LPF PACKAGE

PARAMETER NAME:HK1          TYPE:HK     CLUSTERS:   1
Parameter value from package file is:   1.00000E-03
               LAYER:   1    MULTIPLIER ARRAY: NONE    ZONE ARRAY: ALL

PARAMETER NAME:HK2          TYPE:HK     CLUSTERS:   1
Parameter value from package file is:   1.00000E-04
               LAYER:   2    MULTIPLIER ARRAY: NONE    ZONE ARRAY: ALL

PARAMETER NAME:HK3          TYPE:HK     CLUSTERS:   1
Parameter value from package file is:   2.00000E-04
               LAYER:   3    MULTIPLIER ARRAY: NONE    ZONE ARRAY: ALL

PARAMETER NAME:VKCB1        TYPE:VKCB   CLUSTERS:   1
Parameter value from package file is:    1.0000
               LAYER:   1    MULTIPLIER ARRAY: MULT1    ZONE ARRAY: ALL

PARAMETER NAME:VKCB2        TYPE:VKCB   CLUSTERS:   1
Parameter value from package file is:   0.50000
               LAYER:   2    MULTIPLIER ARRAY: MULT1    ZONE ARRAY: ALL

   HYD. COND. ALONG ROWS FOR LAYER   1 WILL BE DEFINED BY PARAMETERS
(PRINT FLAG=   0)

   HYD. COND. ALONG ROWS is defined by the following parameters:
HK1

   HYD. COND. ALONG ROWS =  1.000000E-03 FOR LAYER   1

     VERTICAL HYD. COND. =   1.00000     FOR LAYER   1

QUASI3D VERT. HYD. COND. FOR LAYER   1 WILL BE DEFINED BY PARAMETERS
(PRINT FLAG=   0)

QUASI3D VERT. HYD. COND. is defined by the following parameters:
VKCB1

QUASI3D VERT. HYD. COND. =  1.000000E-06 FOR LAYER   1
```

Figure A–3. Listing File for example problem with parameters.—Continued

```
   HYD. COND. ALONG ROWS FOR LAYER   2 WILL BE DEFINED BY PARAMETERS
(PRINT FLAG=   0)

   HYD. COND. ALONG ROWS is defined by the following parameters:
HK2

   HYD. COND. ALONG ROWS =  1.000000E-04 FOR LAYER   2

     VERTICAL HYD. COND. =   1.00000     FOR LAYER   2

QUASI3D VERT. HYD. COND. FOR LAYER   2 WILL BE DEFINED BY PARAMETERS
(PRINT FLAG=   0)

QUASI3D VERT. HYD. COND. is defined by the following parameters:
VKCB2

QUASI3D VERT. HYD. COND. =  5.000000E-07 FOR LAYER   2

   HYD. COND. ALONG ROWS FOR LAYER   3 WILL BE DEFINED BY PARAMETERS
(PRINT FLAG=   0)

   HYD. COND. ALONG ROWS is defined by the following parameters:
HK3

   HYD. COND. ALONG ROWS =  2.000000E-04 FOR LAYER   3

     VERTICAL HYD. COND. =   1.00000     FOR LAYER   3

WEL -- WELL PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT   12
    1 Named Parameters        12 List entries
MAXIMUM OF     15 ACTIVE WELLS AT ONE TIME


    1 Well parameters

PARAMETER NAME:WELL1        TYPE:Q
Parameter value from package file is:    1.0000
  NUMBER OF ENTRIES:     12

WELL NO.  LAYER   ROW   COL   STRESS FACTOR
----------------------------------------------------
     1      1      9      8      -5.000
     2      1      9     10      -5.000
     3      1      9     12      -5.000
     4      1      9     14      -5.000
     5      1     11      8      -5.000
     6      1     11     10      -5.000
     7      1     11     12      -5.000
     8      1     11     14      -5.000
     9      1     13      8      -5.000
    10      1     13     10      -5.000
    11      1     13     12      -5.000
    12      1     13     14      -5.000
```

Figure A-3. Listing File for example problem with parameters.—Continued

```
DRN -- DRAIN PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT   13
    1 Named Parameters         2 List entries
MAXIMUM OF      9 ACTIVE DRAINS AT ONE TIME


    1 Drain parameters

PARAMETER NAME:DRN1         TYPE:DRN
Parameter value from package file is:    1.0000
  NUMBER OF ENTRIES:      2

DRAIN NO.  LAYER   ROW   COL     DRAIN EL.  STRESS FACTOR
------------------------------------------------------------------
     1      1      8      2       0.000           1.000
     2      1      8      3       0.000           1.000

RCH -- RECHARGE PACKAGE, VERSION 7, 5/2/2005 INPUT READ FROM UNIT   18
    2 Named Parameters
OPTION 1 -- RECHARGE TO TOP LAYER


    2 Recharge parameters

PARAMETER NAME:RCH1         TYPE:RCH    CLUSTERS:   1
Parameter value from package file is:   3.00000E-08
               MULTIPLIER ARRAY: NONE    ZONE ARRAY: RCHZONES
               ZONE VALUES:    1

PARAMETER NAME:RCH2         TYPE:RCH    CLUSTERS:   1
Parameter value from package file is:   3.00000E-08
               MULTIPLIER ARRAY: NONE    ZONE ARRAY: RCHZONES
               ZONE VALUES:    2

SIP -- STRONGLY-IMPLICIT PROCEDURE SOLUTION PACKAGE
                   VERSION 7, 5/2/2005 INPUT READ FROM UNIT   19
MAXIMUM OF  50 ITERATIONS ALLOWED FOR CLOSURE
 5 ITERATION PARAMETERS

         SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
         -------------------------------------------
MAXIMUM ITERATIONS ALLOWED FOR CLOSURE =       50
                ACCELERATION PARAMETER =     1.0000
     HEAD CHANGE CRITERION FOR CLOSURE =    0.10000E-02
     SIP HEAD CHANGE PRINTOUT INTERVAL =        1

    5 ITERATION PARAMETERS CALCULATED FROM SPECIFIED WSEED = 0.00100000 :

 0.000000E+00 0.822172E+00 0.968377E+00 0.994377E+00 0.999000E+00
1
```

Figure A-3. Listing File for example problem with parameters.—Continued

```
                                 STRESS PERIOD NO.    1, LENGTH =   86400.00
                                 ----------------------------------------------

                                   NUMBER OF TIME STEPS =     1

                                    MULTIPLIER FOR DELT =     1.000

                                 INITIAL TIME STEP SIZE =   86400.00
```

WELL NO.	LAYER	ROW	COL	STRESS RATE
1	3	5	11	-5.000
2	2	4	6	-5.000
3	2	6	12	-5.000

Parameter: WELL1

WELL NO.	LAYER	ROW	COL	STRESS RATE
4	1	9	8	-5.000
5	1	9	10	-5.000
6	1	9	12	-5.000
7	1	9	14	-5.000
8	1	11	8	-5.000
9	1	11	10	-5.000
10	1	11	12	-5.000
11	1	11	14	-5.000
12	1	13	8	-5.000
13	1	13	10	-5.000
14	1	13	12	-5.000
15	1	13	14	-5.000

15 WELLS

DRAIN NO.	LAYER	ROW	COL	DRAIN EL.	CONDUCTANCE
1	1	8	4	10.00	1.000
2	1	8	5	20.00	1.000
3	1	8	6	30.00	1.000
4	1	8	7	50.00	1.000
5	1	8	8	70.00	1.000
6	1	8	9	90.00	1.000
7	1	8	10	100.0	1.000

Parameter: DRN1

DRAIN NO.	LAYER	ROW	COL	DRAIN EL.	CONDUCTANCE
8	1	8	2	0.000	1.000
9	1	8	3	0.000	1.000

9 DRAINS

Figure A–3. Listing File for example problem with parameters.—Continued

```
 RECH array defined by the following parameters:
 Parameter:  RCH1
 Parameter:  RCH2

                 RECHARGE =  3.000000E-08

 SOLVING FOR HEAD

    31 ITERATIONS FOR TIME STEP   1 IN STRESS PERIOD    1

 MAXIMUM HEAD CHANGE FOR EACH ITERATION:

    HEAD CHANGE   HEAD CHANGE   HEAD CHANGE   HEAD CHANGE   HEAD CHANGE
  LAYER,ROW,COL LAYER,ROW,COL LAYER,ROW,COL LAYER,ROW,COL LAYER,ROW,COL
 ----------------------------------------------------------------------
     -22.41         12.48         13.39         48.21         35.91
  (  3,  5, 11) (  1,  1, 15) (  3,  1, 14) (  1,  1, 15) (  3,  1, 13)
      2.482         1.430         6.214         7.411         13.66
  (  1,  9, 14) (  3, 10, 13) (  1, 12, 14) (  3, 11, 14) (  1, 15, 15)
     0.5503        0.4821        0.4711         2.019         2.302
  (  3,  8,  7) (  2,  6,  9) (  3,  5, 10) (  1, 11, 14) (  3,  5, 13)
     0.1108        0.7058E-01    0.2819        0.3141        0.3320
  (  1, 13, 12) (  3, 12, 11) (  1, 14, 14) (  3, 13, 14) (  1, 15, 15)
     0.7853E-02    0.1586E-01    0.1777E-01    0.7910E-01    0.8499E-01
  (  1, 13, 12) (  2, 11, 11) (  3, 11, 10) (  1, 14, 14) (  3,  7, 14)
     0.4169E-02    0.2555E-02    0.9769E-02    0.1082E-01    0.1030E-01
  (  1, 13, 14) (  3, 14, 15) (  1, 14, 14) (  3, 13, 14) (  1, 15, 15)
     0.2430E-03
  (  1, 13, 12)


 OUTPUT CONTROL FOR STRESS PERIOD    1   TIME STEP   1
    PRINT HEAD FOR ALL LAYERS
1
              HEAD IN LAYER   1 AT END OF TIME STEP   1 IN STRESS PERIOD    1
  ---------------------------------------------------------------------------

            1           2           3           4           5           6
            7           8           9          10          11          12
           13          14          15
 .........................................................................
   1    0.000       24.94       44.01       59.26       71.82       82.52
        91.91       100.0       106.9       112.6       117.4       121.3
        124.3       126.4       127.4
   2    0.000       24.45       43.10       57.98       70.17       80.57
        90.12       98.40       105.3       111.0       115.7       119.6
        122.7       124.9       126.1
   3    0.000       23.45       41.30       55.43       66.78       76.21
        86.51       95.20       102.2       107.6       112.0       116.1
        119.6       122.1       123.4
   4    0.000       21.92       38.61       51.75       61.79       68.03
        81.34       90.75       97.64       102.5       106.1       110.7
        114.9       117.9       119.4
```

Figure A–3. Listing File for example problem with parameters.—Continued

```
   5     0.000         19.73         34.92         47.32         57.69         66.74
         77.09         85.76         92.22         96.15         97.29         103.1
         108.8         112.5         114.3
   6     0.000         16.51         29.50         40.90         51.30         61.21
         71.19         79.85         86.47         90.82         93.03         94.23
         102.1         106.4         108.4
   7     0.000         11.55         21.10         31.21         41.40         51.84
         63.08         72.68         79.95         84.92         88.60         91.66
         96.43         99.82         101.8
   8     0.000         3.483         6.832         16.25         26.30         36.97
         52.59         64.31         72.52         77.25         81.99         85.00
         89.27         91.72         94.33
   9     0.000         10.54         19.11         28.12         36.92         45.27
         52.95         55.38         65.15         66.07         73.93         73.79
         80.84         80.17         86.49
  10     0.000         14.62         25.86         35.38         43.49         50.11
         54.93         57.55         62.95         65.55         70.39         72.44
         76.72         78.26         81.79
  11     0.000         17.11         29.96         40.01         47.78         53.24
         55.81         53.33         60.27         59.29         66.43         65.45
         72.22         71.04         77.62
  12     0.000         18.68         32.56         43.07         50.81         55.92
         58.33         58.47         61.93         63.18         67.12         68.50
         72.29         73.46         76.85
  13     0.000         19.67         34.24         45.14         53.01         58.04
         59.91         56.75         62.59         60.91         67.22         65.75
         71.90         70.35         76.48
  14     0.000         20.27         35.27         46.48         54.61         60.08
         63.17         64.52         67.25         68.79         71.64         73.18
         75.84         77.03         79.09
  15     0.000         20.56         35.78         47.16         55.48         61.26
         65.02         67.52         69.94         72.01         74.29         76.22
         78.22         79.66         80.82
1
               HEAD IN LAYER   2 AT END OF TIME STEP   1 IN STRESS PERIOD    1
  ---------------------------------------------------------------------------

             1             2             3             4             5             6
             7             8             9            10            11            12
            13            14            15
 ..................................................................................
   1     0.000         24.66         43.73         59.02         71.61         82.32
         91.72         99.86         106.7         112.5         117.2         121.1
         124.1         126.2         127.3
   2     0.000         24.17         42.83         57.74         69.95         80.36
         89.93         98.22         105.1         110.8         115.5         119.4
         122.6         124.8         125.9
   3     0.000         23.17         41.03         55.19         66.53         75.77
         86.29         95.02         102.0         107.4         111.8         116.0
         119.5         121.9         123.2
   4     0.000         21.65         38.34         51.50         61.35         60.17
         80.90         90.55         97.45         102.3         105.4         110.4
         114.8         117.7         119.2
```

Figure A–3. Listing File for example problem with parameters.—Continued

```
   5    0.000       19.48       34.65       47.07       57.44       66.30
        76.85       85.57       92.00       95.41       91.09       102.1
        108.6       112.4       114.2
   6    0.000       16.27       29.24       40.65       51.07       60.98
        70.98       79.65       86.28       90.54       92.06       86.23
        101.7       106.2       108.3
   7    0.000       11.38       20.95       31.05       41.25       51.70
        62.90       72.48       79.76       84.73       88.35       91.24
        96.22       99.65       101.6
   8    0.000       4.209       8.330       17.58       27.58       38.25
        52.94       64.19       72.34       77.12       81.81       84.86
        89.10       91.59       94.17
   9    0.000       10.38       18.96       27.98       36.79       45.16
        52.86       56.13       65.08       66.79       73.87       74.48
        80.77       80.84       86.38
  10    0.000       14.40       25.61       35.15       43.27       49.91
        54.76       57.48       62.79       65.49       70.24       72.37
        76.57       78.20       81.64
  11    0.000       16.87       29.70       39.78       47.56       53.05
        55.68       54.09       60.20       60.04       66.37       66.18
        72.16       71.75       77.51
  12    0.000       18.43       32.31       42.85       50.60       55.73
        58.16       58.41       61.78       63.12       66.98       68.44
        72.15       73.40       76.69
  13    0.000       19.42       33.98       44.91       52.80       57.85
        59.78       57.50       62.53       61.65       67.16       66.48
        71.84       71.06       76.37
  14    0.000       20.02       35.02       46.26       54.41       59.88
        62.99       64.39       67.08       68.66       71.48       73.06
        75.68       76.91       78.93
  15    0.000       20.30       35.52       46.94       55.28       61.07
        64.84       67.34       69.76       71.84       74.11       76.04
        78.04       79.49       80.65
1
              HEAD IN LAYER   3 AT END OF TIME STEP   1 IN STRESS PERIOD    1
  ---------------------------------------------------------------------------

            1           2           3           4           5           6
            7           8           9          10          11          12
           13          14          15
 ........................................................................
   1    1.800       24.34       43.36       58.70       71.33       82.06
        91.48       99.63       106.5       112.3       117.0       120.9
        123.9       126.0       127.1
   2    1.764       23.85       42.46       57.42       69.66       80.07
        89.68       97.99       104.9       110.6       115.3       119.2
        122.4       124.6       125.7
   3    1.691       22.86       40.67       54.87       66.20       75.28
        85.98       94.77       101.7       107.2       111.5       115.7
        119.3       121.7       123.0
```

Figure A-3. Listing File for example problem with parameters.—Continued

```
   4    1.578       21.35       37.98       51.17       60.85       62.69
        80.41       90.28       97.19       101.9       104.1       110.0
        114.5       117.5       119.0
   5    1.415       19.18       34.30       46.75       57.10       65.80
        76.54       85.30       91.67       94.17       77.46       100.7
        108.2       112.1       114.0
   6    1.176       15.99       28.91       40.33       50.76       60.67
        70.70       79.38       86.01       90.12       90.60       88.55
        101.2       106.0       108.0
   7   0.8273       11.21       20.79       30.88       41.09       51.55
        62.67       72.22       79.50       84.46       87.98       90.77
        95.94       99.41       101.4
   8   0.4331       5.131       10.19       19.27       29.19       39.84
        53.40       64.07       72.11       76.95       81.58       84.68
        88.88       91.44       93.95
   9   0.7543       10.22       18.82       27.84       36.66       45.06
        52.78       57.03       65.02       67.64       73.81       75.31
        80.72       81.64       86.24
  10    1.039       14.13       25.29       34.85       42.99       49.65
        54.54       57.44       62.61       65.44       70.05       72.33
        76.39       78.15       81.43
  11    1.224       16.59       29.37       39.47       47.28       52.79
        55.53       55.01       60.16       60.94       66.33       67.06
        72.13       72.60       77.38
  12    1.341       18.15       31.97       42.54       50.32       55.47
        57.94       58.37       61.60       63.08       66.80       68.41
        71.97       73.36       76.49
  13    1.415       19.14       33.65       44.61       52.53       57.60
        59.63       58.39       62.48       62.54       67.12       67.35
        71.80       71.90       76.24
  14    1.460       19.73       34.68       45.96       54.13       59.63
        62.76       64.24       66.87       68.52       71.27       72.91
        75.47       76.77       78.71
  15    1.481       20.01       35.18       46.63       55.00       60.81
        64.59       67.11       69.52       71.61       73.87       75.82
        77.81       79.27       80.42
1
  VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP  1 IN STRESS PERIOD   1
  -------------------------------------------------------------------------------

     CUMULATIVE VOLUMES      L**3       RATES FOR THIS TIME STEP      L**3/T
     ------------------                 ------------------------

           IN:                                   IN:
           ---                                   ---
             STORAGE =           0.0000                STORAGE =           0.0000
       CONSTANT HEAD =           0.0000          CONSTANT HEAD =           0.0000
               WELLS =           0.0000                  WELLS =           0.0000
              DRAINS =           0.0000                 DRAINS =           0.0000
            RECHARGE =    13608000.0000               RECHARGE =         157.5000

            TOTAL IN =    13608000.0000               TOTAL IN =         157.5000
```

Figure A–3. Listing File for example problem with parameters.—Continued

```
          OUT:                                    OUT:
          ----                                    ----
             STORAGE =           0.0000              STORAGE =           0.0000
       CONSTANT HEAD =     4326522.0000        CONSTANT HEAD =          50.0755
               WELLS =     6480000.0000                WELLS =          75.0000
              DRAINS =     2801081.2500               DRAINS =          32.4199
            RECHARGE =           0.0000             RECHARGE =           0.0000

           TOTAL OUT =    13607603.0000            TOTAL OUT =         157.4954

            IN - OUT =         397.0000             IN - OUT =       4.5929E-03

 PERCENT DISCREPANCY =           0.00     PERCENT DISCREPANCY =           0.00




          TIME SUMMARY AT END OF TIME STEP   1 IN STRESS PERIOD    1
                    SECONDS     MINUTES      HOURS       DAYS        YEARS
                    -----------------------------------------------------------
   TIME STEP LENGTH  86400.      1440.0      24.000      1.0000     2.73785E-03
 STRESS PERIOD TIME  86400.      1440.0      24.000      1.0000     2.73785E-03
         TOTAL TIME  86400.      1440.0      24.000      1.0000     2.73785E-03
1

 Run end date and time (yyyy/mm/dd hh:mm:ss): 2005/11/25  9:54:02
 Elapsed run time:  0.297 Seconds
```

Figure A–3. Listing File for example problem with parameters.—Continued