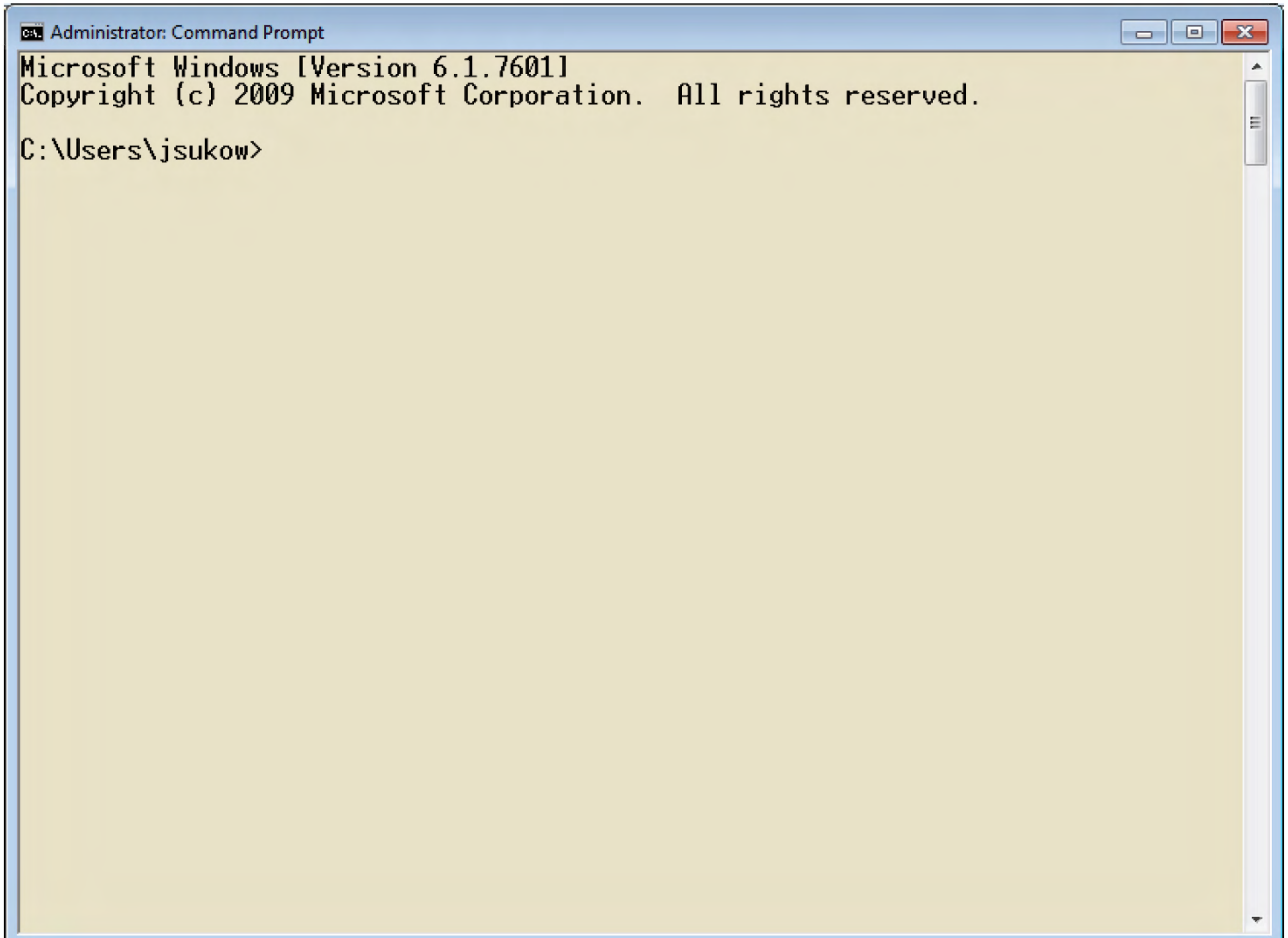
Running the WRV model from the Command Prompt



Files needed to run the model and extract results

- Download MODFLOW-USG V1.2.00 https://idwr.idaho.gov/WaterInformation/Projects/woodriver/ or MODFLOW-USG V1.3.00 http://water.usgs.gov/ogw/mfusg/#downloads
- Edit Path Variable to include location of mfusg.exe, or copy mfusg.exe to local directory
- Download calibrated WRV model files https://pubs.er.usgs.gov/publication/sir20165080 or, https://idwr.idaho.gov/WaterInformation/Projects/woodriver/, copy to local directory
- Download groundwater utilities http://www.pesthomepage.org/Downloads.php
- Edit Path Variable to include location of groundwater utilities, or copy selected utilities to local directory
- Add IDWR post-processing files to local directory https://idwr.idaho.gov/WaterInformation/Projects/woodriver/

Navigate to local directory and run MODFLOW

Administrator: Command Prompt - mfusg

```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

C:\Users\jsukow>f:

F:\>cd F:\WRV\Training\Baseline

F:\WRV\Training\Baseline>mfusg

                                  MODFLOW-USG
    U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUNDWATER FLOW MODEL
                             Version 1.2.00 03/21/2014

  Enter the name of the NAME FILE:
wrv_mfusg1
 Using NAME file: wrv_mfusg1.nam
 Run start date and time (yyyy/mm/dd hh:mm:ss): 2016/09/22 14:48:09

 Solving:  Stress period:     1    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     2    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     3    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     4    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     5    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     6    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     7    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     8    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     9    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    10    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    11    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    12    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    13    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    14    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    15    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    16    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    17    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    18    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    19    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    20    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    21    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    22    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    23    Time step:     1    Groundwater Flow Eqn.
```

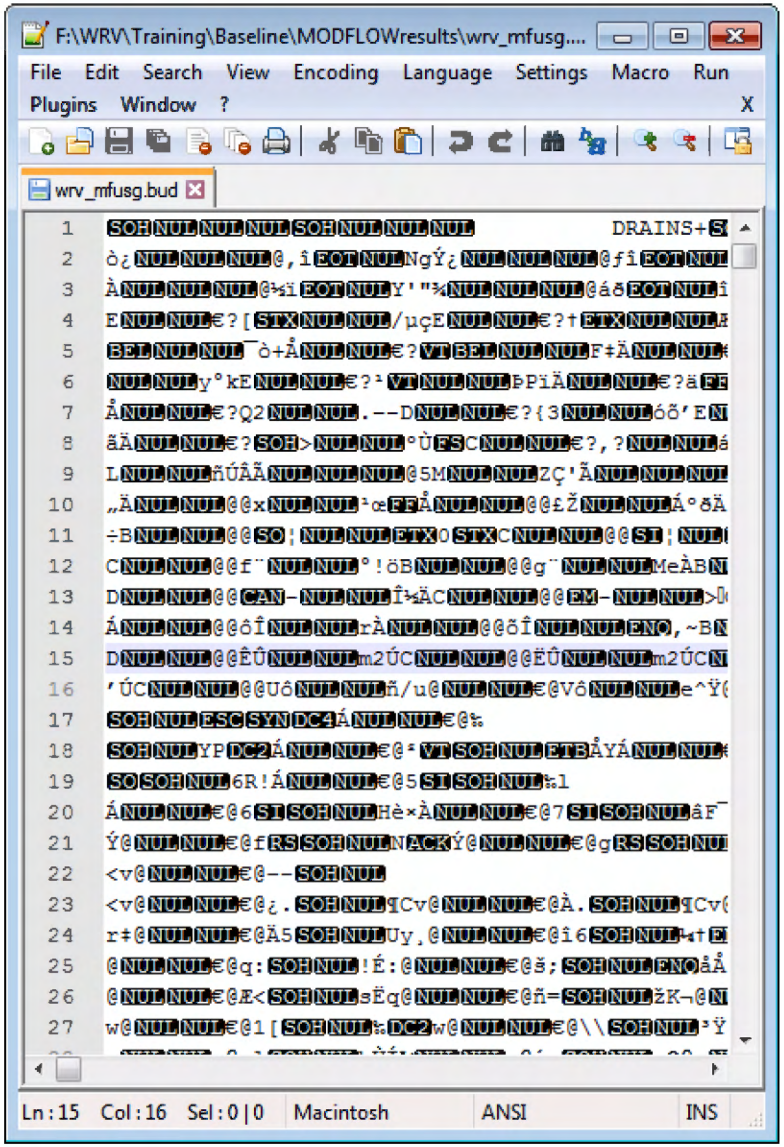
Check for normal termination of MODFLOW and inspect water balance

```
Administrator: Command Prompt
Solving:  Stress period:   146    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   147    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   148    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   149    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   150    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   151    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   152    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   153    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   154    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   155    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   156    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   157    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   158    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   159    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   160    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   161    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   162    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   163    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   164    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   165    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   166    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   167    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   168    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   169    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   170    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   171    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   172    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   173    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   174    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   175    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   176    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   177    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   178    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   179    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   180    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   181    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   182    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   183    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   184    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   185    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   186    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   187    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   188    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   189    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   190    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   191    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   192    Time step:     1    Groundwater Flow Eqn.
Solving:  Stress period:   193    Time step:     1    Groundwater Flow Eqn.
Run end date and time (yyyy/mm/dd hh:mm:ss): 2016/09/22 15:09:39
Elapsed run time: 21 Minutes, 30.437 Seconds

 Normal termination of simulation

F:\WRV\Training\Baseline>
```

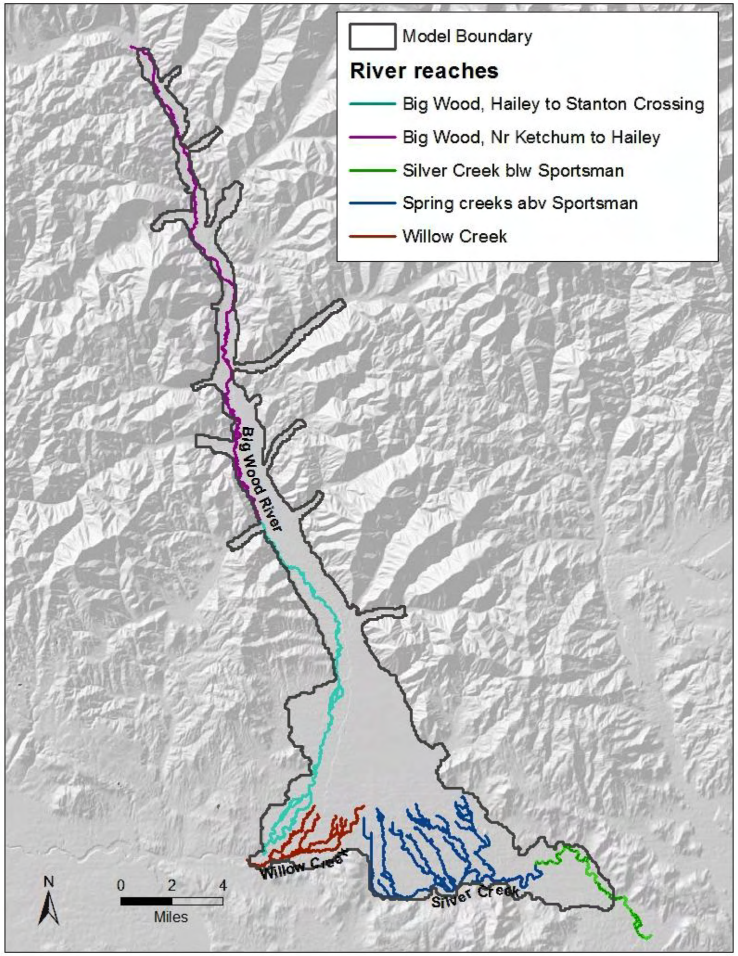
```
VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP      1 IN STRESS PERIOD       7
------------------------------------------------------------------------------------------

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

         IN:                                       IN:
         ---                                       ---
           STORAGE =     14770897.4782               STORAGE =        7868.2132
     CONSTANT HEAD =           0.0000          CONSTANT HEAD =           0.0000
             WELLS =     97810297.5781                 WELLS =      881476.6250
            DRAINS =           0.0000                 DRAINS =           0.0000
     RIVER LEAKAGE =    115997779.1250         RIVER LEAKAGE =      647305.9375

          TOTAL IN =    228578974.1813              TOTAL IN =     1536650.7757

        OUT:                                      OUT:
        ----                                      ----
           STORAGE =     38581014.5758               STORAGE =      388653.6808
     CONSTANT HEAD =           0.0000          CONSTANT HEAD =           0.0000
             WELLS =     21885749.0967                 WELLS =      177686.7500
            DRAINS =      5838730.0923                DRAINS =       34713.0143
     RIVER LEAKAGE =    162289946.0625         RIVER LEAKAGE =      935711.2500

         TOTAL OUT =    228595439.8274             TOTAL OUT =     1536764.6951

          IN - OUT =      -16465.6465               IN - OUT =        -113.9194

PERCENT DISCREPANCY =          -0.01     PERCENT DISCREPANCY =          -0.01


          TIME SUMMARY AT END OF TIME STEP      1 IN STRESS PERIOD       7
                    SECONDS      MINUTES      HOURS       DAYS        YEARS
                    -----------------------------------------------------------
  TIME STEP LENGTH 2.59200E+06  43200.       720.00      30.000      8.21355E-02
STRESS PERIOD TIME 2.59200E+06  43200.       720.00      30.000      8.21355E-02
        TOTAL TIME 1.56384E+07 2.60640E+05   4344.0      181.00      0.49555
```

MODFLOW output

- wrv_mfusg.lst
  - Text file
  - Inspect water balance
  - Troubleshoot failed model runs
- wrv_mfusg.bud
  - Cell-by-cell flow, discharge to river and drain boundaries
  - Unformatted file
- wrv_mfusg.hds
  - Cell-by-cell head
  - Unformatted file



Extract stream-aquifer flux from MODFLOW budget file



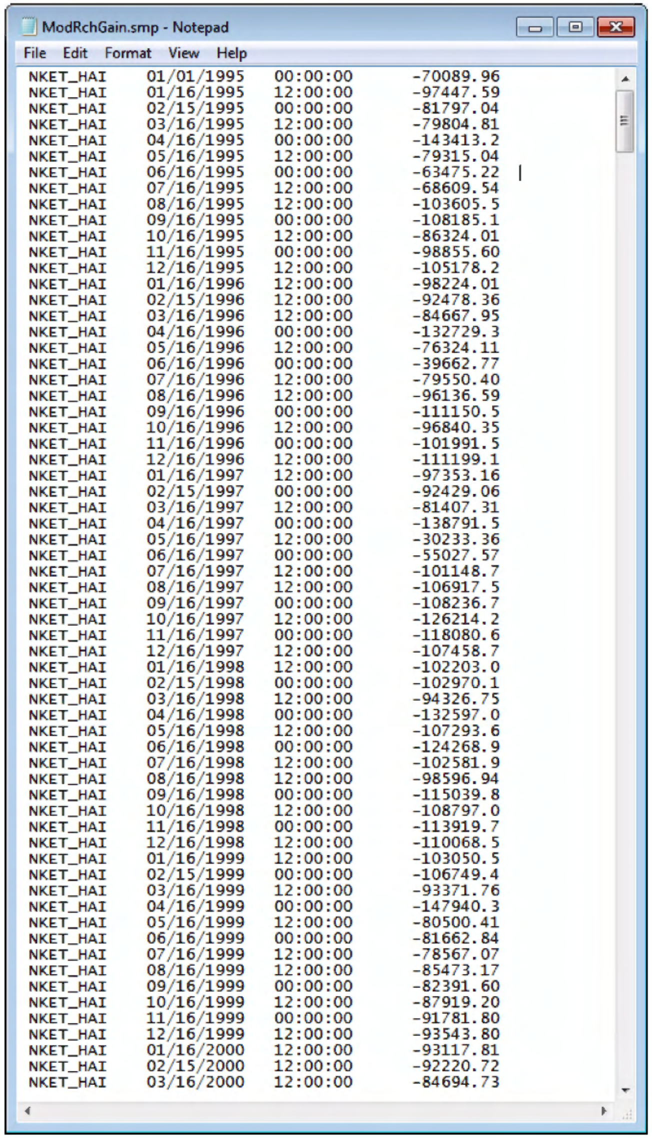
- Bud2smp.exe utility available from John Doherty, author of PEST
- BigRch.inf integer array specifies location of river reaches
- B2s_BigRch.in specifies reach names and other bud2smp input data

Extract stream-aquifer flux from MODFLOW budget file

Administrator: Command Prompt

```
F:\WRV\Training\Baseline>bud2smp<b2s_BigRch.in

 Program BUD2SMP writes a bore sample file of MODFLOW-generated
   inflows/outflows within user-specified zones.

 Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
 are problems in reading files of this type due to incompatibilities between
 different FORTRAN compiliers. If there are any such problems please contact
 johndoherty@ozemail.com.au and I will send you an alternative copy of this
 program.

 Enter name of grid specification file:   - grid specifications read from file w
rv.gsf
 How many layers in model?
 Enter name of MODFLOW unformatted budget output file:  Is this a MODFLOW88 or M
ODFLOW96 budget file  [8/9]?  Enter maximum number of output times:  Enter text
to identify MODFLOW flow type:
 Enter simulation starting date [mm/dd/yyyy]:  Enter simulation starting time [h
h:mm:ss]:  Enter time units employed by model [y/d/h/m/s]:
 Enter name of integer array file for layer 1:   - integer array read from file
bigrch.inf
 Enter name of integer array file for layer 2:   - integer array read from file
bigrch.inf
 Enter name of integer array file for layer 3:   - integer array read from file
bigrch.inf

 A total of 5 different non-zero zones were identified in integer arrays.
 An identifier must now be provided for each zone to appear in the bore
   sample output file:-
   Enter identifier for flows in zone 1 (10 characters or less):    Enter identi
fier for flows in zone 2 (10 characters or less):    Enter identifier for flows
in zone 4 (10 characters or less):    Enter identifier for flows in zone 3 (10 c
haracters or less):    Enter identifier for flows in zone 5 (10 characters or le
ss):
 Enter name for bore sample output file:  Enter flow rate factor:  Assign flows
to beginning, middle or finish of time step?  [b/m/f]:
 Enter name for run record file:
 - data for 193 model output arrays written to file ModRchGain.smp
 - see file BigReach.rec for a record of arrays found in file wrv_mfusg.bud


F:\WRV\Training\Baseline>
```

Bud2smp output for stream-aquifer flux



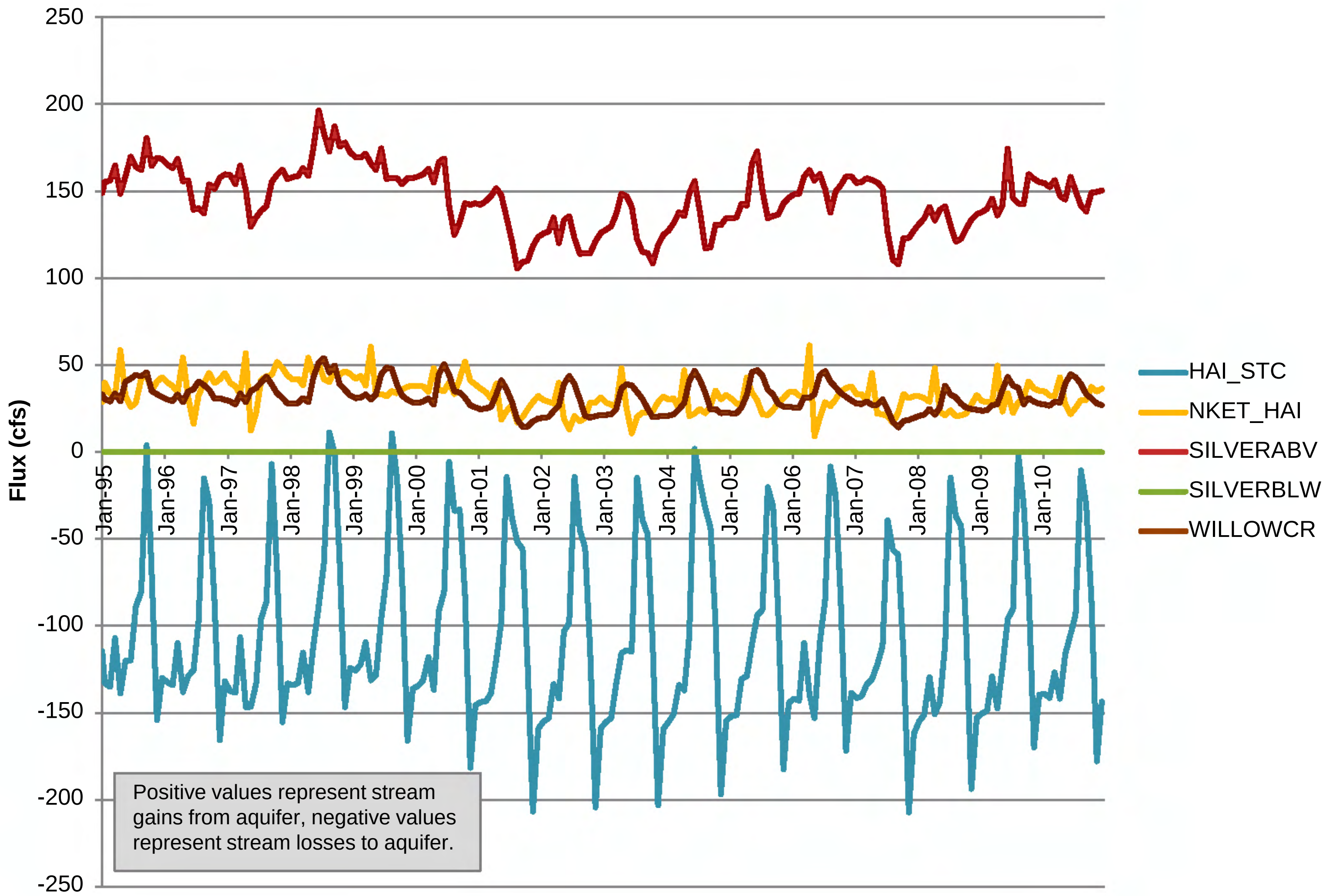
ModRchGain.smp - Notepad

File Edit Format View Help

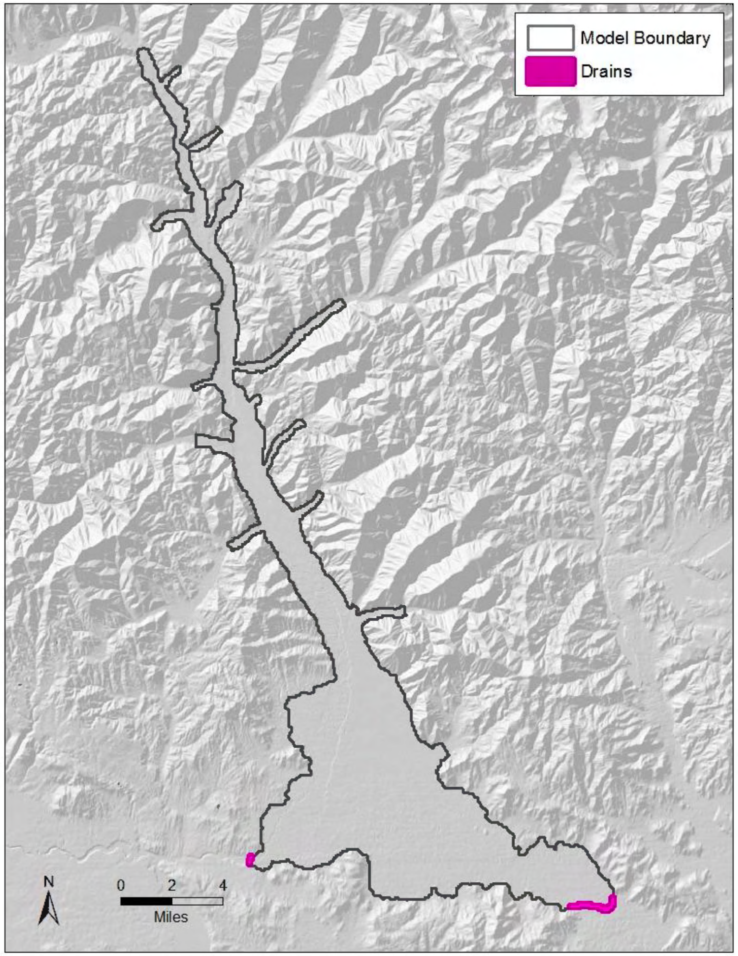
```
NKET_HAI      01/01/1995    00:00:00        -70089.96
NKET_HAI      01/16/1995    12:00:00        -97447.59
NKET_HAI      02/15/1995    00:00:00        -81797.04
NKET_HAI      03/16/1995    12:00:00        -79804.81
NKET_HAI      04/16/1995    00:00:00        -143413.2
NKET_HAI      05/16/1995    12:00:00        -79315.04
NKET_HAI      06/16/1995    00:00:00        -63475.22
NKET_HAI      07/16/1995    12:00:00        -68609.54
NKET_HAI      08/16/1995    12:00:00        -103605.5
NKET_HAI      09/16/1995    00:00:00        -108185.1
NKET_HAI      10/16/1995    12:00:00        -86324.01
NKET_HAI      11/16/1995    00:00:00        -98855.60
NKET_HAI      12/16/1995    12:00:00        -105178.2
NKET_HAI      01/16/1996    12:00:00        -98224.01
NKET_HAI      02/15/1996    12:00:00        -92478.36
NKET_HAI      03/16/1996    12:00:00        -84667.95
NKET_HAI      04/16/1996    00:00:00        -132729.3
NKET_HAI      05/16/1996    12:00:00        -76324.11
NKET_HAI      06/16/1996    00:00:00        -39662.77
NKET_HAI      07/16/1996    12:00:00        -79550.40
NKET_HAI      08/16/1996    12:00:00        -96136.59
NKET_HAI      09/16/1996    00:00:00        -111150.5
NKET_HAI      10/16/1996    12:00:00        -96840.35
NKET_HAI      11/16/1996    00:00:00        -101991.5
NKET_HAI      12/16/1996    12:00:00        -111199.1
NKET_HAI      01/16/1997    12:00:00        -97353.16
NKET_HAI      02/15/1997    00:00:00        -92429.06
NKET_HAI      03/16/1997    12:00:00        -81407.31
NKET_HAI      04/16/1997    00:00:00        -138791.5
NKET_HAI      05/16/1997    12:00:00        -30233.36
NKET_HAI      06/16/1997    00:00:00        -55027.57
NKET_HAI      07/16/1997    12:00:00        -101148.7
NKET_HAI      08/16/1997    12:00:00        -106917.5
NKET_HAI      09/16/1997    00:00:00        -108236.7
NKET_HAI      10/16/1997    12:00:00        -126214.2
NKET_HAI      11/16/1997    00:00:00        -118080.6
NKET_HAI      12/16/1997    12:00:00        -107458.7
NKET_HAI      01/16/1998    12:00:00        -102203.0
NKET_HAI      02/15/1998    00:00:00        -102970.1
NKET_HAI      03/16/1998    12:00:00        -94326.75
NKET_HAI      04/16/1998    00:00:00        -132597.0
NKET_HAI      05/16/1998    12:00:00        -107293.6
NKET_HAI      06/16/1998    00:00:00        -124268.9
NKET_HAI      07/16/1998    12:00:00        -102581.9
NKET_HAI      08/16/1998    12:00:00        -98596.94
NKET_HAI      09/16/1998    00:00:00        -115039.8
NKET_HAI      10/16/1998    12:00:00        -108797.0
NKET_HAI      11/16/1998    00:00:00        -113919.7
NKET_HAI      12/16/1998    12:00:00        -110068.5
NKET_HAI      01/16/1999    12:00:00        -103050.5
NKET_HAI      02/15/1999    00:00:00        -106749.4
NKET_HAI      03/16/1999    12:00:00        -93371.76
NKET_HAI      04/16/1999    00:00:00        -147940.3
NKET_HAI      05/16/1999    12:00:00        -80500.41
NKET_HAI      06/16/1999    00:00:00        -81662.84
NKET_HAI      07/16/1999    12:00:00        -78567.07
NKET_HAI      08/16/1999    12:00:00        -85473.17
NKET_HAI      09/16/1999    00:00:00        -82391.60
NKET_HAI      10/16/1999    12:00:00        -87919.20
NKET_HAI      11/16/1999    00:00:00        -91781.80
NKET_HAI      12/16/1999    12:00:00        -93543.80
NKET_HAI      01/16/2000    12:00:00        -93117.81
NKET_HAI      02/15/2000    12:00:00        -92220.72
NKET_HAI      03/16/2000    12:00:00        -84694.73
```

- Text file
- Flux units are cubic meters per day
- Negative values represent aquifer discharge to stream (gaining stream)
- Positive values represent aquifer recharge from stream (losing stream)
- Units and sign are often converted for presentation of results

Stream-aquifer flux results



Extract groundwater flux across outlet boundaries from MODFLOW budget file



- Bud2smp.exe utility available from John Doherty, author of PEST
- DrainRch.inf integer array specifies location of drain reaches
- B2s_Drain.in specifies reach names and other bud2smp input data

Extract groundwater flux across outlet boundaries from MODFLOW budget file

Administrator: Command Prompt

```
F:\WRV\Training\Baseline>bud2smp<b2s_Drain.in

 Program BUD2SMP writes a bore sample file of MODFLOW-generated
   inflows/outflows within user-specified zones.

 Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
 are problems in reading files of this type due to incompatibilities between
 different FORTRAN compiliers. If there are any such problems please contact
 johndoherty@ozemail.com.au and I will send you an alternative copy of this
 program.

 Enter name of grid specification file:   - grid specifications read from file w
rv.gsf
 How many layers in model?
 Enter name of MODFLOW unformatted budget output file:  Is this a MODFLOW88 or M
ODFLOW96 budget file  [8/9]?  Enter maximum number of output times:  Enter text
to identify MODFLOW flow type:
 Enter simulation starting date [mm/dd/yyyy]:  Enter simulation starting time [h
h:mm:ss]:  Enter time units employed by model [y/d/h/m/s]:
 Enter name of integer array file for layer 1:   - integer array read from file
DrainRch.inf
 Enter name of integer array file for layer 2:   - integer array read from file
DrainRch.inf
 Enter name of integer array file for layer 3:   - integer array read from file
DrainRch.inf

 A total of 2 different non-zero zones were identified in integer arrays.
 An identifier must now be provided for each zone to appear in the bore
   sample output file:-
   Enter identifier for flows in zone 2 (10 characters or less):    Enter identi
fier for flows in zone 1 (10 characters or less):
 Enter name for bore sample output file:  Enter flow rate factor:  Assign flows
to beginning, middle or finish of time step?  [b/m/f]:
 Enter name for run record file:
 - data for 193 model output arrays written to file ModDrain.smp
 - see file Drain.rec for a record of arrays found in file wrv_mfusg.bud


F:\WRV\Training\Baseline>
```

Bud2smp output for flux across outlet boundaries

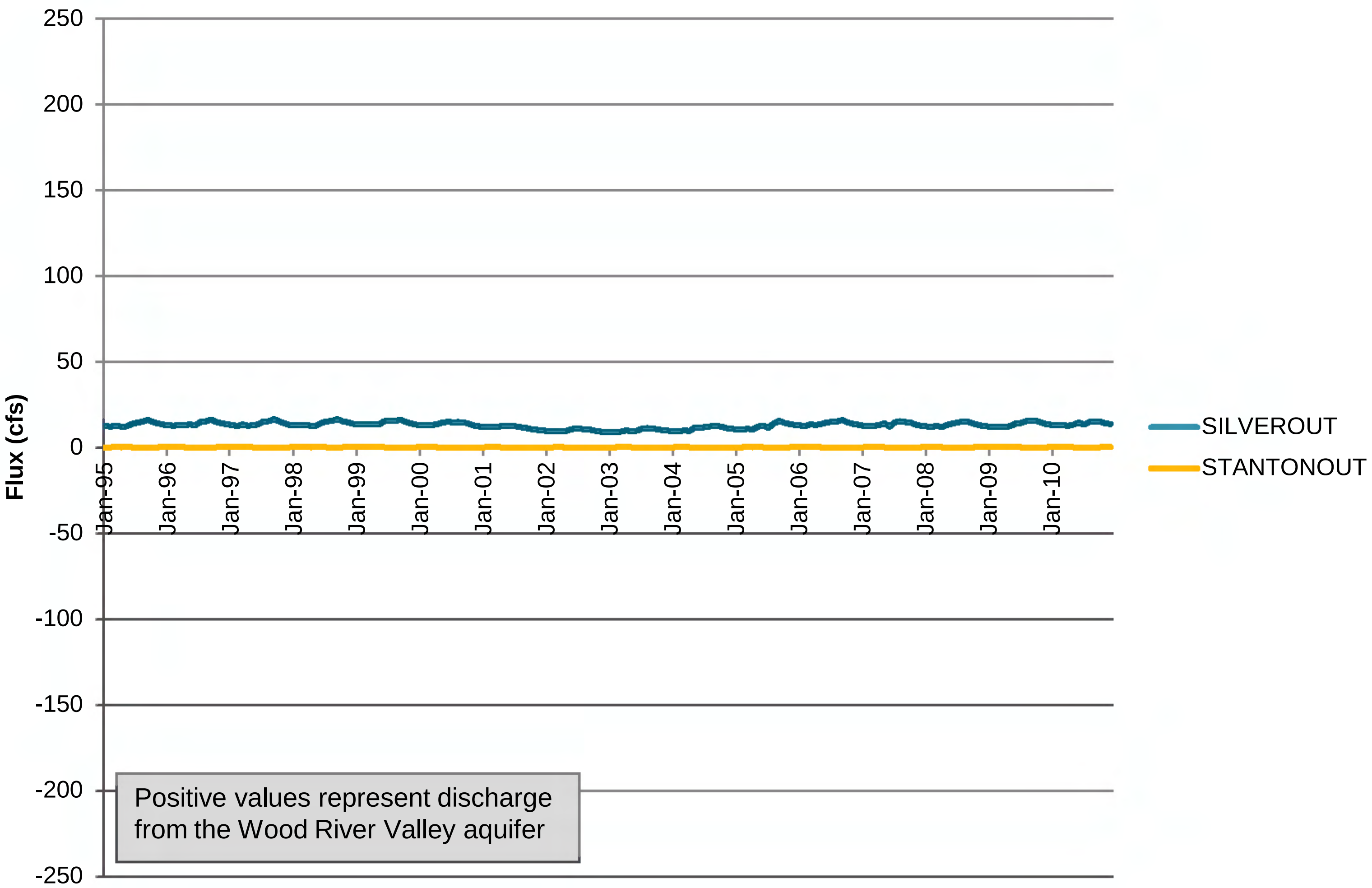
ModDrain.smp - Notepad

File Edit Format View Help

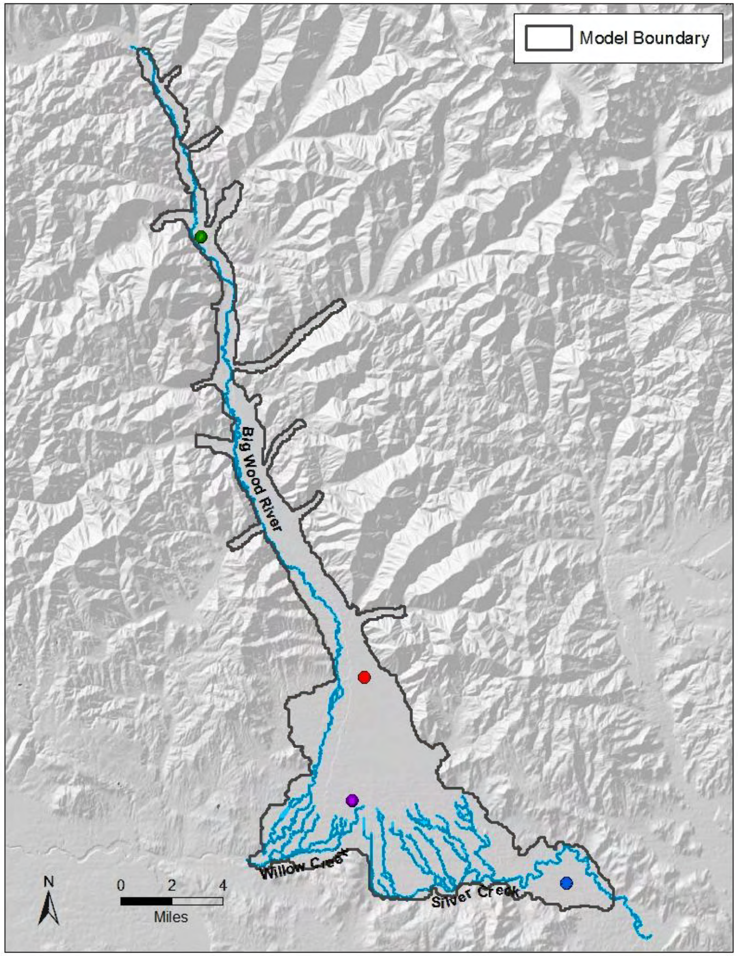
STANTONOUT	01/01/1995	00:00:00	-904.8718
STANTONOUT	01/16/1995	12:00:00	-1018.703
STANTONOUT	02/15/1995	00:00:00	-1028.980
STANTONOUT	03/16/1995	12:00:00	-1334.169
STANTONOUT	04/16/1995	00:00:00	-981.9053
STANTONOUT	05/16/1995	12:00:00	-1062.619
STANTONOUT	06/16/1995	00:00:00	-1006.830
STANTONOUT	07/16/1995	12:00:00	-857.3888
STANTONOUT	08/16/1995	12:00:00	-780.0023
STANTONOUT	09/16/1995	00:00:00	-866.0071
STANTONOUT	10/16/1995	12:00:00	-847.9852
STANTONOUT	11/16/1995	00:00:00	-1010.623
STANTONOUT	12/16/1995	12:00:00	-1032.010
STANTONOUT	01/16/1996	12:00:00	-1034.588
STANTONOUT	02/15/1996	12:00:00	-1047.972
STANTONOUT	03/16/1996	12:00:00	-1289.905
STANTONOUT	04/16/1996	00:00:00	-997.5480
STANTONOUT	05/16/1996	12:00:00	-997.3380
STANTONOUT	06/16/1996	00:00:00	-719.8565
STANTONOUT	07/16/1996	12:00:00	-696.9274
STANTONOUT	08/16/1996	12:00:00	-695.5020
STANTONOUT	09/16/1996	00:00:00	-808.6705
STANTONOUT	10/16/1996	12:00:00	-872.6243
STANTONOUT	11/16/1996	00:00:00	-1082.054
STANTONOUT	12/16/1996	12:00:00	-1069.140
STANTONOUT	01/16/1997	12:00:00	-1064.976
STANTONOUT	02/15/1997	00:00:00	-1033.326
STANTONOUT	03/16/1997	12:00:00	-1389.049
STANTONOUT	04/16/1997	00:00:00	-1043.429
STANTONOUT	05/16/1997	12:00:00	-931.2615
STANTONOUT	06/16/1997	00:00:00	-934.4954
STANTONOUT	07/16/1997	12:00:00	-846.9365
STANTONOUT	08/16/1997	12:00:00	-792.2224
STANTONOUT	09/16/1997	00:00:00	-877.8726
STANTONOUT	10/16/1997	12:00:00	-966.8388
STANTONOUT	11/16/1997	00:00:00	-1030.911
STANTONOUT	12/16/1997	12:00:00	-1001.288
STANTONOUT	01/16/1998	12:00:00	-1038.749
STANTONOUT	02/15/1998	00:00:00	-1079.641
STANTONOUT	03/16/1998	12:00:00	-1241.939
STANTONOUT	04/16/1998	00:00:00	-1023.642
STANTONOUT	05/16/1998	12:00:00	-1155.460
STANTONOUT	06/16/1998	00:00:00	-1120.775
STANTONOUT	07/16/1998	12:00:00	-934.5439
STANTONOUT	08/16/1998	12:00:00	-812.8129
STANTONOUT	09/16/1998	00:00:00	-926.2814
STANTONOUT	10/16/1998	12:00:00	-967.7453
STANTONOUT	11/16/1998	00:00:00	-1082.754
STANTONOUT	12/16/1998	12:00:00	-1035.965
STANTONOUT	01/16/1999	12:00:00	-1047.491
STANTONOUT	02/15/1999	00:00:00	-1128.464
STANTONOUT	03/16/1999	12:00:00	-1229.385
STANTONOUT	04/16/1999	00:00:00	-1037.605
STANTONOUT	05/16/1999	12:00:00	-1041.139
STANTONOUT	06/16/1999	00:00:00	-998.7883
STANTONOUT	07/16/1999	12:00:00	-789.1281
STANTONOUT	08/16/1999	12:00:00	-780.9279
STANTONOUT	09/16/1999	00:00:00	-813.7114
STANTONOUT	10/16/1999	12:00:00	-914.1893
STANTONOUT	11/16/1999	00:00:00	-991.2870
STANTONOUT	12/16/1999	12:00:00	-1008.381
STANTONOUT	01/16/2000	12:00:00	-1034.239
STANTONOUT	02/15/2000	12:00:00	-1105.653
STANTONOUT	03/16/2000	12:00:00	-1205.944

- Text file
- Flux units are cubic meters per day
- Negative values represent subsurface outflow from the Wood River Valley aquifer
- No positive values (MODFLOW drains only allow simulation of discharge from the aquifer)
- Units and sign are often converted for presentation of results

Flux across outlet boundaries

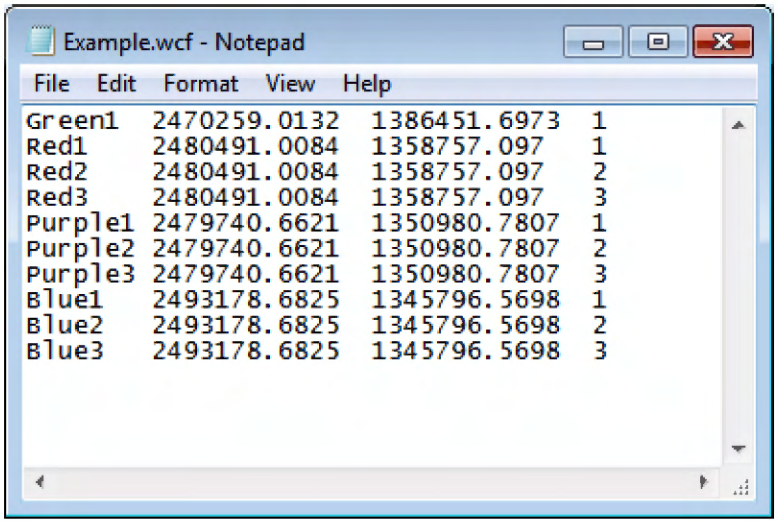


Extract aquifer heads at selected locations from MODFLOW heads file



- mod2smp.exe utility available from John Doherty, author of PEST
- Other utilities are available for extracting heads, download groundwater utilities program descriptions from PEST website for more information

Extract aquifer heads at selected locations from MODFLOW heads file




```
Green1   2470259.0132  1386451.6973  1
Red1     2480491.0084  1358757.097   1
Red2     2480491.0084  1358757.097   2
Red3     2480491.0084  1358757.097   3
Purple1  2479740.6621  1350980.7807  1
Purple2  2479740.6621  1350980.7807  2
Purple3  2479740.6621  1350980.7807  3
Blue1    2493178.6825  1345796.5698  1
Blue2    2493178.6825  1345796.5698  2
Blue3    2493178.6825  1345796.5698  3
```

- “Bore coordinate file” a.k.a. “Well coordinate file” specifies x, y coordinates of location (must be in meters and IDTM83 projection) and model layer
- Bore or well name is limited to 10 characters or less

Extract aquifer heads at selected locations from MODFLOW heads file

```
Administrator: Command Prompt

F:\WRV\Training\Baseline>mod2smp<m2s_example.in

 Program MOD2SMP writes a bore sample file of model-generated heads over
   time, interpolated to the sites of user-supplied bores.

 Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
 are problems in reading files of this type due to incompatibilities between
 different FORTRAN compilers. If there are any such problems please contact
 johndoherty@ozemail.com.au and I will send you an alternative copy of this
 program.

 Enter name of grid specification file:   - grid specifications read from file w
rv.gsf
 Enter name of bore coordinates file:   - 10 bores and coordinates read from bor
e coordinates file example.wcf
 Enter name of bore listing file:   - 10 bores read from bore listing file examp
le.wcf

 Enter name of unformatted model-generated file:  Is this a MODFLOW or MT3D file
?  [f/t]:  How many different output times are represented in this file?  Enter
blanking threshold value for arrays in this file:  Enter time units used by mode
l (yr/day/hr/min/sec) [y/d/h/m/s]:
 Enter simulation starting date [mm/dd/yyyy]:  Enter simulation starting time [h
h:mm:ss]:
 Enter name for bore sample output file:
 Working .....

 - 579 arrays, covering 193 different model output times, read from file
   wrv_mfusg.hds
 - bore sample file examplehds.smp written ok.


F:\WRV\Training\Baseline>_
```

mod2smp output for aquifer heads

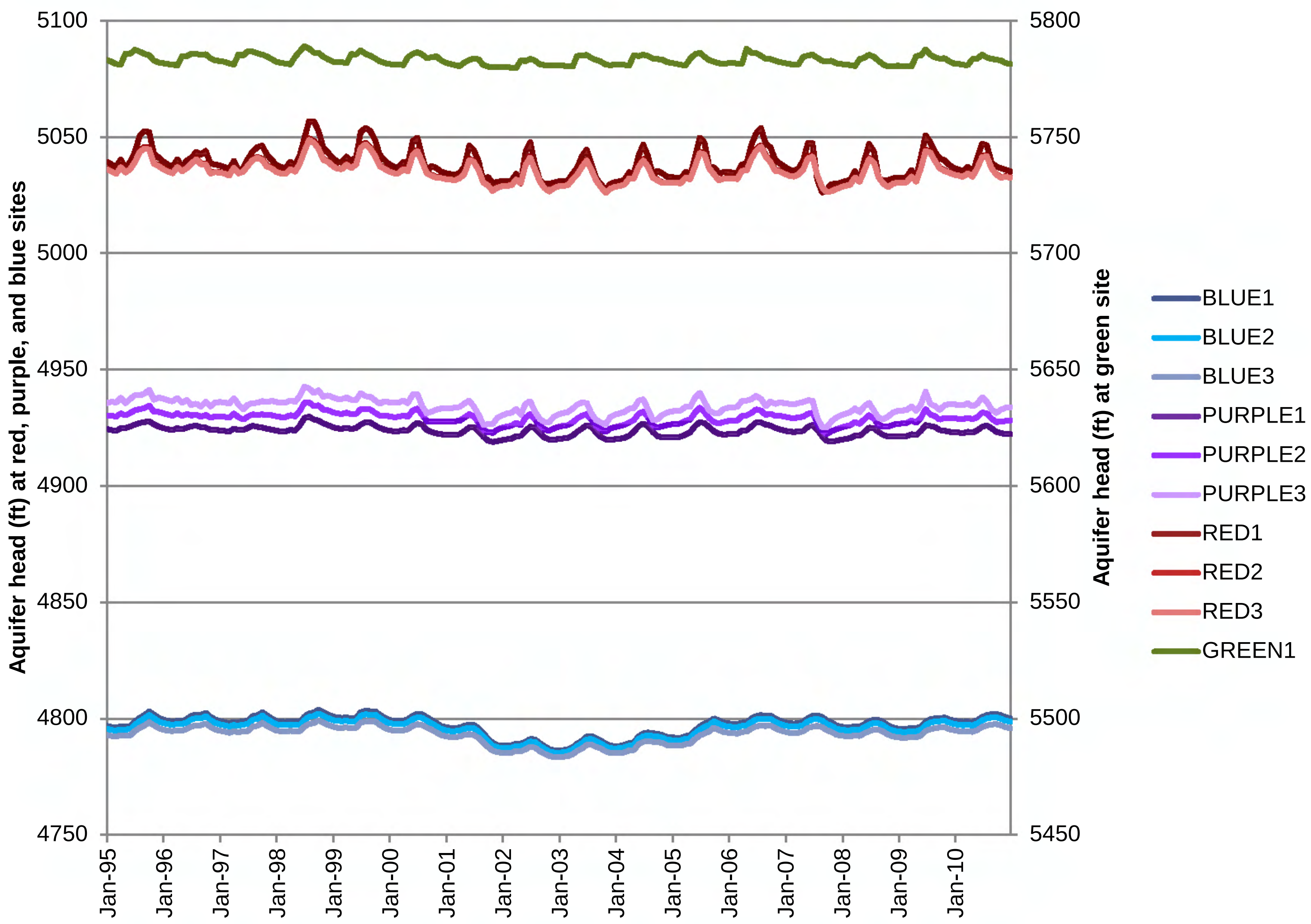
examplehds.smp - Notepad

File Edit Format View Help

```
GREEN1        01/01/1995    00:00:00     1762.683
GREEN1        02/01/1995    00:00:00     1762.430
GREEN1        03/01/1995    00:00:00     1762.137
GREEN1        04/01/1995    00:00:00     1762.125
GREEN1        05/01/1995    00:00:00     1763.525
GREEN1        06/01/1995    00:00:00     1763.471
GREEN1        07/01/1995    00:00:00     1764.021
GREEN1        08/01/1995    00:00:00     1763.792
GREEN1        09/01/1995    00:00:00     1763.497
GREEN1        10/01/1995    00:00:00     1763.300
GREEN1        11/01/1995    00:00:00     1762.606
GREEN1        12/01/1995    00:00:00     1762.358
GREEN1        01/01/1996    00:00:00     1762.260
GREEN1        02/01/1996    00:00:00     1762.147
GREEN1        03/01/1996    00:00:00     1762.067
GREEN1        04/01/1996    00:00:00     1761.984
GREEN1        05/01/1996    00:00:00     1763.145
GREEN1        06/01/1996    00:00:00     1763.197
GREEN1        07/01/1996    00:00:00     1763.471
GREEN1        08/01/1996    00:00:00     1763.499
GREEN1        09/01/1996    00:00:00     1763.346
GREEN1        10/01/1996    00:00:00     1763.451
GREEN1        11/01/1996    00:00:00     1762.908
GREEN1        12/01/1996    00:00:00     1762.606
GREEN1        01/01/1997    00:00:00     1762.534
GREEN1        02/01/1997    00:00:00     1762.435
GREEN1        03/01/1997    00:00:00     1762.212
GREEN1        04/01/1997    00:00:00     1762.066
GREEN1        05/01/1997    00:00:00     1763.425
GREEN1        06/01/1997    00:00:00     1763.260
GREEN1        07/01/1997    00:00:00     1763.837
GREEN1        08/01/1997    00:00:00     1763.763
GREEN1        09/01/1997    00:00:00     1763.543
GREEN1        10/01/1997    00:00:00     1763.359
GREEN1        11/01/1997    00:00:00     1763.157
GREEN1        12/01/1997    00:00:00     1762.787
GREEN1        01/01/1998    00:00:00     1762.423
GREEN1        02/01/1998    00:00:00     1762.296
GREEN1        03/01/1998    00:00:00     1762.229
GREEN1        04/01/1998    00:00:00     1762.106
GREEN1        05/01/1998    00:00:00     1763.088
GREEN1        06/01/1998    00:00:00     1763.815
GREEN1        07/01/1998    00:00:00     1764.469
GREEN1        08/01/1998    00:00:00     1764.180
GREEN1        09/01/1998    00:00:00     1763.643
GREEN1        10/01/1998    00:00:00     1763.633
GREEN1        11/01/1998    00:00:00     1763.080
GREEN1        12/01/1998    00:00:00     1762.764
GREEN1        01/01/1999    00:00:00     1762.474
GREEN1        02/01/1999    00:00:00     1762.359
GREEN1        03/01/1999    00:00:00     1762.391
GREEN1        04/01/1999    00:00:00     1762.259
GREEN1        05/01/1999    00:00:00     1763.460
GREEN1        06/01/1999    00:00:00     1763.403
GREEN1        07/01/1999    00:00:00     1763.950
GREEN1        08/01/1999    00:00:00     1763.486
GREEN1        09/01/1999    00:00:00     1763.219
GREEN1        10/01/1999    00:00:00     1762.925
GREEN1        11/01/1999    00:00:00     1762.524
GREEN1        12/01/1999    00:00:00     1762.302
GREEN1        01/01/2000    00:00:00     1762.158
GREEN1        02/01/2000    00:00:00     1762.129
GREEN1        03/01/2000    00:00:00     1762.113
GREEN1        04/01/2000    00:00:00     1762.009
```

- Text file
- Head units are meters above mean sea level
- Heads are interpolated from model cell center to user-specified location in well coordinate file
- Heads correspond to model layer specified by user in well coordinate file

Aquifer heads at selected locations



Scenarios

- Calibrated model can be used as a baseline for running “what if” scenarios
- If aquifer recharge or withdrawals had been different, how would fluxes and aquifer head change?
- Model simulations can be used to predict
  - Changes in aquifer discharge to Big Wood River, Willow Creek, Silver Creek
  - Changes in aquifer discharge to ESPA
  - Changes in aquifer head
  - Regional-scale model best used for regional-scale predictions

Principle of superposition

- In a linear model, the net effect of multiple applied stresses equals the sum of the effects of each individual applied stress.
- The principle of superposition may be applied to model simulations if the model is linear, or sufficiently close to linear.
- Seasonal changes in the number of perched river cells in the Hailey to Stanton Crossing reach of the Big Wood River cause non-linearity in the WRV model.
- Application of the principle of superposition to the WRV model is not recommended.

Running scenarios with the fully populated WRV model

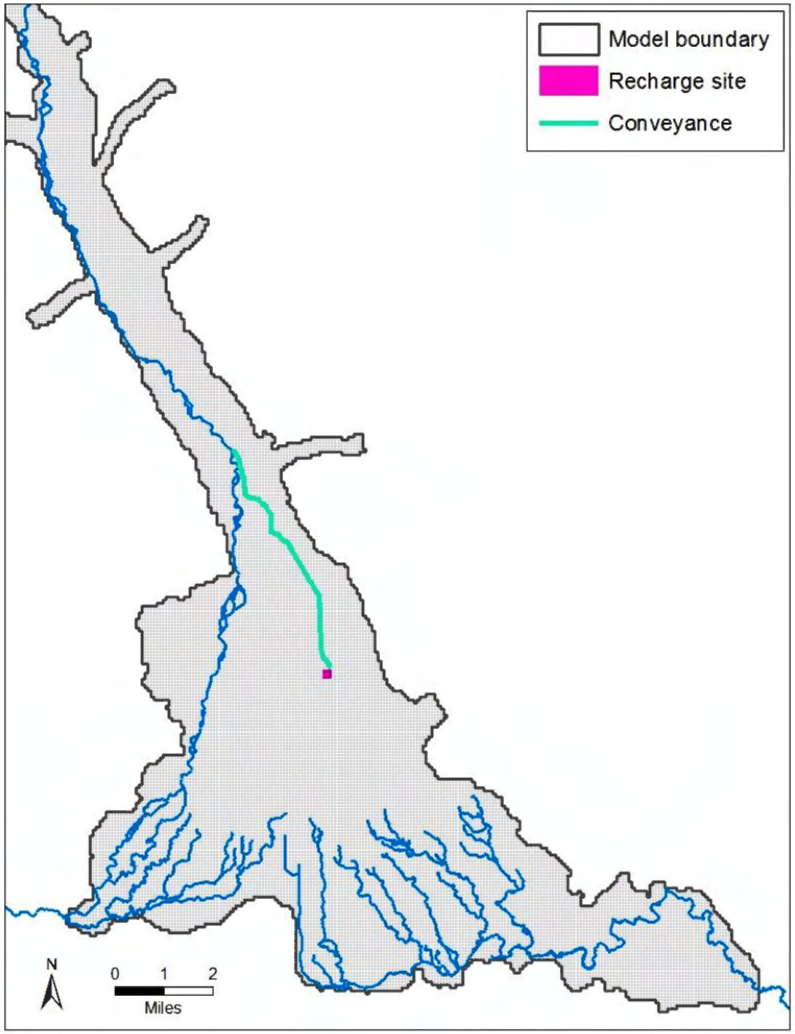
1. A “baseline” simulation is generated by running the WRV model with the historic water budget from model calibration (we’ve already completed this step)

2. Stresses are added to the historic water budget and the WRV model is run again with the revised *.wel file

3. Results from the scenario simulation and the baseline simulation are differenced to find the predicted change in flux or head

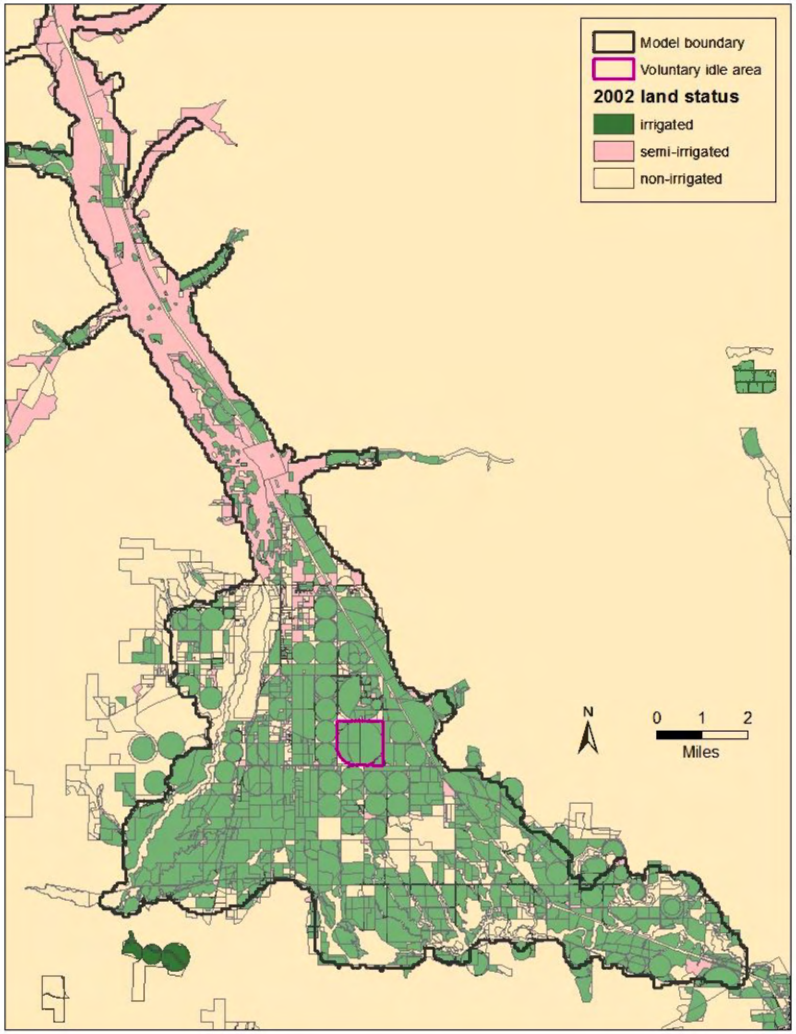
Overview of example scenario 1

- 20 cfs diverted for recharge for one month
- 60% (12 cfs) modeled as conveyance loss
- 40% (8 cfs) modeled as seepage at recharge site
- Build *.wel file manually
- Run simulation and post-process results from Command Prompt



Overview of example scenario 2

- Voluntary idle a section of irrigated land (~600 acres) during 1995-2010
- Modify several input files used to calculate aquifer recharge and withdrawals
- Use R script to calculate aquifer recharge and withdrawals and build *.wel file
- Run simulation and post-process results using R



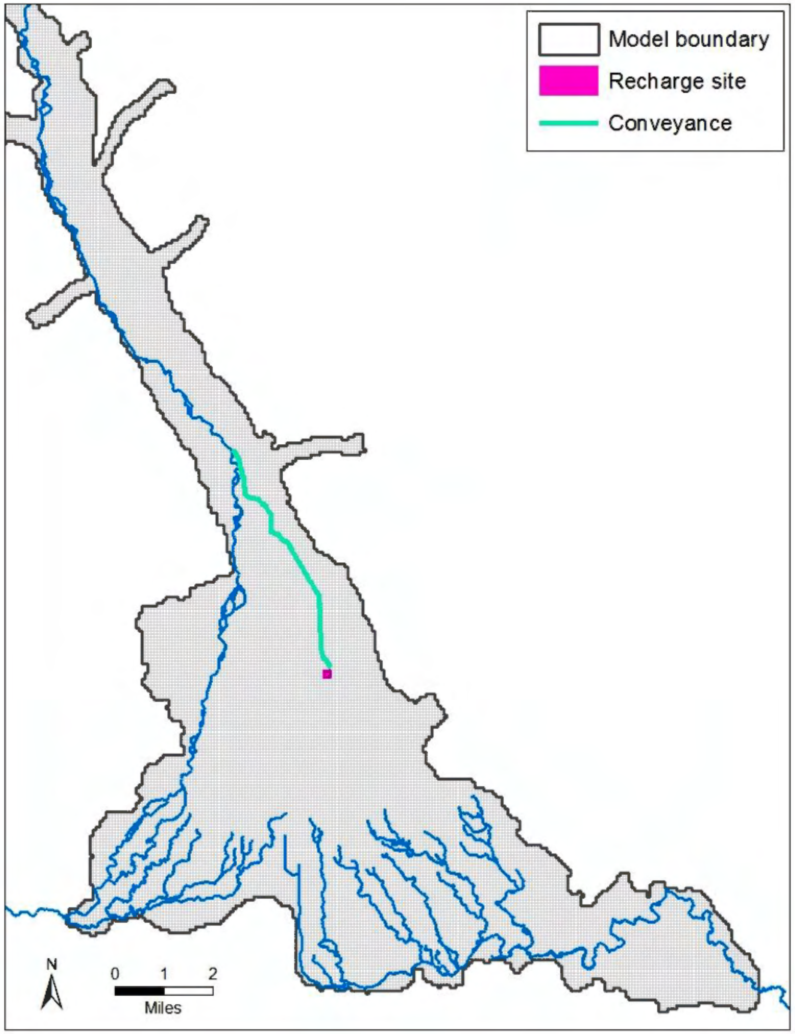
Example scenario 2 input file revisions

- Irrigated lands shapefiles – change status of parcel to "non-irrigated"
- ET rasters, reduce ET within parcel to equal monthly precipitation during irrigation season
- Remove associated pumping wells from input files
  - pod.gw.csv
  - pod.wells
  - comb.sw.irr.csv files
- Files that don't need to be changed for this scenario, but might for similar scenarios
  - Div.sw.csv – we are assuming surface water associated with the parcel is now delivered to other junior users within the same canal service area
  - Div.gw.csv – if there had been <u>measured</u> groundwater diversions associated with the parcel, those would need to be deleted

BREAK

Example scenario 1

- 20 cfs diverted for recharge for one month
- 60% (12 cfs) modeled as conveyance loss
- 40% (8 cfs) modeled as seepage at recharge site
- Build *.wel file manually
- Run simulation and post-process results from Command Prompt



Modify *.wel file

- Identify model cells for applied stress
  - 106 conveyance cells
  - 9 recharge site cells
  - recharge applied to layer 1
- 12 cfs/106 cells = 276.98 cmd/cell
- 8 cfs/9 cells = 2,174.81 cmd/cell
- Save as space delimited text file (*.prn)

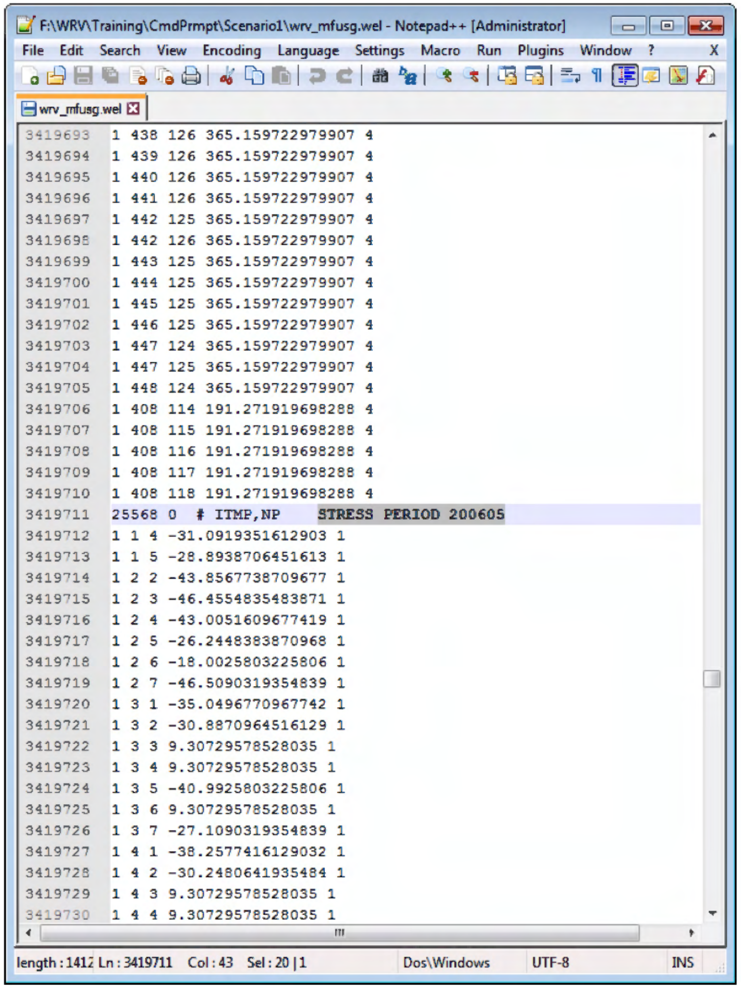
Scenario1.prn - Notepad

File Edit Format View Help

```
     115
     115
       1     430     156     2174.813154
       1     430     157     2174.813154
       1     430     158     2174.813154
       1     431     156     2174.813154
       1     431     157     2174.813154
       1     431     158     2174.813154
       1     432     156     2174.813154
       1     432     157     2174.813154
       1     432     158     2174.813154
       1     357     125     276.9809206
       1     357     126     276.9809206
       1     358     126     276.9809206
       1     358     127     276.9809206
       1     359     127     276.9809206
       1     360     127     276.9809206
       1     360     128     276.9809206
       1     361     128     276.9809206
       1     362     128     276.9809206
       1     363     128     276.9809206
       1     364     128     276.9809206
       1     364     129     276.9809206
       1     365     129     276.9809206
       1     366     129     276.9809206
       1     367     129     276.9809206
       1     368     129     276.9809206
       1     369     129     276.9809206
       1     370     129     276.9809206
       1     370     130     276.9809206
       1     371     130     276.9809206
       1     372     130     276.9809206
       1     372     131     276.9809206
       1     372     132     276.9809206
       1     373     132     276.9809206
       1     373     133     276.9809206
       1     373     134     276.9809206
       1     374     134     276.9809206
       1     374     135     276.9809206
       1     375     135     276.9809206
       1     375     136     276.9809206
       1     375     137     276.9809206
       1     376     137     276.9809206
       1     377     137     276.9809206
       1     377     138     276.9809206
       1     378     138     276.9809206
       1     379     138     276.9809206
       1     380     138     276.9809206
       1     381     138     276.9809206
```

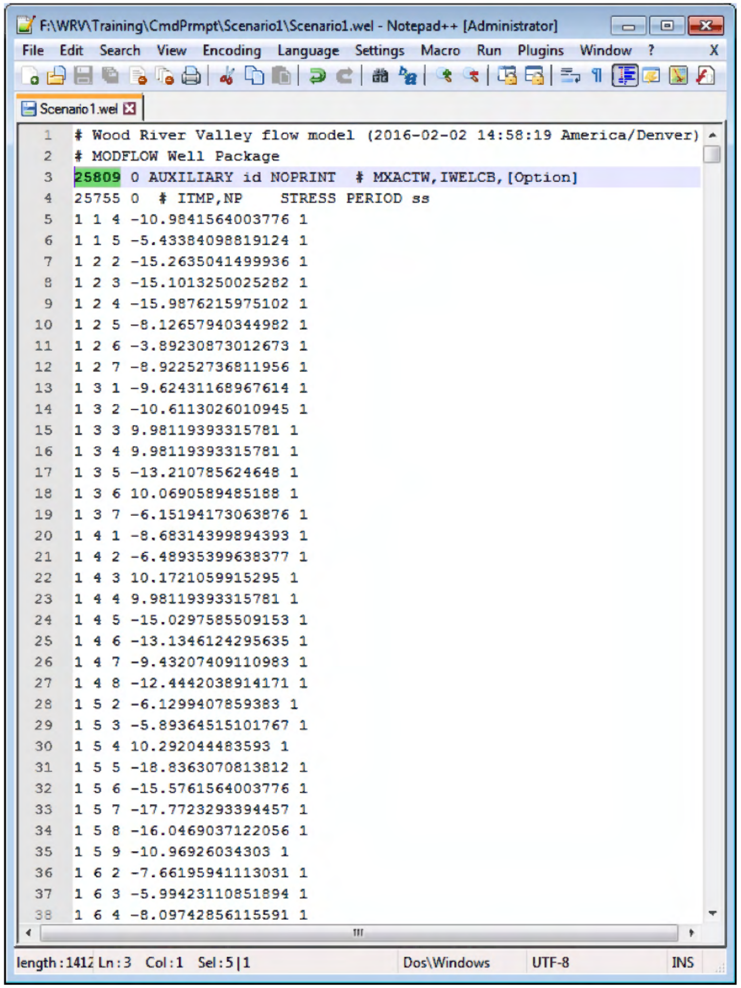
Modify *.wel file

- Open baseline wrv_mfusg.wel file in Notepad++
- Paste stress for recharge scenario into selected stress period(s)
- Add to well count for each stress period (25568 + 115 = 25683)



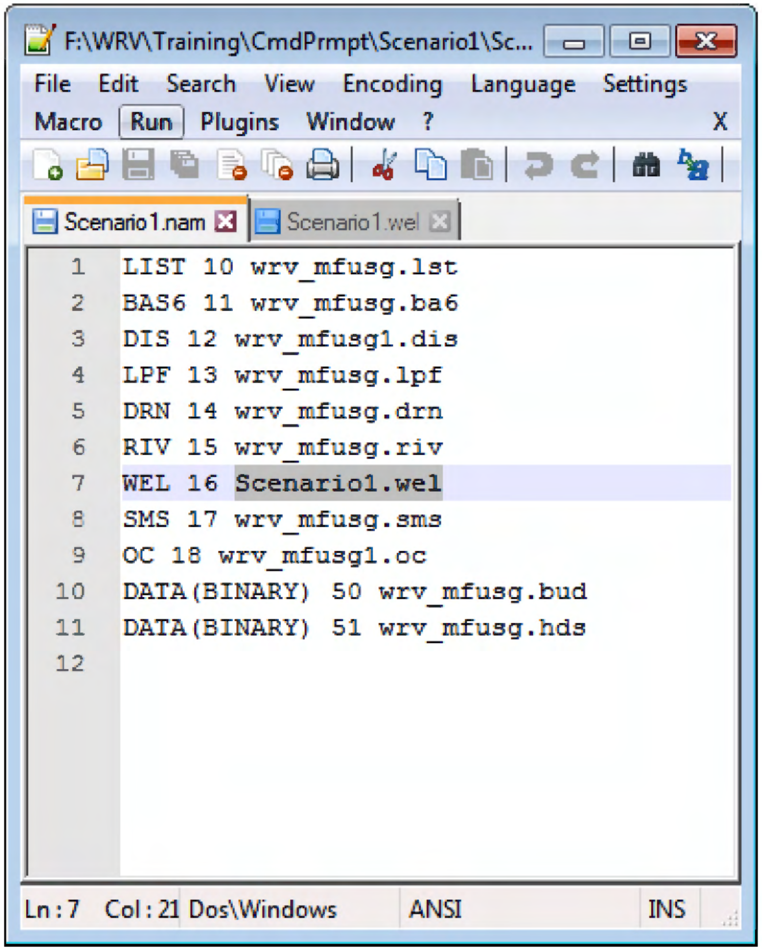
Modify *.wel file

- Add to maximum well count at beginning of file (25809 + 115 = 25924)
- Save file as Scenario1.wel



Modify *.nam file

- Change name of WEL file from wrv_mfusg.wel to Scenario1.wel
- Save file as Scenario1.nam



Navigate to local directory and run MODFLOW

```
Administrator: Command Prompt - mfusg
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

C:\Users\jsukow>f:

F:\>cd F:\WRV\Training\CmdPrmpt\Scenario1

F:\WRV\Training\CmdPrmpt\Scenario1>mfusg

                                  MODFLOW-USG
    U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUNDWATER FLOW MODEL
                             Version 1.2.00 03/21/2014

  Enter the name of the NAME FILE:
Scenario1
 Using NAME file: Scenario1.nam
 Run start date and time (yyyy/mm/dd hh:mm:ss): 2016/09/26 12:03:30

 Solving:  Stress period:     1    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     2    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     3    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     4    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     5    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     6    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     7    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     8    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:     9    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    10    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    11    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    12    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    13    Time step:     1    Groundwater Flow Eqn.
 Solving:  Stress period:    14    Time step:     1    Groundwater Flow Eqn.
```

Check for normal termination of MODFLOW and inspect water balance

Administrator: Command Prompt

```
Solving:  Stress period:   146    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   147    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   148    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   149    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   150    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   151    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   152    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   153    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   154    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   155    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   156    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   157    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   158    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   159    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   160    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   161    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   162    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   163    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   164    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   165    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   166    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   167    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   168    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   169    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   170    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   171    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   172    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   173    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   174    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   175    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   176    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   177    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   178    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   179    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   180    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   181    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   182    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   183    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   184    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   185    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   186    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   187    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   188    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   189    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   190    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   191    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   192    Time step:      1     Groundwater Flow Eqn.
Solving:  Stress period:   193    Time step:      1     Groundwater Flow Eqn.
Run end date and time (yyyy/mm/dd hh:mm:ss): 2016/09/26 14:34:31
Elapsed run time: 21 Minutes, 41.875 Seconds

 Normal termination of simulation

F:\WRV\Training\CmdPrmpt\Scenario1>
```

wrv_mfusg.lst - Notepad

File Edit Format View Help

```
 HEAD WILL BE SAVED ON UNIT   51 AT END OF TIME STEP   1, STRESS PERIOD  193
1
  VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP       1 IN STRESS PERIOD     193
  ---------------------------------------------------------------------------------------

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

           IN:                                      IN:
           ---                                      ---
             STORAGE =   969217988.8101               STORAGE =       47881.7057
       CONSTANT HEAD =           0.0000         CONSTANT HEAD =           0.0000
               WELLS =  3483689944.5938                 WELLS =      233822.3750
              DRAINS =           0.0000                DRAINS =           0.0000
       RIVER LEAKAGE =  3495345184.9375         RIVER LEAKAGE =      670951.1875

            TOTAL IN =  7948253118.3413              TOTAL IN =      952655.2682

          OUT:                                     OUT:
          ----                                     ----
             STORAGE =   978128808.6586               STORAGE =       60726.8254
       CONSTANT HEAD =           0.0000         CONSTANT HEAD =           0.0000
               WELLS =  1812842946.0225                 WELLS =       14968.5010
              DRAINS =   193059485.3343                DRAINS =       34972.8743
       RIVER LEAKAGE =  4965205641.0625         RIVER LEAKAGE =      842059.3125

           TOTAL OUT =  7949236881.0778             TOTAL OUT =      952727.5132

            IN - OUT =     -983762.7500              IN - OUT =         -72.2450

 PERCENT DISCREPANCY =            -0.01     PERCENT DISCREPANCY =            -0.01



          TIME SUMMARY AT END OF TIME STEP         1 IN STRESS PERIOD       193
                    SECONDS     MINUTES      HOURS       DAYS        YEARS
                    -----------------------------------------------------------
   TIME STEP LENGTH 2.67840E+06  44640.       744.00      31.000      8.48734E-02
 STRESS PERIOD TIME 2.67840E+06  44640.       744.00      31.000      8.48734E-02
         TOTAL TIME 5.04922E+08 8.41536E+06 1.40256E+05  5844.0       16.000
1
```

Extract stream-aquifer flux from MODFLOW budget file

```
Administrator: Command Prompt

F:\WRV\Training\CmdPrmpt\Scenario1>bud2smp<b2s_BigRch.in

 Program BUD2SMP writes a bore sample file of MODFLOW-generated
   inflows/outflows within user-specified zones.

 Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
 are problems in reading files of this type due to incompatibilities between
 different FORTRAN compiliers. If there are any such problems please contact
 johndoherty@ozemail.com.au and I will send you an alternative copy of this
 program.

 Enter name of grid specification file:   - grid specifications read from file w
rv.gsf
 How many layers in model?
 Enter name of MODFLOW unformatted budget output file:  Is this a MODFLOW88 or M
ODFLOW96 budget file  [8/9]?  Enter maximum number of output times:  Enter text
to identify MODFLOW flow type:
 Enter simulation starting date [mm/dd/yyyy]:  Enter simulation starting time [h
h:mm:ss]:  Enter time units employed by model [y/d/h/m/s]:
 Enter name of integer array file for layer 1:   - integer array read from file
bigrch.inf
 Enter name of integer array file for layer 2:   - integer array read from file
bigrch.inf
 Enter name of integer array file for layer 3:   - integer array read from file
bigrch.inf

 A total of 5 different non-zero zones were identified in integer arrays.
 An identifier must now be provided for each zone to appear in the bore
   sample output file:-
   Enter identifier for flows in zone 1 (10 characters or less):    Enter identi
fier for flows in zone 2 (10 characters or less):    Enter identifier for flows
in zone 4 (10 characters or less):    Enter identifier for flows in zone 3 (10 c
haracters or less):    Enter identifier for flows in zone 5 (10 characters or le
ss):
 Enter name for bore sample output file:  Enter flow rate factor:  Assign flows
to beginning, middle or finish of time step?  [b/m/f]:
 Enter name for run record file:
 - data for 193 model output arrays written to file ModRchGain.smp
 - see file BigReach.rec for a record of arrays found in file wrv_mfusg.bud


F:\WRV\Training\CmdPrmpt\Scenario1>
```

Extract groundwater flux across outlet boundaries from MODFLOW budget file

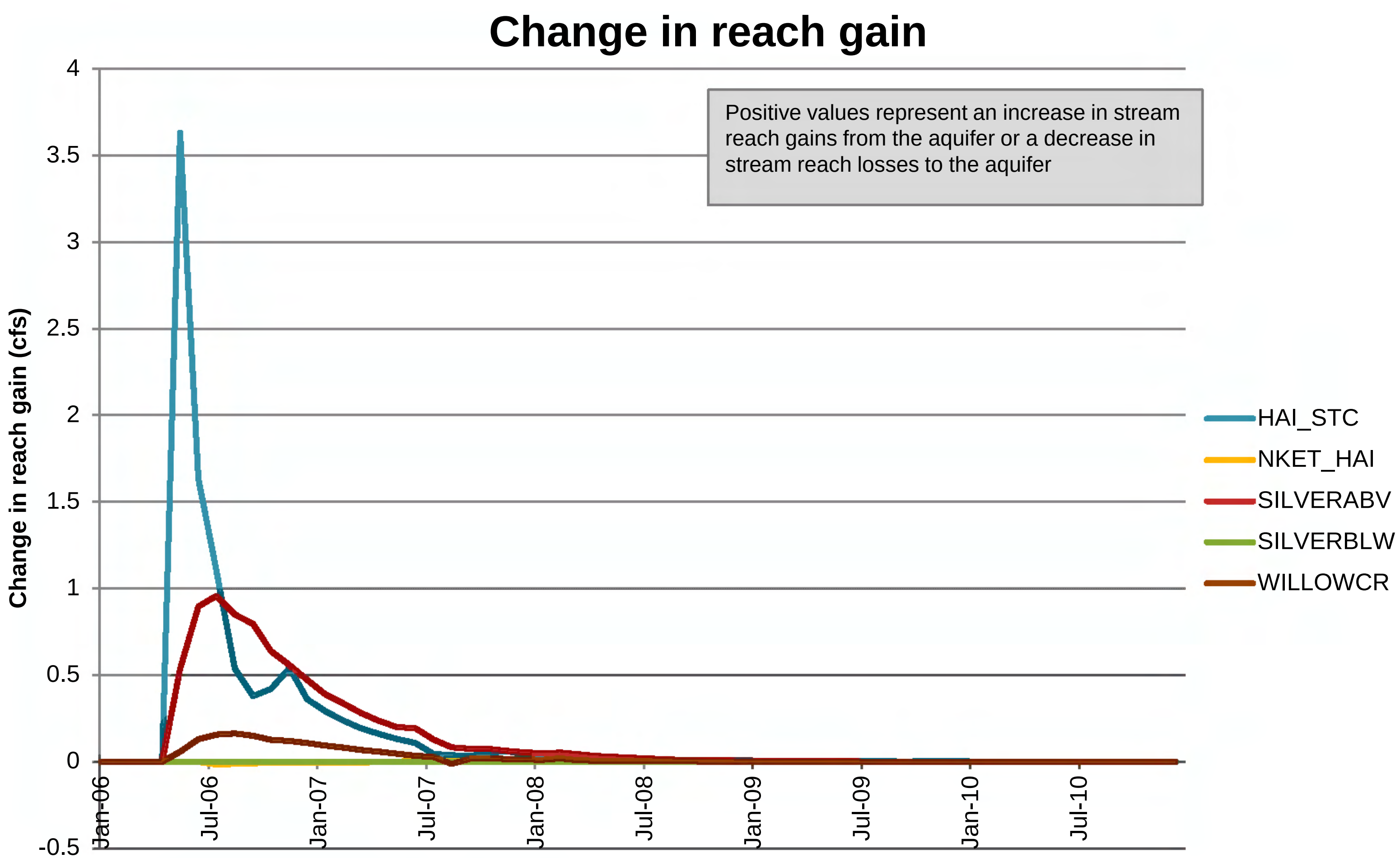
```
Administrator: Command Prompt

F:\WRV\Training\CmdPrmpt\Scenario1>bud2smp<b2s_Drain.in

 Program BUD2SMP writes a bore sample file of MODFLOW-generated
   inflows/outflows within user-specified zones.

 Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
 are problems in reading files of this type due to incompatibilities between
 different FORTRAN compilers. If there are any such problems please contact
 johndoherty@ozemail.com.au and I will send you an alternative copy of this
 program.

 Enter name of grid specification file:   - grid specifications read from file w
rv.gsf
 How many layers in model?
 Enter name of MODFLOW unformatted budget output file:  Is this a MODFLOW88 or M
ODFLOW96 budget file  [8/9]?  Enter maximum number of output times:  Enter text
to identify MODFLOW flow type:
 Enter simulation starting date [mm/dd/yyyy]:  Enter simulation starting time [h
h:mm:ss]:  Enter time units employed by model [y/d/h/m/s]:
 Enter name of integer array file for layer 1:   - integer array read from file
DrainRch.inf
 Enter name of integer array file for layer 2:   - integer array read from file
DrainRch.inf
 Enter name of integer array file for layer 3:   - integer array read from file
DrainRch.inf

 A total of 2 different non-zero zones were identified in integer arrays.
 An identifier must now be provided for each zone to appear in the bore
   sample output file:-
   Enter identifier for flows in zone 2 (10 characters or less):    Enter identi
fier for flows in zone 1 (10 characters or less):
 Enter name for bore sample output file:  Enter flow rate factor:  Assign flows
to beginning, middle or finish of time step?  [b/m/f]:
 Enter name for run record file:
 - data for 193 model output arrays written to file ModDrain.smp
 - see file Drain.rec for a record of arrays found in file wrv_mfusg.bud


F:\WRV\Training\CmdPrmpt\Scenario1>_
```

Extract aquifer heads at selected locations from MODFLOW heads file

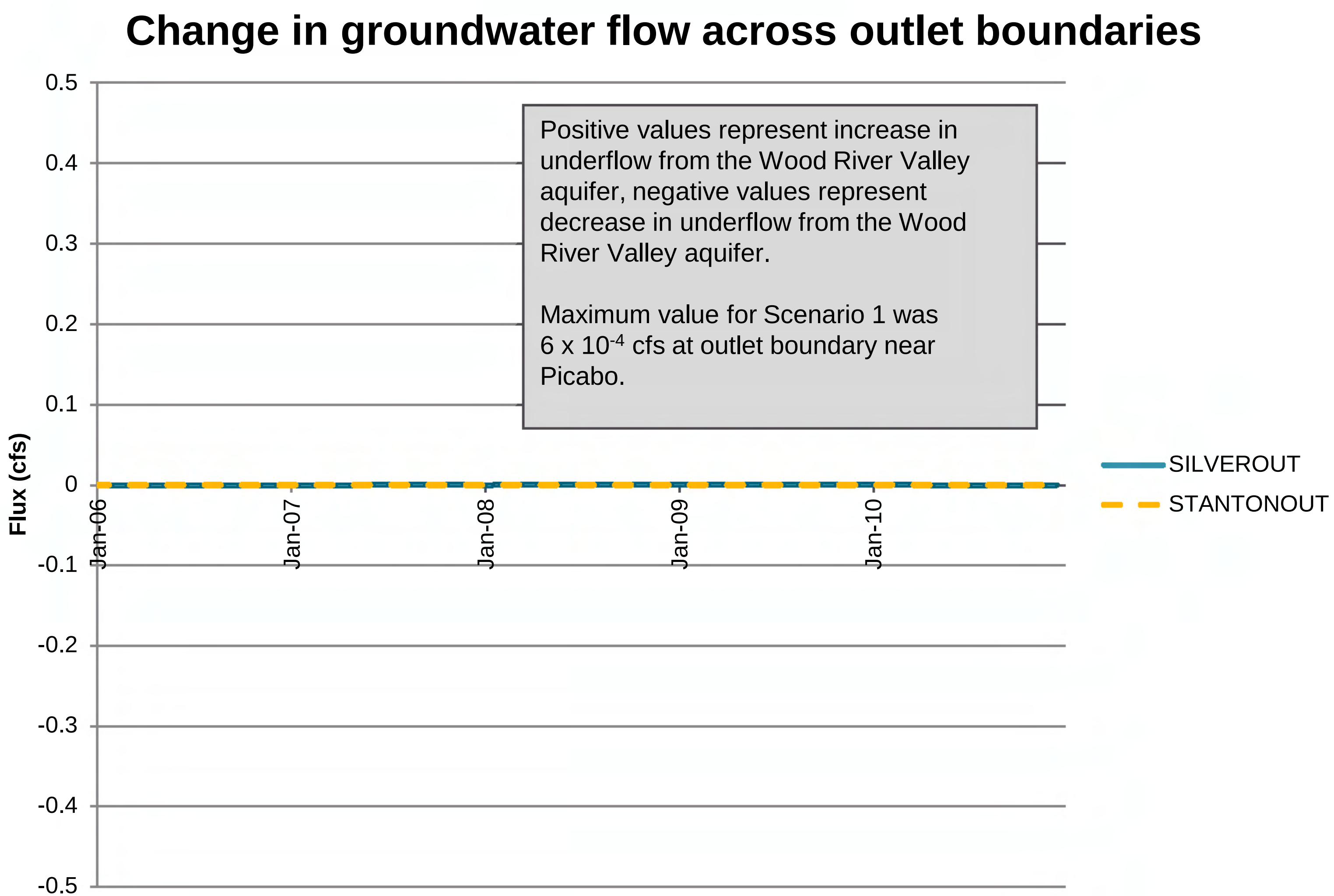
Administrator: Command Prompt

```
F:\WRV\Training\CmdPrmpt\Scenario1>mod2smp<m2s_example.in

 Program MOD2SMP writes a bore sample file of model-generated heads over
   time, interpolated to the sites of user-supplied bores.

 Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
 are problems in reading files of this type due to incompatibilities between
 different FORTRAN compiliers. If there are any such problems please contact
 johndoherty@ozemail.com.au and I will send you an alternative copy of this
 program.

 Enter name of grid specification file:   - grid specifications read from file w
rv.gsf
 Enter name of bore coordinates file:   - 10 bores and coordinates read from bor
e coordinates file example.wcf
 Enter name of bore listing file:   - 10 bores read from bore listing file examp
le.wcf

 Enter name of unformatted model-generated file:  Is this a MODFLOW or MT3D file
?  [f/t]:  How many different output times are represented in this file?  Enter
blanking threshold value for arrays in this file:  Enter time units used by mode
l (yr/day/hr/min/sec) [y/d/h/m/s]:
 Enter simulation starting date [mm/dd/yyyy]:  Enter simulation starting time [h
h:mm:ss]:
 Enter name for bore sample output file:
 Working .....

 - 579 arrays, covering 193 different model output times, read from file
   wrv_mfusg.hds
 - bore sample file examplehds.smp written ok.


F:\WRV\Training\CmdPrmpt\Scenario1>
```

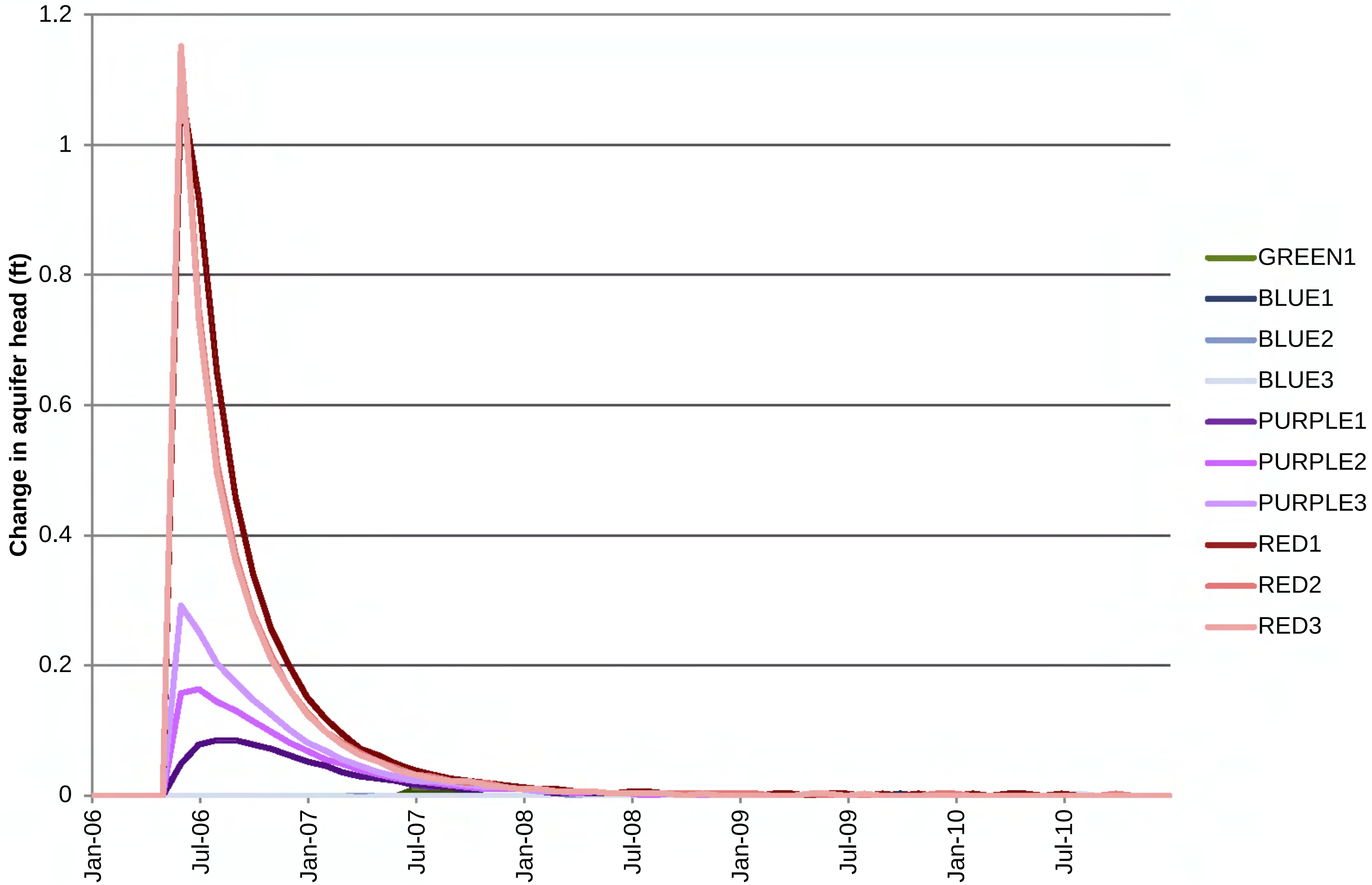
Difference baseline results from scenario stream flux results



Difference baseline results from scenario drain flux results



Change in aquifer heads at selected locations



Example head locations with respect to recharge site