**APPENDIX – B**

**The Results of Model Calibration Using PEST**

**(**Partial data are shown. See *BPK_STEADY.REC* in a CD-Rom for full details**)**

**PEST RUN RECORD: CASE bpk_steady_calibrated (PEST)**

```
PEST run mode:-
Parameter estimation mode
Case dimensions:-

   Number of parameters                          :   35
   Number of adjustable parameters               :   35
   Number of parameter groups                    :    1
   Number of observations                        :  179
   Number of prior estimates                     :    0

Model command line(s):-
MODELRUN.BAT
Jacobian command line:-
   na
Model interface files:-
   Templates:
      upw1tpl.dat
      ghbtpl.dat
      rivtpl.dat
      evttpl.dat
      rchtpl.dat
   for model input files:
      upw1.dat
      ghb.dat
      riv.dat
      evt.dat
      rch.dat

   (Parameter values written using single precision protocol.)
   (Decimal point omitted where possible to save space.)

   Instruction files:
      INSTRUCT.DAT
   for reading model output files:
     MODELOUT.DAT

PEST-to-model message file:-
   na

Derivatives calculation:-

Param    Increment   Increment   Increment   Forward or   Multiplier  Method
group    type                    low bound   central     (central) (central)
g1       relative    5.0000E-02  none        switch       1.000    parabolic

Parameter definitions:-

Name     Trans-       Change     Initial      Lower          Upper
         formation    limit      value        bound          bound

evt_13    log         factor   7.2200E-05   1.0000E-10     1.00000
evt_14    log         factor   3.8000E-06   1.0000E-10     1.00000
evt_15    log         factor   1.9700E-04   1.0000E-10     1.00000
evt_16    log         factor   1.0000E-05   1.0000E-10     1.00000
evt_17    log         factor   1.0000E-05   1.0000E-10     1.00000
hk_1      log         factor   3.1400E-03   1.0000E-10     100.000
hk_10     log         factor   4.0300E-02   1.0000E-10     100.000
hk_11     log         factor   0.13700      1.0000E-10     100.000
hk_2      log         factor   2.6700E-03   1.0000E-10     100.000
hk_3      log         factor   8.7800E-04   1.0000E-10     100.000
hk_4      log         factor   0.84100      1.0000E-10     100.000
```

| | | | | | |
|---|---|---|---|---|---|
| hk_5 | log | factor | 0.23700 | 1.0000E-10 | 100.000 |
| hk_6 | log | factor | 0.29500 | 1.0000E-10 | 100.000 |
| hk_7 | log | factor | 0.77800 | 1.0000E-10 | 100.000 |
| hk_8 | log | factor | 5.0600E-02 | 1.0000E-10 | 100.000 |
| hk_9 | log | factor | 6.8300E-02 | 1.0000E-10 | 100.000 |
| rch_18 | log | factor | 9.3800E-05 | 1.0000E-10 | 1.00000 |
| rch_19 | log | factor | 8.3500E-05 | 1.0000E-10 | 1.00000 |
| rch_20 | log | factor | 1.7600E-05 | 1.0000E-10 | 1.00000 |
| rch_21 | log | factor | 8.4000E-05 | 1.0000E-10 | 1.00000 |
| rch_22 | log | factor | 2.8300E-05 | 1.0000E-10 | 1.00000 |
| rch_23 | log | factor | 2.1400E-05 | 1.0000E-10 | 1.00000 |
| rch_24 | log | factor | 5.5200E-08 | 1.0000E-10 | 1.00000 |
| rch_25 | log | factor | 9.0700E-06 | 1.0000E-10 | 1.00000 |
| vani_12 | log | factor | 1.00000 | 1.0000E-05 | 100000. |
| ghb_27 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| ghb_28 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| ghb_29 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| ghb_30 | log | factor | 1000.00 | 1.0000E-10 | 1.0000E+10 |
| ghb_31 | log | factor | 1000.00 | 1.0000E-10 | 1.0000E+10 |
| riv_32 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| riv_33 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| riv_34 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| riv_35 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |
| riv_36 | log | factor | 10000.0 | 1.0000E-10 | 1.0000E+10 |

| Name | Group | Scale | Offset | Model command number |
|---|---|---|---|---|
| evt_13 | g1 | 1.00000 | 0.00000 | 1 |
| evt_14 | g1 | 1.00000 | 0.00000 | 1 |
| evt_15 | g1 | 1.00000 | 0.00000 | 1 |
| evt_16 | g1 | 1.00000 | 0.00000 | 1 |
| evt_17 | g1 | 1.00000 | 0.00000 | 1 |
| hk_1 | g1 | 1.00000 | 0.00000 | 1 |
| hk_10 | g1 | 1.00000 | 0.00000 | 1 |
| hk_11 | g1 | 1.00000 | 0.00000 | 1 |
| hk_2 | g1 | 1.00000 | 0.00000 | 1 |
| hk_3 | g1 | 1.00000 | 0.00000 | 1 |
| hk_4 | g1 | 1.00000 | 0.00000 | 1 |
| hk_5 | g1 | 1.00000 | 0.00000 | 1 |
| hk_6 | g1 | 1.00000 | 0.00000 | 1 |
| hk_7 | g1 | 1.00000 | 0.00000 | 1 |
| hk_8 | g1 | 1.00000 | 0.00000 | 1 |
| hk_9 | g1 | 1.00000 | 0.00000 | 1 |
| rch_18 | g1 | 1.00000 | 0.00000 | 1 |
| rch_19 | g1 | 1.00000 | 0.00000 | 1 |
| rch_20 | g1 | 1.00000 | 0.00000 | 1 |
| rch_21 | g1 | 1.00000 | 0.00000 | 1 |
| rch_22 | g1 | 1.00000 | 0.00000 | 1 |
| rch_23 | g1 | 1.00000 | 0.00000 | 1 |
| rch_24 | g1 | 1.00000 | 0.00000 | 1 |
| rch_25 | g1 | 1.00000 | 0.00000 | 1 |
| vani_12 | g1 | 1.00000 | 0.00000 | 1 |
| ghb_27 | g1 | 1.00000 | 0.00000 | 1 |
| ghb_28 | g1 | 1.00000 | 0.00000 | 1 |
| ghb_29 | g1 | 1.00000 | 0.00000 | 1 |
| ghb_30 | g1 | 1.00000 | 0.00000 | 1 |
| ghb_31 | g1 | 1.00000 | 0.00000 | 1 |
| riv_32 | g1 | 1.00000 | 0.00000 | 1 |
| riv_33 | g1 | 1.00000 | 0.00000 | 1 |
| riv_34 | g1 | 1.00000 | 0.00000 | 1 |
| riv_35 | g1 | 1.00000 | 0.00000 | 1 |
| riv_36 | g1 | 1.00000 | 0.00000 | 1 |

Prior information:-

No prior information supplied

Observations:-

| Observation name | Observation | Weight | Group |
|---|---|---|---|
| 1 | -3.69000 | 2.308 | pm_default |
| 2 | -21.7100 | 1.402 | pm_default |
| 3 | 44.7200 | 0.2112 | pm_default |
| 4 | -7.56000 | 0.1894 | pm_default |
| 5 | 38.6500 | 0.2104 | pm_default |
| 6 | 57.1500 | 0.5627 | pm_default |
| 7 | -25.2000 | 8.4000E-02 | pm_default |
| 8 | -9.00000 | 1.027 | pm_default |
| 9 | -7.76000 | 0.2981 | pm_default |
| 10 | -5.93000 | 0.6429 | pm_default |
| 11 | -7.58000 | 1.169 | pm_default |
| 12 | 57.2300 | 0.5951 | pm_default |
| 13 | -3.07000 | 0.4983 | pm_default |
| 14 | -8.16000 | 1.551 | pm_default |
| 15 | 0.170000 | 0.7126 | pm_default |
| 16 | -2.06000 | 2.211 | pm_default |
| 17 | 13.0900 | 0.8079 | pm_default |
| 18 | -1.41000 | 0.2494 | pm_default |
| 19 | 13.4300 | 0.7690 | pm_default |
| 20 | 2.27000 | 2.638 | pm_default |
| 21 | -13.3500 | 0.3406 | pm_default |
| 22 | -4.06000 | 0.4107 | pm_default |
| 23 | -13.7600 | 0.3938 | pm_default |
| 24 | -15.7600 | 0.2684 | pm_default |
| 25 | -16.1500 | 1.424 | pm_default |
| 26 | 15.2700 | 0.2613 | pm_default |
| 27 | 14.1500 | 0.3118 | pm_default |
| 28 | -9.40000 | 4.242 | pm_default |
| 29 | -10.3000 | 0.1548 | pm_default |
| 30 | -0.310000 | 0.5156 | pm_default |
| 31 | -1.44000 | 2.467 | pm_default |
| 32 | -4.22000 | 0.8203 | pm_default |
| 33 | 3.37000 | 1.417 | pm_default |
| 34 | -1.98000 | 0.3603 | pm_default |
| 35 | -2.64000 | 2.447 | pm_default |
| 36 | 11.7800 | 0.6586 | pm_default |
| 37 | 23.0900 | 0.4227 | pm_default |
| 38 | 36.9300 | 1.752 | pm_default |
| 39 | 63.0600 | 1.561 | pm_default |
| 40 | 2.50000 | 1.146 | pm_default |
| 41 | 11.9100 | 1.497 | pm_default |
| 42 | 14.8900 | 0.9076 | pm_default |
| 43 | -9.22000 | 0.9593 | pm_default |
| 44 | 0.960000 | 1.820 | pm_default |
| 45 | 26.1300 | 1.042 | pm_default |
| 46 | 1.43000 | 2.239 | pm_default |
| 47 | -23.6100 | 1.150 | pm_default |
| 48 | 17.0400 | 1.023 | pm_default |
| 49 | 15.1200 | 0.5508 | pm_default |
| 50 | -14.7400 | 0.2637 | pm_default |
| 51 | -14.7200 | 0.6429 | pm_default |
| 52 | -19.1700 | 0.1214 | pm_default |
| 53 | 18.8900 | 0.8406 | pm_default |
| 54 | -1.33000 | 1.054 | pm_default |
| 55 | 64.4400 | 0.9559 | pm_default |
| 56 | -3.12000 | 0.5851 | pm_default |

| | | | |
|---|---|---|---|
| 57 | 1.49000 | 0.6429 | pm_default |
| 58 | 1.08000 | 2.064 | pm_default |
| 59 | -8.09000 | 2.619 | pm_default |
| 60 | -9.01000 | 0.1076 | pm_default |
| 61 | -2.61000 | 3.631 | pm_default |
| 62 | 1.13000 | 0.1376 | pm_default |
| 63 | -1.23000 | 6.234 | pm_default |
| 64 | -18.4500 | 0.9880 | pm_default |
| 65 | 21.2800 | 0.1447 | pm_default |
| 66 | -4.86000 | 0.8402 | pm_default |
| 67 | 5.82000 | 1.075 | pm_default |
| 68 | -3.04000 | 3.695 | pm_default |
| 69 | -7.82000 | 0.1650 | pm_default |
| 70 | 3.86000 | 1.103 | pm_default |

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**(See full detail in accompanied CD-ROM)**

Control settings:-

| | |
|---|---|
| Initial lambda | : 10.000 |
| Lambda adjustment factor | : 2.0000 |
| Sufficient new/old phi ratio per optimisation iteration | : 0.30000 |
| Limiting relative phi reduction between lambdas | : 1.0000E-02 |
| Maximum trial lambdas per iteration | : 8 |
| Forgive model run failure during lamda testing | : no |
| Perform Broyden's update of Jacobian matrix | : no |
| Maximum factor parameter change (factor-limited changes) | : 10.000 |
| Maximum relative parameter change (relative-limited changes) | : na |
| Fraction of initial parameter values used in computing change limit for near-zero parameters | : 1.0000E-03 |
| Allow bending of parameter upgrade vector | : no |
| Allow parameters to stick to their bounds | : no |
| Relative phi reduction below which to begin use of central derivatives | : 0.10000 |
| Iteration at which to first consider derivatives switch | : 1 |
| Relative phi reduction indicating convergence | : 0.1000E-02 |
| Number of phi values required within this range | : 3 |
| Maximum number of consecutive failures to lower phi | : 3 |
| Minimal relative parameter change indicating convergence | : 0.1000E-01 |
| Number of consecutive iterations with minimal param change | : 3 |
| Maximum number of optimisation iterations | : 25 |
| Attempt automatic user intervention | : no |
| Attempt reuse of parameter sensitivities | : no |

File saving options: -

| | |
|---|---|
| Save multiple JCO files | : no |
| Save multiple REI files | : no |

**OPTIMISATION RECORD**

INITIAL CONDITIONS:
Sum of squared weighted residuals (ie phi) = 1.56607E+05

```
 Current parameter values
 evt_13          7.220000E-05
 evt_14          3.800000E-06
 evt_15          1.970000E-04
 evt_16          1.000000E-05
 evt_17          1.000000E-05
 hk_1            3.140000E-03
 hk_10           4.030000E-02
 hk_11           0.137000
 hk_2            2.670000E-03
 hk_3            8.780000E-04
 hk_4            0.841000
 hk_5            0.237000
 hk_6            0.295000
 hk_7            0.778000
 hk_8            5.060000E-02
 hk_9            6.830000E-02
 rch_18          9.380000E-05
 rch_19          8.350000E-05
 rch_20          1.760000E-05
 rch_21          8.400000E-05
 rch_22          2.830000E-05
 rch_23          2.140000E-05
 rch_24          5.520000E-08
 rch_25          9.070000E-06
 vani_12          1.00000
 ghb_27           10000.0
 ghb_28           10000.0
 ghb_29           10000.0
 ghb_30           1000.00
 ghb_31           1000.00
 riv_32           10000.0
 riv_33           10000.0
 riv_34           10000.0
 riv_35           10000.0
 riv_36           10000.0

OPTIMISATION ITERATION NO.       : 1
  Model calls so far             : 1
  Starting phi for this iteration:  1.56607E+05

    Lambda =   10.000     ----->
       Phi =  1.54981E+05  (  0.990 of starting phi)

    Lambda =   5.0000     ----->
       Phi =  1.55087E+05  (  0.990 of starting phi)

    Lambda =   20.000     ----->
       Phi =  1.54891E+05  (  0.989 of starting phi)

  No more lambdas: relative phi reduction between lambdas less than 0.0100
  Lowest phi this iteration:  1.54891E+05
  Relative phi reduction between optimisation iterations less than 0.1000
  Switch to central derivatives calculation

 Current parameter    values            Previous parameter    values
 evt_13          7.362610E-05          evt_13          7.220000E-05
 evt_14          3.920070E-06          evt_14          3.800000E-06
 evt_15          1.965918E-04          evt_15          1.970000E-04
 evt_16          1.031582E-05          evt_16          1.000000E-05
 evt_17          1.045260E-05          evt_17          1.000000E-05
 hk_1            3.057653E-03          hk_1            3.140000E-03
 hk_10           4.038394E-02          hk_10           4.030000E-02
 hk_11           0.135477              hk_11           0.137000
```

| | | | |
|---|---|---|---|
| hk_2 | 2.717259E-03 | hk_2 | 2.670000E-03 |
| hk_3 | 8.820994E-04 | hk_3 | 8.780000E-04 |
| hk_4 | 0.840334 | hk_4 | 0.841000 |
| hk_5 | 0.135595 | hk_5 | 0.237000 |
| hk_6 | 0.294764 | hk_6 | 0.295000 |
| hk_7 | 0.752647 | hk_7 | 0.778000 |
| hk_8 | 1.261804E-02 | hk_8 | 5.060000E-02 |
| hk_9 | 6.809142E-02 | hk_9 | 6.830000E-02 |
| rch_18 | 9.343804E-05 | rch_18 | 9.380000E-05 |
| rch_19 | 8.290712E-05 | rch_19 | 8.350000E-05 |
| rch_20 | 1.760290E-05 | rch_20 | 1.760000E-05 |
| rch_21 | 8.401974E-05 | rch_21 | 8.400000E-05 |
| rch_22 | 2.835495E-05 | rch_22 | 2.830000E-05 |
| rch_23 | 2.146997E-05 | rch_23 | 2.140000E-05 |
| rch_24 | 5.673239E-08 | rch_24 | 5.520000E-08 |
| rch_25 | 9.133510E-06 | rch_25 | 9.070000E-06 |
| vani_12 | 1.00241 | vani_12 | 1.00000 |
| ghb_27 | 1000.00 | ghb_27 | 10000.0 |
| ghb_28 | 4216.54 | ghb_28 | 10000.0 |
| ghb_29 | 5135.96 | ghb_29 | 10000.0 |
| ghb_30 | 1088.00 | ghb_30 | 1000.00 |
| ghb_31 | 940.067 | ghb_31 | 1000.00 |
| riv_32 | 9730.31 | riv_32 | 10000.0 |
| riv_33 | 10233.6 | riv_33 | 10000.0 |
| riv_34 | 10301.8 | riv_34 | 10000.0 |
| riv_35 | 10452.9 | riv_35 | 10000.0 |
| riv_36 | 2889.58 | riv_36 | 10000.0 |

Maximum factor change: 10.00 ["ghb_27"]
Maximum relative change: 0.9000 ["ghb_27"]

**OPTIMISATION ITERATION NO. : 2**
Model calls so far : 39
Starting phi for this iteration: 1.54891E+05

Lambda = 20.000 ----->
Phi = 1.54764E+05 ( 0.999 of starting phi)

Lambda = 10.000 ----->
Phi = 1.54904E+05 ( 1.000 times starting phi)

Lambda = 40.000 ----->
Phi = 1.54564E+05 ( 0.998 of starting phi)

No more lambdas: relative phi reduction between lambdas less than 0.0100
Lowest phi this iteration: 1.54564E+05

| Current parameter | values | Previous parameter | values |
|---|---|---|---|
| evt_13 | 7.401458E-05 | evt_13 | 7.362610E-05 |
| evt_14 | 3.972632E-06 | evt_14 | 3.920070E-06 |
| evt_15 | 1.964310E-04 | evt_15 | 1.965918E-04 |
| evt_16 | 1.052305E-05 | evt_16 | 1.031582E-05 |
| evt_17 | 1.022549E-05 | evt_17 | 1.045260E-05 |
| hk_1 | 2.915090E-03 | hk_1 | 3.057653E-03 |
| hk_10 | 4.042881E-02 | hk_10 | 4.038394E-02 |
| hk_11 | 0.132460 | hk_11 | 0.135477 |
| hk_2 | 2.777109E-03 | hk_2 | 2.717259E-03 |
| hk_3 | 8.873411E-04 | hk_3 | 8.820994E-04 |
| hk_4 | 0.841821 | hk_4 | 0.840334 |
| hk_5 | 1.355951E-02 | hk_5 | 0.135595 |
| hk_6 | 0.294743 | hk_6 | 0.294764 |
| hk_7 | 0.745158 | hk_7 | 0.752647 |
| hk_8 | 1.288376E-02 | hk_8 | 1.261804E-02 |
| hk_9 | 6.804309E-02 | hk_9 | 6.809142E-02 |

```
   rch_18          9.333042E-05          rch_18          9.343804E-05
   rch_19          8.252703E-05          rch_19          8.290712E-05
   rch_20          1.759875E-05          rch_20          1.760290E-05
   rch_21          8.420831E-05          rch_21          8.401974E-05
   rch_22          2.847978E-05          rch_22          2.835495E-05
   rch_23          2.160901E-05          rch_23          2.146997E-05
   rch_24          6.565098E-08          rch_24          5.673239E-08
   rch_25          9.096302E-06          rch_25          9.133510E-06
   vani_12          1.00829              vani_12          1.00241
   ghb_27           983.102              ghb_27           1000.00
   ghb_28           5472.86              ghb_28           4216.54
   ghb_29           4083.51              ghb_29           5135.96
   ghb_30           1039.11              ghb_30           1088.00
   ghb_31           1019.43              ghb_31           940.067
   riv_32           9788.25              riv_32           9730.31
   riv_33           10041.5              riv_33           10233.6
   riv_34           9344.20              riv_34           10301.8
   riv_35           10567.5              riv_35           10452.9
   riv_36           2476.64              riv_36           2889.58
 Maximum   factor change:  10.00     ["hk_5"]
 Maximum relative change: 0.9000     ["hk_5"]


OPTIMISATION ITERATION NO.        : 3
 Model calls so far               : 112
 Starting phi for this iteration:  1.54564E+05

    Lambda =   40.000     ----->
       Phi =  1.36158E+05  (  0.881 of starting phi)

    Lambda =   20.000     ----->
       Phi =  1.39106E+05  (  0.900 of starting phi)

    Lambda =   80.000     ----->
       Phi =  1.31470E+05  (  0.851 of starting phi)

    Lambda =   160.00     ----->
       Phi =  1.25465E+05  (  0.812 of starting phi)

    Lambda =   320.00     ----->
       Phi =  1.17795E+05  (  0.762 of starting phi)

    Lambda =   640.00     ----->
       Phi =  1.08890E+05  (  0.704 of starting phi)

    Lambda =   1280.0     ----->
       Phi =  1.01837E+05  (  0.659 of starting phi)

    Lambda =   2560.0     ----->
       Phi =  1.00214E+05  (  0.648 of starting phi)

 No more lambdas: allowed lambdas per iteration =  8
 Lowest phi this iteration:  1.00214E+05

Current parameter     values          Previous parameter      values
   evt_13          1.548673E-04          evt_13          7.401458E-05
   evt_14          9.038478E-06          evt_14          3.972632E-06
   evt_15          1.559819E-04          evt_15          1.964310E-04
   evt_16          1.290730E-05          evt_16          1.052305E-05
   evt_17          1.022549E-06          evt_17          1.022549E-05
   hk_1            5.161745E-04          hk_1            2.915090E-03
   hk_10           4.396776E-02          hk_10           4.042881E-02
   hk_11           3.322542E-02          hk_11           0.132460
   hk_2            1.366398E-02          hk_2            2.777109E-03
```

```
      hk_3            1.837130E-03            hk_3            8.873411E-04
      hk_4            0.984120                hk_4            0.841821
      hk_5            1.504005E-02            hk_5            1.355951E-02
      hk_6            0.259756                hk_6            0.294743
      hk_7            0.259174                hk_7            0.745158
      hk_8            2.444706E-02            hk_8            1.288376E-02
      hk_9            5.604129E-02            hk_9            6.804309E-02
      rch_18          7.512485E-05            rch_18          9.333042E-05
      rch_19          4.904933E-05            rch_19          8.252703E-05
      rch_20          1.678643E-05            rch_20          1.759875E-05
      rch_21          1.125136E-04            rch_21          8.420831E-05
      rch_22          3.399125E-05            rch_22          2.847978E-05
      rch_23          4.684871E-05            rch_23          2.160901E-05
      rch_24          9.744121E-08            rch_24          6.565098E-08
      rch_25          1.930415E-06            rch_25          9.096302E-06
      vani_12          1.79301                vani_12          1.00829
      ghb_27           1016.85                ghb_27           983.102
      ghb_28           5428.25                ghb_28           5472.86
      ghb_29           649.998                ghb_29           4083.51
      ghb_30           468.627                ghb_30           1039.11
      ghb_31           763.172                ghb_31           1019.43
      riv_32           10626.7                riv_32           9788.25
      riv_33           9188.99                riv_33           10041.5
      riv_34           4541.00                riv_34           9344.20
      riv_35           32721.3                riv_35           10567.5
      riv_36           1799.26                riv_36           2476.64
   Maximum   factor change:  10.00     ["evt_17"]
   Maximum relative change:  3.920     ["hk_2"]
                                        .
                                        .
                                        .
```

**(See full detail in accompanied CD-ROM)**

```
Optimisation complete: the 3 lowest phi's are within a relative distance
                       of eachother of 1.000E-03
   Total model calls:    849

   The model has been run one final time using best parameters.
   Thus all model input files contain best parameter values, and model
   output files contain model results based on these parameters.
```

OPTIMISATION RESULTS

Parameters ----->

| Parameter | Estimated value | 95% percent confidence limits lower limit | upper limit |
|---|---|---|---|
| evt_13 | 1.092180E-04 | 1.673041E-53 | 7.129870E+44 |
| evt_14 | 6.690132E-05 | 1.718833-207 | 2.603968+198 |
| evt_15 | 3.160806E-04 | 3.126091E-06 | 3.195906E-02 |
| evt_16 | 6.821238E-05 | 5.016882E-16 | 9.274544E+06 |
| evt_17 | 5.529828E-08 | 5.529828-308 | 5.529828+292 |
| hk_1 | 4.022503E-04 | 9.580913-102 | 1.688829E+94 |
| hk_10 | 3.611337E-02 | 7.877736E-04 | 1.65552 |
| hk_11 | 5.689086E-03 | 2.316762-175 | 1.397023+170 |
| hk_2 | 0.331131 | 7.938142E-03 | 13.8128 |
| hk_3 | 6.520539E-04 | 5.901657-102 | 7.204321E+94 |
| hk_4 | 1.71802 | 0.277394 | 10.6405 |
| hk_5 | 4.497056E-02 | 4.497056-302 | 4.497056+298 |
| hk_6 | 0.190079 | 7.327821E-02 | 0.493053 |
| hk_7 | 1.06771 | 1.864399E-40 | 6.114541E+39 |

| | | | |
|---|---|---|---|
| hk_8 | 0.417940 | 4.179400-301 | 4.179400+299 |
| hk_9 | 6.572968E-02 | 6.288747E-03 | 0.687003 |
| rch_18 | 4.831285E-05 | 1.918101E-05 | 1.216897E-04 |
| rch_19 | 2.153714E-07 | 8.213184-206 | 5.647607+191 |
| rch_20 | 1.131729E-05 | 3.658382E-06 | 3.501031E-05 |
| rch_21 | 2.189493E-04 | 2.327221E-05 | 2.059916E-03 |
| rch_22 | 1.374856E-04 | 9.681342E-06 | 1.952446E-03 |
| rch_23 | 1.672557E-04 | 1.009719E-05 | 2.770520E-03 |
| rch_24 | 7.157253E-07 | 2.371270E-39 | 2.160288E+26 |
| rch_25 | 4.829259E-07 | 1.084894E-97 | 2.149681E+84 |
| vani_12 | 9.297520E-02 | 1.187535E-99 | 7.279272E+96 |
| ghb_27 | 885.781 | 5.525054-120 | 1.420090+125 |
| ghb_28 | 2441.68 | 1.037276-130 | 5.747549+136 |
| ghb_29 | 4.94691 | 1.872688E-03 | 13067.8 |
| ghb_30 | 8.70279 | 0.936707 | 80.8561 |
| ghb_31 | 368.824 | 1.927114E-72 | 7.058797E+76 |
| riv_32 | 91901.5 | 9.190152-296 | 1.000000+300 |
| riv_33 | 1723.31 | 5.591759E-12 | 5.311025E+17 |
| riv_34 | 42.7821 | 0.157531 | 11618.8 |
| riv_35 | 48056.1 | 4.805611-296 | 1.000000+300 |
| riv_36 | 7651.20 | 1.728363-218 | 3.387070+225 |

Note: confidence limits provide only an indication of parameter uncertainty.
They rely on a linearity assumption which may not extend as far in parameter space as the confidence limits themselves - see PEST manual.

See file pestctl.sen for parameter sensitivities.

Observations ----->

| Observation | Measured value | Calculated value | Residual | Weight | Group |
|---|---|---|---|---|---|
| 1 | -3.69000 | 17.6200 | -21.3100 | 2.308 | pm_default |
| 2 | -21.7100 | -1.65082 | -20.0592 | 1.402 | pm_default |
| 3 | 44.7200 | 21.4692 | 23.2508 | 0.2112 | pm_default |
| 4 | 7.56000 | 8.60653 | -16.1665 | 0.1894 | pm_default |
| 5 | 38.6500 | 19.3741 | 19.2759 | 0.2104 | pm_default |
| 6 | 57.1500 | 30.1461 | 27.0039 | 0.5627 | pm_default |
| 7 | -25.2000 | -4.49772 | -20.7023 | 8.40E-2 | pm_default |
| 8 | -9.00000 | -7.06029 | -1.93971 | 1.027 | pm_default |
| 9 | -7.76000 | -8.42708 | 0.667081 | 0.2981 | pm_default |
| 10 | -5.93000 | -8.34692 | 2.41692 | 0.6429 | pm_default |
| 11 | -7.58000 | -5.64721 | -1.93279 | 1.169 | pm_default |
| 12 | 57.2300 | 27.3476 | 29.8824 | 0.5951 | pm_default |
| 13 | -3.07000 | -4.65281 | 1.58281 | 0.4983 | pm_default |
| 14 | -8.16000 | -0.754312 | -7.40569 | 1.551 | pm_default |
| 15 | 0.17000 | -0.297426 | 0.467426 | 0.7126 | pm_default |
| 16 | -2.06000 | -2.52578 | 0.465780 | 2.211 | pm_default |
| 17 | 13.0900 | 30.6791 | -17.5891 | 0.8079 | pm_default |
| 18 | -1.41000 | -1.66606 | 0.256062 | 0.2494 | pm_default |
| 19 | 13.4300 | 11.1524 | 2.27764 | 0.7690 | pm_default |
| 20 | 2.27000 | -2.00610 | 4.27610 | 2.638 | pm_default |
| 21 | -13.3500 | -2.02770 | -11.3223 | 0.3406 | pm_default |
| 22 | -4.06000 | 0.528812 | -4.58881 | 0.4107 | pm_default |
| 23 | -13.7600 | 0.529569 | -14.2896 | 0.3938 | pm_default |
| 24 | -15.7600 | -3.28096 | -12.4790 | 0.2684 | pm_default |
| 25 | -16.1500 | -3.28150 | -12.8685 | 1.424 | pm_default |
| 26 | 15.2700 | 32.4521 | -17.1821 | 0.2613 | pm_default |
| 27 | 14.1500 | 32.4542 | -18.3042 | 0.3118 | pm_default |
| 28 | -9.40000 | -0.519224 | -8.88078 | 4.242 | pm_default |
| 29 | -10.3000 | -1.40031 | -8.89969 | 0.1548 | pm_default |
| 30 | -0.31000 | -1.39741 | 1.08741 | 0.5156 | pm_default |
| 31 | -1.44000 | -3.67035 | 2.23035 | 2.467 | pm_default |

| | | | | | |
|---|---|---|---|---|---|
| 32 | -4.22000 | -1.35378 | -2.86622 | 0.8203 | pm_default |
| 33 | 3.37000 | -7.40047 | 10.7705 | 1.417 | pm_default |
| 34 | -1.98000 | -0.812701 | -1.16730 | 0.3603 | pm_default |
| 35 | -2.64000 | 1.54684 | -4.18684 | 2.447 | pm_default |
| 36 | 11.7800 | 20.0311 | -8.25106 | 0.6586 | pm_default |
| 37 | 23.0900 | 35.1789 | -12.0889 | 0.4227 | pm_default |
| 38 | 36.9300 | 37.8293 | -0.899290 | 1.752 | pm_default |
| 39 | 63.0600 | 47.6536 | 15.4064 | 1.561 | pm_default |
| 40 | 2.50000 | 1.12508 | 1.37492 | 1.146 | pm_default |
| 41 | 11.9100 | 30.0963 | -18.1863 | 1.497 | pm_default |
| 42 | 14.8900 | 25.9501 | -11.0601 | 0.9076 | pm_default |
| 43 | -9.22000 | -5.22766 | -3.99234 | 0.9593 | pm_default |
| 44 | 0.960000 | -5.23344 | 6.19344 | 1.820 | pm_default |
| 45 | 26.1300 | 35.4863 | -9.35634 | 1.042 | pm_default |
| 46 | 1.43000 | 5.05617 | -3.62617 | 2.239 | pm_default |
| 47 | -23.6100 | -2.01958 | -21.5904 | 1.150 | pm_default |
| 48 | 17.0400 | 31.9859 | -14.9459 | 1.023 | pm_default |
| 49 | 15.1200 | 26.4429 | -11.3229 | 0.5508 | pm_default |
| 50 | -14.7400 | 0.318249 | -15.0582 | 0.2637 | pm_default |
| 51 | -14.7200 | 0.710540 | -15.4305 | 0.6429 | pm_default |
| 52 | -19.1700 | 0.695632 | -19.8656 | 0.1214 | pm_default |
| 53 | 18.8900 | 26.1549 | -7.26490 | 0.8406 | pm_default |
| 54 | -1.33000 | 1.70853 | -3.03853 | 1.054 | pm_default |
| 55 | 64.4400 | 46.8702 | 17.5698 | 0.9559 | pm_default |
| 56 | -3.12000 | 80.3114 | -83.4314 | 0.5851 | pm_default |
| 57 | 1.49000 | 2.36697 | -0.876971 | 0.6429 | pm_default |
| 58 | 1.08000 | 2.81045 | -1.73045 | 2.064 | pm_default |
| 59 | -8.09000 | 0.908756 | -8.99876 | 2.619 | pm_default |
| 60 | -9.01000 | 10.2979 | -19.3079 | 0.1076 | pm_default |
| 61 | -2.61000 | 2.95787 | -5.56786 | 3.631 | pm_default |
| 62 | 1.13000 | 9.25882 | -8.12882 | 0.1376 | pm_default |
| 63 | -1.23000 | 0.862584 | -2.09258 | 6.234 | pm_default |
| 64 | -18.4500 | 0.970866 | -19.4209 | 0.9880 | pm_default |
| 65 | 21.2800 | 37.9378 | -16.6578 | 0.1447 | pm_default |
| 66 | -4.86000 | 1.34696 | -6.20696 | 0.8402 | pm_default |
| 67 | 5.82000 | 6.83197 | -1.01197 | 1.075 | pm_default |
| 68 | -3.04000 | 12.2881 | -15.3281 | 3.695 | pm_default |
| 69 | -7.82000 | 10.0253 | -17.8453 | 0.1650 | pm_default |
| 70 | 3.86000 | 5.49625 | -1.63625 | 1.103 | pm_default |
| 71 | 0.430000 | 5.04172 | -4.61172 | 3.151 | pm_default |
| 72 | 1.55000 | 10.6953 | -9.14526 | 1.585 | pm_default |
| 73 | 3.32000 | 9.02725 | -5.70725 | 1.068 | pm_default |
| 74 | 6.79000 | 13.6884 | -6.89840 | 0.6585 | pm_default |
| 75 | -2.28000 | 6.80263 | -9.08263 | 0.2691 | pm_default |
| 76 | 7.02000 | 7.89771 | -0.877714 | 0.2263 | pm_default |
| 77 | -9.68000 | 9.25790 | -18.9379 | 1.286 | pm_default |
| 78 | 11.9500 | 21.4190 | -9.46900 | 0.2884 | pm_default |
| 79 | 10.8700 | 9.40645 | 1.46355 | 1.147 | pm_default |
| 80 | 34.5100 | 43.9420 | -9.43199 | 1.234 | pm_default |
| 81 | 14.1000 | 28.8485 | -14.7485 | 0.6429 | pm_default |
| 82 | 8.27000 | 11.5277 | -3.25769 | 0.3147 | pm_default |
| 83 | -25.3100 | 1.57731 | -26.8873 | 0.8627 | pm_default |
| 84 | 2.65000 | 8.27993 | -5.62993 | 0.9152 | pm_default |
| 85 | 15.6800 | 16.7614 | -1.08144 | 0.6429 | pm_default |
| 86 | 14.3700 | 16.7222 | -2.35222 | 0.1516 | pm_default |
| 87 | 8.63000 | 10.6505 | -2.02047 | 0.3683 | pm_default |
| 88 | -0.610000 | 1.32272 | -1.93272 | 0.6429 | pm_default |
| 89 | 5.77000 | 8.12412 | -2.35412 | 0.5996 | pm_default |
| 90 | 5.96000 | 8.75954 | -2.79954 | 1.031 | pm_default |
| 91 | 7.38000 | 8.32225 | -0.942245 | 1.552 | pm_default |
| 92 | 7.13000 | 6.78773 | 0.342270 | 1.995 | pm_default |
| 93 | 5.73000 | 11.9847 | -6.25469 | 1.466 | pm_default |
| 94 | 5.72000 | 5.80966 | -8.966200E-02 | 2.201 | pm_default |
| 95 | 4.54000 | 6.09934 | -1.55934 | 1.083 | pm_default |

| | | | | | |
|---|---|---|---|---|---|
| 96 | 5.90000 | 4.73949 | 1.16051 | 0.7443 | pm_default |
| 97 | 15.7100 | 11.2227 | 4.48726 | 4.910 | pm_default |
| 98 | 17.1000 | 11.2248 | 5.87523 | 1.028 | pm_default |
| 99 | 24.4700 | 17.4444 | 7.02560 | 0.9725 | pm_default |
| 100 | 5.06000 | 6.62724 | -1.56724 | 2.257 | pm_default |
| 101 | 5.84000 | 9.74251 | -3.90251 | 1.868 | pm_default |
| 102 | -0.570000 | 10.3143 | -10.8843 | 1.710 | pm_default |
| 103 | -0.740000 | 2.33480 | -3.07480 | 0.1160 | pm_default |
| 104 | 5.26000 | 6.82430 | -1.56430 | 1.145 | pm_default |
| 105 | 7.52000 | 6.82605 | 0.693947 | 0.6549 | pm_default |
| 106 | 35.2400 | 24.0178 | 11.2222 | 0.3621 | pm_default |
| 107 | 11.6400 | 13.9982 | -2.35824 | 10.91 | pm_default |
| 108 | 26.9100 | 27.6144 | -0.704410 | 0.8940 | pm_default |
| 109 | 11.6900 | 9.87869 | 1.81131 | 6.139 | pm_default |
| 110 | 7.98000 | 12.7501 | -4.77011 | 0.8507 | pm_default |
| 111 | 28.2700 | 23.7990 | 4.47105 | 2.619 | pm_default |
| 112 | 38.4600 | 23.7880 | 14.6720 | 1.712 | pm_default |
| 113 | -10.1800 | 3.93169 | -14.1117 | 1.226 | pm_default |
| 114 | 5.83000 | 7.62483 | -1.79483 | 2.572 | pm_default |
| 115 | 7.92000 | 10.0084 | -2.08840 | 1.352 | pm_default |
| 116 | 36.1900 | 25.0998 | 11.0902 | 0.6429 | pm_default |
| 117 | 18.1900 | 21.8119 | -3.62193 | 2.796 | pm_default |
| 118 | 15.8700 | 17.9222 | -2.05217 | 0.8371 | pm_default |
| 119 | -8.80000 | 9.53106 | -18.3311 | 0.8103 | pm_default |
| 120 | 14.5100 | 22.3039 | -7.79388 | 1.055 | pm_default |
| 121 | 12.7200 | 19.3576 | -6.63759 | 1.483 | pm_default |
| 122 | 2.47000 | 10.1029 | -7.63292 | 3.617 | pm_default |
| 123 | 7.93000 | 10.1513 | -2.22131 | 0.8454 | pm_default |
| 124 | 7.81000 | 9.61354 | -1.80354 | 0.9607 | pm_default |
| 125 | 9.53000 | 15.6619 | -6.13185 | 0.9768 | pm_default |
| 126 | 33.7700 | 30.5491 | 3.22089 | 2.927 | pm_default |
| 127 | 34.5700 | 25.4073 | 9.16274 | 0.8546 | pm_default |
| 128 | -8.22000 | 10.7965 | -19.0165 | 2.348 | pm_default |
| 129 | 93.0200 | 84.9831 | 8.03693 | 0.5275 | pm_default |
| 130 | 92.1100 | 84.9849 | 7.12511 | 1.879 | pm_default |
| 131 | 4.98000 | 3.95536 | 1.02464 | 1.508 | pm_default |
| 132 | 1.87000 | 4.14705 | -2.27705 | 0.7476 | pm_default |
| 133 | 4.74000 | 3.85421 | 0.885788 | 5.204 | pm_default |
| 134 | 5.62000 | 11.9047 | -6.28465 | 0.2896 | pm_default |
| 135 | 7.86000 | 12.3128 | -4.45279 | 1.283 | pm_default |
| 136 | 33.9000 | 30.1731 | 3.72690 | 2.241 | pm_default |
| 137 | 4.91000 | 10.6297 | -5.71971 | 1.885 | pm_default |
| 138 | 9.02000 | 19.4789 | -10.4589 | 0.1605 | pm_default |
| 139 | 34.8800 | 34.4598 | 0.420220 | 0.9126 | pm_default |
| 140 | 5.48000 | 10.3338 | -4.85375 | 8.884 | pm_default |
| 141 | 35.8800 | 28.7735 | 7.10650 | 0.9821 | pm_default |
| 142 | 32.4400 | 27.7915 | 4.64849 | 0.5214 | pm_default |
| 143 | 45.8100 | 46.4782 | -0.668170 | 1.935 | pm_default |
| 144 | 46.3100 | 46.4813 | -0.171340 | 1.249 | pm_default |
| 145 | 54.3300 | 44.8284 | 9.50160 | 2.233 | pm_default |
| 146 | 2.99000 | 9.98065 | -6.99065 | 1.144 | pm_default |
| 147 | 7.96000 | 9.98020 | -2.02020 | 1.976 | pm_default |
| 148 | 16.5000 | 20.0626 | -3.56264 | 1.267 | pm_default |
| 149 | 56.6200 | 47.8997 | 8.72034 | 1.914 | pm_default |
| 150 | 35.9700 | 18.9778 | 16.9922 | 1.570 | pm_default |
| 151 | 6.63000 | 6.61673 | 1.327300E-02 | 2.231 | pm_default |
| 152 | 34.5600 | 38.9974 | -4.43735 | 0.8250 | pm_default |
| 153 | 30.1700 | 30.8752 | -0.705170 | 0.7713 | pm_default |
| 154 | 1.60000 | 9.43347 | -7.83347 | 0.1450 | pm_default |
| 155 | 11.1700 | 9.43302 | 1.73698 | 2.856 | pm_default |
| 156 | 10.8600 | 16.1434 | -5.28340 | 1.388 | pm_default |
| 157 | 54.4800 | 60.1342 | -5.65417 | 1.982 | pm_default |
| 158 | 51.7300 | 49.9446 | 1.78544 | 0.4541 | pm_default |
| 159 | 37.6200 | 34.7463 | 2.87375 | 1.779 | pm_default |

| | | | | | |
|---|---|---|---|---|---|
| 160 | 78.3600 | 66.8468 | 11.5133 | 1.173 | pm_default |
| 161 | 75.2100 | 70.9274 | 4.28262 | 1.344 | pm_default |
| 162 | 67.2700 | 63.8894 | 3.38060 | 2.293 | pm_default |
| 163 | 38.7400 | 32.1903 | 6.54969 | 0.9309 | pm_default |
| 164 | 56.7700 | 69.2314 | -12.4614 | 1.119 | pm_default |
| 165 | 21.4200 | 26.6785 | -5.25848 | 0.6000 | pm_default |
| 166 | 34.0700 | 32.7938 | 1.27621 | 1.464 | pm_default |
| 167 | 17.8100 | 23.7301 | -5.92014 | 2.415 | pm_default |
| 168 | 46.4500 | 40.3242 | 6.12576 | 1.778 | pm_default |
| 169 | 26.6900 | 31.1070 | -4.41699 | 0.8205 | pm_default |
| 170 | 61.6700 | 71.7833 | -10.1133 | 0.8413 | pm_default |
| 171 | 46.2900 | 56.0326 | -9.74263 | 1.261 | pm_default |
| 172 | 56.4400 | 46.8690 | 9.57099 | 0.7749 | pm_default |
| 173 | 57.4100 | 46.8676 | 10.5424 | 2.268 | pm_default |
| 174 | 75.7200 | 74.6612 | 1.05883 | 5.766 | pm_default |
| 175 | 45.4200 | 37.0840 | 8.33597 | 1.011 | pm_default |
| 176 | 72.4300 | 79.1447 | -6.71470 | 0.9084 | pm_default |
| 177 | 77.4700 | 79.1471 | -1.67706 | 2.648 | pm_default |
| 178 | 99.4100 | 105.301 | -5.89050 | 2.998 | pm_default |
| 179 | 75.5100 | 84.9291 | -9.41908 | 0.6429 | pm_default |

See file pestctl.res for more details of residuals in graph-ready format.

See file pestctl.seo for composite observation sensitivities.

Objective function ----->

Sum of squared weighted residuals (ie phi) = 3.1559E+04

Correlation Coefficient ----->

Correlation coefficient = 0.9702

Analysis of residuals ----->

All residuals:-

| | |
|---|---|
| Number of residuals with non-zero weight | = 179 |
| Mean value of non-zero weighted residuals | = -3.600 |
| Maximum weighted residual [observation "150"] | = 26.68 |
| Minimum weighted residual [observation "68"] | = -56.64 |
| Standard variance of weighted residuals | = 219.2 |
| Standard error of weighted residuals | = 14.80 |

Note: the above variance was obtained by dividing the objective function by the number of system degrees of freedom (ie. number of observations with non-zero weight plus number of prior information articles with non-zero weight minus the number of adjustable parameters.)
If the degrees of freedom is negative the divisor becomes the number of observations with non-zero weight plus the number of prior information items with non-zero weight.

K-L information statistics ----->

AIC = 997.8302
AICC = 1016.591
BIC = 1112.576
KIC = 744.2018

Parameter covariance matrix ----->

| | evt_13 | evt_14 | evt_15 | evt_16 | evt_17 | hk_1 | hk_10 | hk_11 |
|---|---|---|---|---|---|---|---|---|
| | hk_2 | hk_3 | hk_4 | hk_5 | hk_6 | hk_7 | hk_8 | hk_9 |
| | rch_18 | rch_19 | rch_20 | rch_21 | rch_22 | rch_23 | rch_24 | rch_25 |
| | vani_12 | ghb_27 | ghb_28 | ghb_29 | ghb_30 | ghb_31 | riv_32 | riv_33 |
| | riv_34 | riv_35 | riv_36 | | | | | |
| evt_13 | 620.3 | 1010. | -0.9189 | -6.215 | 435.7 | -134.2 | 1.459 | -166.1 |
| | -0.5719 | -150.2 | 0.5389 | 7.4156E+4 | 0.1652 | 35.49 | -140.0 | -4.2E-2 |
| | 0.2544 | 148.1 | -0.1338 | 0.9188 | -1.656E-3 | 0.5583 | 33.31 | -51.32 |
| | -142.3 | -31.27 | 85.52 | 2.688 | -0.5691 | -6.484 | -386.7 | -13.49 |
| | -0.6007 | 93.59 | 379.7 | | | | | |

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**(See full detail in accompanied CD-ROM)**