Input Data For SSTAR4.
```
* This is a new version of SSTAR which has been revised to *
* include a subroutine to formulate the Present Value of   *
* Net Return objective function. Also,another subroutine   *
* called MINART was developed to generate a new initial fea*
* sible solution. Besides the original constraints on pump *
* ing and recharge, the constraint on minimum availability *
* of groundwater in selected subsystems is included.       *
*********************************************************
```

These are the definitions and format for the main input file for
SSTAR4.

There are four objective functions available to date (11/86),
these include 1) maximimize total regional groundwater withdrawl,
2) minimize total cost of satisfying regional needs, and 3)
maximize the sum of selected local withdrawls, and 4) maximize
the present value of total net economic return.

Card A. Format (F10.8)

Field 1: Hydraulic conductivity in (Feet per Year)*E-06.

Card B. Format(4I5)

Field 1:   ISTART; Minimum I-coordinate associated with a finite-
                  difference cell.
Field 2:   IMAX; Maximum I-coordinate associated with a finite-
                  difference cell.
Field 3:   JMAX; Maximum J-coordinate associated with a finite-
                  difference cell.
Field 4:   ICELL; Total number of cells in the study area.

Card C. Format (6I5)

Field 1: IRCH; Index defining whether recharge will be
constrained. If IRCH = 0 No recharge constraints. If IRCH =
1 There will be recharge constraints.

Field 2:   IM3; Index defining which objective functions will
be executed. If IM3 = 1, only linear objective (max. total
pumping) is run. If IM3 = 2, only quadratic (min cost) objective
is executed. If IM3 = 0 Both the first linear and the quadratic
objective functions will be executed. If IM3 = 3 the second
linear objective function (max. pumping in selected cells) is
run. If IM3 = 4 both the maximum pumping in selected cells and
the minimization of costs will be run. If IM3 = 5 both linear
objective functions will be examined. If IM3 = 6 all three
objective functions will be executed. If IM3 = 8 only quadratic
(max net) objective function is executed.

1

Field 3:   ITER; Index defining whether optimal results will be
used   as initial conditions for purposes of re-ititialization.
If ITER = 0 initial conditions will be read from main data file
and results will not be saved on FT23F001.   If ITER = 1 initial
conditions will be read from main data file and results saved on
FT23F001. If ITER = 2, input will be read from FT23F001 and
results will not be saved on FT23F001.   If ITER = 3 input will be
read from FT23F001 and results saved on FT23F001.

Field 4:   IPDM; Index defining whether matrix of quadratic terms
will be checked for condition of positive definite.   If IPDM = 0
no check will be performed.   If IPDM = 1, matrix will be checked
and message indicating state of matrix will be issued on
FT07F001. Because this matrix can be quite large, it is
recommended that in an effort to conserve execution time and
space, this matrix be checked only once for a given set of cost
values.

Field 5:   IW: Index defining whether some input data will be
output in map format. If IW = 0, no input data will be output in
map format.   If IW = 1, selected input data will be output in map
format.

Field 6:   IMS; Index defining which model is selected when Max.
Present Value O.F. is desired. If IMS = 1, the undeveloped region
model is selected.   If IMS = 2, the developed region strategy is
selected.

Field 7:   ISF; Index defining whether initial feasible solution
is calculated from minimizing artificial variables added to the
constraints.   If ISF = 0 initial feasible solution is read from
FORTRAN UNIT 15 which is either the output from min. artificial
variables optimization or the solution found by max. pumping
objective function.
If ISF = 1, subroutine MINART is called to calculate the initial
solution for main objective function by minimizing the artificial
variables; and optimal solution will be saved on FORTRAN UNIT 15.
The initial solution to this linear function is calculated in
subroutine GSIMEQ.   In this case subroutine REEDIN in QPTHOR will
be called which is a revised version of subroutine READIN built
in QPTHOR for minimizing the artificial variables.
If ISF = 2 the initial feasible solution is directly calculated
in subroutine GSIMEQ.

Card D. Format (715)

Field 1:   ISP; Index defining whether sensitivity analysis on
the results of the Linear (max pumping) Objective function will
be performed. If ISP = 0 No sensitivity analysis.   If ISP = 1
Sensitivity analysis of optimal solution will be performed.

Field 2: ISC; Index defining whether sensitivity analysis on the results of the Quadratic (min cost) Objective function will be performed. If ISC = 0 No sensitivity analysis. If ISC = 1 Sensitivity analysis of optimal solution will be performed.

Field 3: ISS; Index defining whether sensitivity analysis on the result of the second linear objective function (max pumping in selected cells) will be performed. If ISS = 0 no sensitivity analysis. If ISS = 1 sensitivity analysis of optimal solution will be performed.

Field 4: IWP; Index defining whether results of Linear Objective function will be output in map format. If IWP = 0 No map output of optimal solution. If IWP = 1 Results will be output in map format. Also, if IWP = 1 optimal drawdowns and pumping values will be output to FT08F001 for input to "CUES" and "SPGRIDIT".

Field 5: IWC; Index defining whether results of Quadratic Objective function will be output in map format. If IWC = 0 No map output of optimal solution. If IWC = 1 Results will be output in map format.

Field 6: IWS; Index defining whether results of second linear objective function will be output in map format. If IWS = 0 no map output of optimal solution. If IWS = 1 results will be output in map format.

Field 7: IQPSET; Index defining whether appropriate arrays will be output to FT12F001 to be used as input to QPSTEP. If IQPSTEP = 0, No information will be output. If IQPSTEP = 1 the necessary data will be output to FT12F001 for use by QPSTEP.

Card E. Format (2I5)

Field 1: IMLOP; Index defining whether multi-objective analysis will be performed. If IMLOP = 0 No multi-objective analysis. If IMLOP = 1 A multi-objective analysis will be performed between the first linear objective function and the quadratic objective function. If IMLOP=5, the second linear objective function and the quadratic objective function will be simultaneously considered. If IMLOP = 6, all three objective functions will be involved in the multi-objective analysis.

Field 2: NOF; Number of objective functions which will be used as additional constraints. If NOF = 1, the first linear objective function will be used as an additional constraint. If NOF = 2, both linear objective functions will be used as additional constraints.

3

Card F. Format(2I5)

Field 1:   JSTART(1);   The smallest/lower-most/southern-most J-coordinate in the left-most/western-most column, column 1.

Field 2:   JEND(1);   The largest/upper-most/northern-most J-coordinate in column 1.

Continue with the next F-Card for I=2 (column 2) with the smallest and largest J-coordinate in column 2.   Then an F-Card for column 3....   The total number of F-Cards should equal IMAX (Card B, Field 2).

Card G. Format(3I5)

Field 1:   NCH; The total number of constant head cells.

Field 2:   NVRSUB; The total number of variable cells subsystems.

Field 3:   NCHSUB; The total number of constant head cells subsystems.

Card H. Format(3I5)

Field 1:   ICH(1);   The I-coordinate of the first constant head cell.

Field 2:   JCH(1);   The J-coordinate of the first constant head cell.

Field 3:   IRH(1);   An index defining whether a constant head cell is part of a constant head cell subsystem. If IRH = 0, the cell is constrained alone. If IRH is greater than zero, IRH indicates the constant head subsystem to which the constant head cell belongs. The largest value of IRH is NCHSUB.

Continue with H-Cards until all constant head cells have been located.   The total number of H-Cards equals NCH (Card G, Field 1).

If NVRSUB = 0, (Card G, Field 2), skip the Card I.
If NCHSUB = 0, (Card G, Field 3), skip the Card J.

Card I. Format (F10.2)   (Optional)

Field 1: VRX(1); The lower limit on total pumping in variable cells subsystem 1.

Continue with the next I-Card for variable cells subsystem 2. The total number of I-Card is equal to NVRSUB (Card G, Field 2)

4

Card J. Format (F10.2)   (Optional)

Field 1:   CHX(1); The lower limit on total recharge in constant head subsystem 1.

Continue with the next J-Card for constant head subsystem 2. the total number of J-Cards is equal to NCHSUB (Card G, Field 3).

Card K. Format (I5)

Field 1:   NCF; Total number of Constant Flux cells. If NCF = 0 then skip to card M.

Card L. Format (2I5)   (Optional)

Field 1:   ICF; The I-coordinate of the first constant flux cell.
Field 2:   JCF; The J-coordinate of the first constant flux cell.

Continue with J-Cards until all constant flux cells have been located.   The total number of J-Cards equals NCF (Card I, Field 1).

Card M. Format (5I5)

Field 1: NSA; Total number of Stream/Aquifer cells. If NSA = 0 then skip to Card O.

Card N. Format (2I5)   (Optional)

Field 1: ISA(1); I-coordinate of first Stream/Aquifer cell.

Field 2: JSA(1); J-coordinate of first Stream/Aquifer cell.

Field 3:   XSST; The elevation of the water in the stream at cell (ISA,JSA).

Field 4:   STMAX; The maximum allowable interflow between the stream and the aquifer at cell (ISA,JSA).   Use appropriate sign convention.

Field 5:   XAPS;   The reach transmissivity at cell (IAS,JSA) in units of (square feet per year)*E-06.

Continue with L-Cards until all Stream Aquifer cells have been located. The total number of L-Cards should equal NSA (Card K, Field 1).

5

<u>Card O.</u> Format(1X,I2,1X,I4,8F9.2)

Field 1:   I2; The I-coordinate of any cell in the study area.

Field 2:   J2; The cooresponding J-coordinate of the cell partially located in field 1.

Field 3:   ISW; An index defining which cells will be used in the maximization of selected groundwater withdrawl. These same cells will be used as cells with no surface water available and corresponding cost will be assumed as opportunity cost. If ISW = Ø, the cell will be included in the second linear optimization and associated cost will be opportunity cost. If ISW = 1, the cell will be excluded from the second linear optimization and associated cost will be surface water cost. The classification of cost as opportunity cost or surface water cost does not affect the results of the optimization.

Field 4:   ISB; An index defining whether a variable cell is part of a variable cell subsystem. If ISB = Ø, the cell is constrained alone. If ISB is greater than zero, it indicates the variable subsystem to which the variable cell belong. The largest value of ISB is NVRSUB.

Field 5: XELEV; The initial elevation of the potentiometric surface at cell (I2,J2) in feet.

Field 6:   XTOP; The elevation of the top of the aquifer at cell (I2,J2) in feet.

Field 7:   XBOT;   The elevation of the bottom of the aquifer at cell (I2,J2) in feet.

Field 8:   XSATM; The minimum acceptable saturated thickness in cell (I2,J2) in feet.

Field 9:   XACN; The minimum acceptable accretion (max recharge) in cell (I2,J2) in acre-feet.

Field 10: XACX; The maximum allowable accretion on cell (I2,J2) in acre-feet.

Field 11: XPMIN; The minimum acceptable groudwater pumping in cell (I2,J2) in acre-feet.

Field 12: XPMAX;   The maximum allowable groundwater pumping in cell (I2,J2) in acre-feet.

Continue with M-Cards until all cells have been assigned these characteristics. The total number of M-Cards must equal ICELL (Card B, Field 4). The order is not important. If IM3 (Card C, Field 2) is equal to 1, then this completes the data set.

Card P.   Format (3i2,2F8.2,2F6.3,E11.3,2F7.2)

 'd 1: I2; See Card M, Field 1.

 ' ' ?' J2; See Card M, Field 1.

Field 3: XGRSUR;   The elevation of the ground surface at cell
(I2,J2) in feet.

Field 4:   XWAN;   The water needs or demand of cell (I2,J2) in
acre-feet.

Field 5:   XCG;   The variable cost of groundwater associated with
energy requirements of pumping.   The power cost and the engine
maintenance and repair.   This value has units of $/acre-feet-
feet.

Field 6:   XCG2; The variable cost of groundwater associated with
the quantity pumped.   The pump maintenance and repair.   This
value has units of $/aacre-feet.

Field 7:   XCS; The variable cost of supplemental water.   This
value has units of $/acre-feet.

Field 8:   XXA; The ratio of Aquacultural acreage in cell I2,J2.

Field 9:   XSB; The net return value of dryland crop which will be
practice in cells with no surface water and no pumping available
($/acre).

Continue with N-Cards until all cells have been assigned these
characteristics.   The   total number of P-Cards must equal ICELL
(Card C, Field 4) The order is not important.

7

SSTAR

Steady State TARget potentiometric surface model

Version 1.5

USERS MANUAL

Peralta,R.C., Killian,P.W., Yazdanian,A., and Kumar,V.

IIC – 89 / 2

Department of Agricultural and Irrigation Engineering

Utah State University

Logan, Utah 84322-4105.

(801) 750 2786

Table of Contents

1.0: INTRODUCTION:

The Steady State TARget (SSTAR) potentiometric surface model computes optimal sustained yield groundwater pumping strategies. The optimal withdrawal strategies are based on either of the following two objectives.

(1) Maximization of total withdrawal from the aquifer subject to sustained yield hydraulic constraints.

(2) Maximization of the degree of the sustainably maintaining a predetermined potentiometric surface.

Developing strategies for these objectives requires the following steps.

(a) Select the desired objective function.

(b) Select a cell discretization and grid system.

(c) Select the boundary conditions of the S/A system.

(d) Select the upper and lower bounds on decision variables.

(e) If using the second objective, develop the standard error of estimation for target heads.

2.0: THE MODELS:

The two objectives are expressed in operations research form as follows.

The objective functions are:

$$\text{Maximize: } Z_1 = \sum_{k=1}^{nc} Q_k \tag{1}$$

$$\text{Minimize: } Z_2 = \sum_{k=1}^{nc} [(H_k - H_k^t).a_k]^2 \tag{2}$$

Subject to:

— The relationship defining steady groundwater discharge or recharge in a particular cell as a function of average steady-state head in that cell and the neighboring cells (ie, the finite difference form of the Boussinesq equation):

$$-Q_{k,r} + Q_k = f(H) \qquad k = 1,.....,n_c \tag{3}$$

— Pumping in a particular cell must equal or exceed a given minimum value or, recharge in a boundary (constant head) cell must be greater than or equal to a given value:

$$Q_k \geq Q_{min,k} \qquad k = 1,.....,n_c \tag{4}$$

- The pumping or recharge in a particular cell is less than or equal to a given maximum value. The upper bound on pumping is determined by maximum estimated water demand for that cell.

$$Q_k \leq Q_{max,k} \qquad k = 1,.....,n_c \tag{5}$$

–   The steady-state head in a particular cell equals or exceeds a specified minimum value.

$$H_k \geq H_k{}^L \qquad\qquad k = 1,.....,n_c \qquad\qquad (6)$$

-    The steady-state water level is below the ground surface in cell k:

$$(G_k - H_k) \geq 0 \qquad\qquad k = 1,.....,n_c \qquad\qquad (7)$$

-    The recharge to the aquifer in a subsystem of interconnected cells with S/A connections does not exceed a specified upper bound.

$$\sum_{k=1}^{K_r} Q_{k,r} \leq SQ_{r,max} \qquad r = 1,.....,n_r \qquad\qquad (8)$$

-    The interflow between the aquifer and a stream in saturated hydraulic connection is:

$$Q_{k,r} = T_k{}^r \cdot (H_k{}^S - H_k) \qquad r = 1,.....,n_r \qquad\qquad (9)$$

The following notation is used:

$Q_k =$ withdrawal (+) or recharge (-) in cell k (coordinates i,j), except for that due to streamflow (L^3). If representing pumping, discharge is uniformly distributed across the cell, and may represent the pumping from many wells.

$H_k =$ average steady-state head in cell k (L)

$G_k =$ ground surface elevation (L)

$H_k{}^t =$ target (specified) steady-state head in cell k, (L)

$a_k =$ weighting factor assigned to achievement of the target head in cell k (dimensionless)

$Q_{min,k} =$ minimum allowable pumping (extraction) or recharge in cell k (L^3)

$Q_{max,k} =$ maximum allowable pumping or recharge in cell k, determined by total water supply demand in cell k (L^3)

$H_k^L =$ minimum allowable steady-state head in cell k (L)

$f(.) =$ function of

$n_c =$ total number of cells in the system (study area)

$Q_{k,r} =$ stream/aquifer interflow for cell k, belonging to stream/aquifer (S/A) subsystem r (L^3/T)

$SQ_{r,max} =$ maximum allowable total recharge or minimum allowable total discharge for the stream/aquifer cells in S/A subsystem r (L^3/T)

$K_r =$ total number of cells belonging to S/A subsystem r

$n_r =$ total number of S/A subsystems in the study area

$T_k^r =$ positive valued reach transmissivity of cell k,(L^2/T).

$H_k^S =$ elevation of the water surface in the stream at cell k (L).

The first objective function and all the constraints are linear. Because the second power of the decision variables are used in the second objective function, that objective is quadratic. The global optimality of solutions from the second model was verified using the method of minors. The target elevations in the second model, selected by planning agency, are the current springtime potentiometric surface elevations. The utilized weighting factors, a_k, are the reciprocal of the standard deviations of the estimation errors for estimating these elevations using kriging.

Constraints defining sustained yield hydraulic stresses are incorporated in both models. Sustained yield pumping values at each of the

4

finite difference cells can be defined as that value of withdrawal from the aquifer averaged over a given time period, which will maintain time-averaged constant potentiometric surface elevations. Although such a situation may appear to be somewhat idealistic, it has been empirically demonstrated (Peralta and Peralta, 1984; Yazdanian and Peralta, 1985) that a steady-state potentiometric surface is generally maintained over the long term if the total time varying excitation during each year of a given time period equals the appropriate annual steady excitation rate.

2.1: SUBROUTINES USED IN SSTAR

Subroutine MAIN

The main function of this subroutine is to direct the execution to other subroutines. This subroutine also initializes the input unit, IN, and the two output units, ITOUT and IMAP. This subroutine directly calls subroutines READRO, TSAVG, COEF3, COEF1, SWCON, LPMIN, TARGET, INFOUT, SENSE and CHECK. Additional subroutines describing other objective functions may be called from subroutine MAIN any time after the call to subroutine COEF1.

Subroutine READRO

This subroutine reads in data from the main data file from unit IN. Some variables and arrays are initialized for subsequent subroutines including QPTHOR. From the input data, this subroutine calculates the initial saturated thickness, the initial drawdowns, and the midpoint transmissivities. If IW=1, the following information is output to unit IMAP: the cell numbering system, the initial potentiometric surface elevations, the initial drawdowns, the upper bound on drawdown, the initial saturated thickness, the minimum allowable recharge, and the upper and lower limits on groundwater pumping. The subroutines directly called from subroutine READRO include NUMBER and MAP.

Subroutine NUMBER

This subroutine assigns a one-dimensional integral value to identify each finite difference cell located by (I,J) coordinates. The set of cells is defined by a cartesian coordinate system with the origin located at I=0, J=0. An integer designation is assigned separately to each variable-head cell and each constant-head cell. The variable-head cells are numbered beginning with the cell in column one which is in the row with the smallest J-value. Sequential numbering

6

continues in the vertical direction until reaching the last row in column one. The next number is assigned to the cell in column two which is in the row with the smallest J-value. This pattern continues until all NVAR variable cells have been numbered. The constant-head cells are similarly numbered beginning with one and ending with NCH.

Subroutine TSAVG

From the midpoint transmissivity values determined by subroutine READRO, this subroutine calculates the five-point finite difference transmissivities. A geometric averaging method is used to determine the average transmissivity between each finite difference cell and the cells immediately adjacent to it in the positive I-direction and the positive J-direction. The transmissivity values are in units of (square feet per year)*E- 06. Values are truncated one place after the decimal point.

Subroutine MAP

This subroutine takes the data in the array which is passed to it, and outputs this data on unit IMAP in a map format. The data in the argument array must be identified by (I,J) coordinates.

Subroutine COEF3

This subroutine formulates the constraints imposed on recharge in every constant-head cell in which ISW is equal to zero. This set of KCH constraints limit the recharge in constant-head cells such that it is greater than ACCRN. The upper limit on recharge is imposed in subroutine LPMIN or TARGET (whichever is called) in the form of an upper bound on the slack variable associated with inequality constraints (NVAR+1) to (NVAR+KCH). Subroutine COEF3 also formulates a constraint for every constant-head cell subsystem. There are NCHSUB additional constraints. The lower limit on total recharge in each constant-head

7

subsystem is set equal to CHSMIN. The upper limit is imposed in subroutine LPMIN (or TARGET) in the form of an upper bound on the slack variable associated with inequality constraints (NVAR+KCH+1) to (NVAR+KCH+NCHSUB).

Subroutine COEF1

The finite difference transmissivity values are utilized in this subroutine to determine the coefficients and the right hand side of the linear constraints on pumping in all variable cells. The constraint limiting groundwater pumping to be greater than PMIN is formulated. The upper limit on groundwater pumping is imposed in subroutine LPMIN (or TARGET) in the form of an upper bound on the slack variable associated with the first NVAR inequality constraints.

Subroutine SWCON

This subroutine formulates the final NSUB inequality constraints. A constraint for each stream/aquifer subsystem is developed limiting the sum of the stream/aquifer response to be greater than or equal to SWMIN and less than or equal to SWMAX. The index ISA indicates to which subsystem a stream/aquifer cell belongs.

Subroutine LPMIN

In this subroutine, the linear objective function to maximize total regional groundwater pumping is formulated and submitted to QPTHOR. Upper and lower limits on drawdown, are applied to the first NVAR variables. Limits on the slack variable associated with the pumping constraints are imposed on the next NVAR variables. The upper and lower limit on the slack variables associated with the recharge constraints are applied to the next KCH variables. The limits on the recharge in the constant- head subsystems are applied to the next NCHSUB variables. Finally, the limits on stream/aquifer interaction in each

stream/aquifer subsystem are applied to the last NSUB variables.   This subroutine is directly called from the main program when the index ISUS = 0. The subroutines directly called from subroutine LPMIN include subroutine GSIMEQ, and QPTHOR.

Subroutine GSIMEQ

The function of this subroutine is to develop an initial feasible solution from which the optimization process will begin.   A Gauss-Sidel iterative method is used to solve the set of simultaneous equations to compute the drawdown values for which the groundwater pumping in all cells is equal to PMIN. If the lower limit on pumping in all cells is zero, this strategy represents an unstressed aquifer condition. From the initial set of drawdown values, the recharge necessary to support minimum groundwater requirements is computed and compared to the imposed recharge constraints. If the maximum amount of recharge at any constant-head cell is exceeded, a message is output to unit IOUT.

Subroutine QPTHOR

This subroutine optimizes the objective function formulated by subroutine LPMIN (or TARGET) under the constraints defined by subroutines COEF1 and COEF3. It has the capability of optimizing both the linear and quadratic objective functions. This subroutine is a slightly modified version of the QPTHOR written by Leifsson and others (1981). A user's manual of the unmodified program may be purchased from H. J. Morel-Seytoux, Civil Eng. Dept., Colorado State University, Ft. Collins, CO 80523. QPTHOR is not to be extracted from SSTAR5 and used for other purposes without the permission of H. J. Morel-Seytoux.

Subroutine INFOUT

This subroutine outputs the results from subroutine QPTHOR in a map format on output unit IMAP. The information

output from this subroutine includes; drawdowns, elevations, groundwater pumping, recharge, total excitation, the percent of maximum recharge used, stream/aquifer response, and optimal saturated thickness.

Subroutine SENSE

This subroutine writes out the constrained derivatives associated with each decision variable to output unit ITOUT. The constrained derivatives indicate the change in the value of the objective function due to a change in the value of a single decision variable. The information from this subroutine is useful in determining the effect of relaxing a constraining condition on drawdown, pumping, or recharge.

Subroutine TARGET

This subroutine formulates a quadratic goal-programming objective function to create a set of optimized potentiometric levels so that the deviations of the latter set from the input elevations (current or any given set of 'target' elevations), are regionally at a minimum. Limits are imposed on variables in the same way as in subroutine LPMIN. Subroutine QPTHOR is called for optimization. Subroutine INFOUT is called subsequently, to calculate the steady-state pumping values that correspond to this optimized set i.e., sustained yield strategy for the optimized elevations.

If this subroutine is being called, an input data file containing the weighting factors (as described under methodology) must be provided. The description of this input file is given in the next section.

This subroutine is called directly from the main program if the value of the index ISUS on card C is set to one of its values other than 0 (i.e., 1, 2 or 3). In other words, if ISUS equals 0, this subroutine is not executed (see Input Data to SSTAR). Under specific

options, calls are also made by this subroutine to subroutines LPMIN, GSIMEQ and DETERM.

Subroutine CHECK

This subroutine is included to print out, on unit ITOUT, the optimum value of all variables, including original and slack variables, and their corresponding lower and upper bounds. The combination of feasibility and optimality conditions dictates that all the optimal values must be within, or at one of, their bounds. This print out is provided, however, to indicate any remotely probable instance when the condition may be violated due computational inaccuracy encountered in extremely large size problems. In such a case, the message 'Violated' is printed on the same line as the violating variable and its bounds.

The output from this subroutine is also provided for a practical purpose. That is, a computer file containing the optimal values may also be saved if future use of these values as initial feasible solution to a subsequent optimization is envisaged.

The optional call to this subroutine is made from the main program only if the index ICHK = 1, on card C.

Subroutine DETERM

Subroutine QPTHOR is designed for minimization of convex quadratic functions. In other words, global optimality of a solution is assured only when the function is convex (concave in the case of maximization). The necessary and sufficient condition for convexity is that the coefficient matrix of quadratic terms, called the Hessian matrix, must be positive definite. A matrix is positive definite if the determinants of all minors are greater than zero. The coefficient matrix of the objective function introduced here is a diagonal matrix whose diagonal elements are reciprocals of squares of the weighting factors. Therefore they are all nonzeros and positive. This guarantees the positive definiteness of this

11

matrix. However, the present subroutine is included as a capability for the management model to check the condition of any Hessian matrix that may arise by using different quadratic objective functions. The subroutine first transforms the Hessian matrix to a lower triangular matrix. It then examines whether all diagonal elements are positive. The result of this test is printed on unit ITOUT as a message stating whether the coefficient matrix is or is not positive definite.

2.2:INPUT DATA FORMAT FOR SSTAR

These are the definitions and format for the input data to SSTAR.

Card A. Format (F10.8,F10.6)

Field 1: Hydraulic conductivity in feet per year

Field 2: Computational accuracy criterion (ACC). The suggested value for ACC for optimization of both objective functions is 0.002.

Card B. Format(4I5)

Field 1: ISTART;Minimum I-coordinate associated with a finite-difference cell.

Field 2: IMAX; Maximum I-coordinate associated with a finite-difference cell.

Field 3: JMAX; Maximum J-coordinate associated with a finite-difference cell.

Field 4: ICELL; Total number of cells in the study area.

Card C. Format (5I5)

Field 1: IRCH; Index defining whether recharge will be constrained. If IRCH = 0 no recharge constraints are recognized. If IRCH = 1 there are recharge constraints.

Field 2: ITER; Index defining whether optimal results will be used as initial conditions for purposes of sequential optimization If ITER = 0 initial conditions are read from main data file and results are not saved on FT23F001. If ITER = 1 initial conditions are read from main data file and results saved on FT23F001. If ITER = 2, input is read from FT23F001 and results are not saved on FT23F001. If ITER = 3 input is read from FT23F001 and results saved on FT23F001.

Field 3: ISUS; Index defining whether the subroutine TARGET is to be called. If ISUS = 0 no call is made. If ISUS equals 1, 2 or 3 this subroutine is called. Whenever this subroutine is called, an input file containing the cell co-ordinates and the weighting factors for all cells in the region must be provided under FORTRAN UNIT 11. The input format for this file

is (2I5, F10.3). The three fields correspond to the cell co-ordinates I,J and the reciprocals of the weighting factors respectively. The reciprocals are needed because subroutine TARGET has been developed to use the inverse of the standard deviations from kriging as the weighting factors and these standard deviations were directly input to the program. Therefore, if any other weighting factor is to be used, its reciprocal must be input.

The three values of index ISUS determine the source of the initial feasible solution (IFS) to be used by Subroutine QPTHOR for optimization:

If ISUS = 1, subroutine LPMIN is called by TARGET, and the solution found by that subroutine is transferred as an IFS to QPTHOR.

If ISUS = 2, an IFS must be provided as an input file on unit 25. The file must have the initial feasible values for each of the original variables (variables in the objective function) in continuous sequence from variable number one to number N, according to the variable numbering system explained in a following section of this report. The format for this file is (15X,F15.7).

If ISUS = 3, subroutine GSIMEQ is called to generate the IFS.

For a large size aquifer system, the numerical difficulties inherent in optimization of quadratic objective functions require the fairly careful selection of an IFS and an accuracy criterion. It has been observed that for the Boeuf-Tensas Basin, which is a fairly unstressed system, an IFS generated by subroutine GSIMEQ (ISUS = 3) and an ACC = 0.002 are most appropriate. Our experience has been that when using subroutine TARGET an IFS that is close to target levels will cause a more rapid convergence and a satisfactory set of water levels than an IFS that is far from the target elevations.

For large size problems, subroutine TARGET may take a considerable amount of computer time even for a fairly small number of iterations. For the Boeuf-Tensas Basin, a problem with 660 variables and 346

14

constraints, a computer run required 1661 seconds of CPU time to perform 68 iterations. The most important single factor determining the computer run time is, of course, the size of the problem. Run time increases exponentially with increase in size. Accuracy is another factor that affects execution time. More accurate solution is normally associated with more iterations and, thus, with more CPU time. Therefore, the model user must decide whether he can afford more iterations required by a smaller ACC in order to achieve a more satisfactory solution.

Field 4: ICHK; Index defining whether subroutine CHECK is called. If ICHK = 1, the subroutine is called; if it is zero no call is made.

Field 5: IPDM; Index defining whether subroutine DETERM is called. The subroutine is called for IPDM = 1; for IPDM = 0, no call is made. If ISUS = 0, IPDM should be zero too.

Card D. Format (3I5)

Field 1: ISP; Index defining whether sensitivity analysis on the optimization results is performed. If ISP = 0 no sensitivity analysis is performed. If ISP = 1 sensitivity analysis of optimal solution is performed by subroutine SENSE.

Field 2: IWP; Index defining whether results of optimization are output in map format. If IWP = 0 no map output of optimal solution is provided. If IWP = 1 results are output in map format.

Field 3: IW; Index defining whether any input data is output in map format. If IW = 0, no input data is output in map format. If IW = 1, selected input data is output in map format.

Card E. Format(I5)

Field 1: NSUB; Total number of stream/aquifer subsystems. If NSUB = 0 skip to Card G.

Card(s) F. Format(F10.8) (optional)

Field 1: SWMIN(1); The lower limit on interflow, in acre feet per year, from the stream in stream/aquifer subsystem 1 to the aquifer.

Continue with the next F-Card for stream/aquifer subsystem 2. The total

15

number of F-Cards is equal to NSUB, (Card E, Field 1).

Card(s) G. Format (2I5)

Field 1: JSTART(1); The smallest, lower-most J-coordinate in the left-most column, column 1.

Field 2: JEND(1); The largest, upper-most J-coordinate in column 1.

Continue with the next G-Card for I=2 (column 2) with the smallest and largest J-coordinate in column 2. Then a G-Card for column 3.... The total number of G-Cards should equal IMAX (Card B, Field 2).

Card H. Format(2I5)

Field 1: NCH; The total number of constant-head cells. If NCH = 0 then skip to Card K.

Field 2: NCHSUB; The total number of constant-head cell subsystems.

Card(s) I. Format(3I5) (optional)

Field 1: ICH(1); The I-coordinate of the first constant-head cell.

Field2: JCH(1); The J-coordinate of the first constant-head cell.

Field 3: ICF(1); An index defining whether a constant-head cell is part of a constant-head cell subsystem. If ICF = 0, the cell is constrained alone. If ICF is greater than zero, ICF indicates the constant-head subsystem to which the constant-head cell belongs. The largest value of ICF is NCHSUB. Continue with I-Cards until all constant-head cells have been located. The total number of I-Cards equals NCH (Card H, Field 1).

If NCHSUB = 0, (Card H, Field 2), skip to Card K.

Card(s) J. Format (F10.8) (optional)

Field 1: CHSMIN(1); The lower limit on total recharge in constant-head subsystem 1.

Continue with the next J-Card for constant-head subsystem 2. The total number of J-Cards is equal to NCHSUB (Card H, Field 2)

Card K. Format (I5)

Field 1: NSA;Total number of stream/aquifer cells.If NSA = 0 then skip to Card M.

Card(s) L. Format (3I5,F10.2,E12.6,F10.2) (optional)

16

Field 1: I2; I-coordinate of first stream/aquifer cell.

Field 2: J2; J-coordinate of first Stream/Aquifer cell.

Field 3: ISA(1); An index defining whether cell (I2,J2) is in a stream/aquifer subsystem. The integral value of ISA indicates the subsystem to which the stream/aquifer cell belongs. The largest value of ISA is NSUB. If ISA is equal to 0, cell (I2,J2) does not belong to a stream/aquifer subsystem and is constrained by STMAX, (Field 6).

Field 4: XSST; The elevation of the water in the stream at cell (I2,J2).

Field 5: XAPS; The reach transmissivity at cell (I2,J2) in units of square feet per year.

Field 6: STMAX; The minimum allowable interflow between the stream and the aquifer at cell (I2,J2) in acre-feet per year. Use appropriate sign convention. If STMAX is equal to 0, the cell is constrained only as part of a stream/aquifer subsystem. If STMAX is not equal to zero, the drawdown in cell (I2,J2) is limited such that STMAX is not exceeded.

Continue with L-Cards until all stream/aquifer cells have been located. The total number of L-Cards should equal NSA (Card K, Field 1).

Card(s) M. Format(1X,I2,1X,2I2,8F9.2)

Field 1: I2; The I-coordinate of any cell in the study area.

Field 2: J2; The corresponding J-coordinate of the cell partially identified by field 1.

Field 3: ISW; An index defining which cells will be used in the maximization of selected groundwater withdrawal. If ISW = 1, the cell will be included in the linear optimization. If ISW = 0, the cell will be excluded from the linear optimization. If ISW = 0 for a constant-head cell, the constant-head cell is constrained by XACN and XACX (Field 8 and Field 9) If ISW = 1 for a constant-head cell, the constant-head cell is constrained only as part of a constant-head cell subsystem.

Field 4: XELEV; The initial (current or target) elevation of the potentiometric surface at cell (I2,J2) in feet.

17

Field 5: XTOP; The elevation of the top of the aquifer at cell (I2,J2) in feet.

Field 6: XBOT; The elevation of the base of the aquifer at cell (I2,J2) in feet.

Field 7: XSATM; The minimum acceptable saturated thickness in cell (I2,J2) in feet.

Field 8: XACN; The minimum acceptable recharge (maximum flux from outside the system) in cell (I2,J2) in acre-feet per year. If cell (I2,J2) is a variable-head cell, this value is considered a constant.

Field 9: XACX; The maximum allowable recharge in cell (I2,J2)in acre-feet per year. If cell (I2,J2) is a variable-head cell, this value is ignored.

Field10: XPMIN; The minimum acceptable groudwater pumping in cell (I2,J2) in acre-feet per year. If cell (I2,J2) is a constant-head cell, this value is considered a constant.

Field 11: XPMAX; The maximum allowable groundwater pumping in cell (I2,J2) in acre-feet per year. If cell (I2,J2) is a constant-head cell, this value is ignored.

Continue with M-Cards until all cells have been assigned these characteristics. The total number of M-Cards must equal ICELL (Card B, Field 4). The order is not important.

2.3: MATRIX DIMENSIONS

To modify SSTAR to execute for any given study area, the following matrix dimensions must be changed based on the characteristics of the region. The matrix modifications listed for QPTHOR are from the QPTHOR User's Manual (Leifsson and others, 1981).

COMMON/BUNCH 1/ISTART,IMAX,JMAX,JSTART(IMAX),JEND(IMAX)

COMMON/BUNCH 3/NCELL(IMAX,JMAX),NCHN(IMAX,JMAX),ICH(NCH),JCH(NCH),
*ICF(NCH),ISW(ICELL)

COMMON/CHUNK 1/DTR(IMAX,JMAX),DTU(IMAX,JMAX),T(IMAX,JMAX)

COMMON/CHUNK 2/ACCRX(IMAX,JMAX),ACCRN(IMAX,JMAX),PMAX(IMAX,JMAX),
*PMIN(IMAX,JMAX),XM(IMAX,JMAX),SI(IMAX,JMAX)

COMMON/BLOCK 1/CA(NVAR+K),AA(K,NVAR+K),R(K),B(K,K),D(K,NVAR),V(NVAR)

COMMON/BLOCK2/X(NVAR+K),ITYPE(NVAR+K),XO(NVAR+K),XU(NVAR+K),
*XL(NVAR+K)

COMMON/BLOCK 3/NS(K),ND(NVAR),NN(NVAR+K)

COMMON/OPOUT/QG(IMAX,JMAX),SSOP(IMAX,JMAX)

COMMON/SWC1/NSUB,SWMIN(NSUB),SWMAX(NSUB),CHSMIN(NCHSUB),
*CHSMAX(NCHSUB)

COMMON/AQUIF/TOP(ICELL),BOT(ICELL)

COMMON/STAQ/SST(IMAX,JMAX),APS(IMAX,JMAX),ISA(ICELL)

COMMON/QUA 1/Q(NVAR,NVAR)

COMMON/AAA/TAR(IMAX,JMAX)

COMMON/YAZ/SD(IMAX,JMAX), S2(ICELL)

DIMENSION DATA(IMAX,JMAX)

DIMENSION SCR(IMAX,JMAX)

19

DIMENSION CH(IMAX,JMAX)

DIMENSION FACTOR(NVAR)

DIMENSION TV(NVAR),SCR(NVAR),SCR2(VAR)

DIMENSION SS(NVAR),SCR(IMAX,JMAX),SCR2(IMAX,JMAX),SCR3(IMAX,JMAX)

DIMENSION RT(NSUB+NCHSUB)

DIMENSION Z(NVAR+K)

The following definitions apply to the above variable dimensions.

IMAX = the maximum number of columns in the finite difference cell system.

JMAX = the maximum number of rows in the finite difference cell system.

NCH = the total number of constant-head cells in the study area.

NVAR = the total number of variable-head cells in the study area.

ICELL = the total number of finite difference cells in the study area.
ICELL = NCH + NVAR. The smallest system tested using this program has had one row of **seven** cells. The largest has had **376** cells in 21 rows and 35 columns. Larger systems cannot be run without changing the matrix dimensions.
K = the total number of constraints in the problem
= NVAR + KCH + NCHSUB + NSUB.

KCH = the total number of individually constrained constant-head cells.

NCHSUB = the total number of constant-head subsystems. This model will handle upto **four** constant-head systems.

NSUB = the total number of stream/aquifer subsystems. This model will handle upto **three** stream/aquifer systems.

2.4. DEVICE INPUT UNITS FOR SSTAR:

The following is a listing of the computing device units used by the SSTAR water management model to read in data:

<u>Unit IN</u>

The main input, described under INPUT DATA FORMAT FOR SSTAR, should be provided on this unit. IN is currently assigned to unit 4.

<u>Unit 11</u>

If the index ISUS (Card C, Field 3) is either 1, 2 or 3, the input file containing the weighting factors must be provided on this unit. Format and order for this input file are given under Field 3 of Card C (page 13).

<u>Unit 23</u>

This unit is used if values of ITER (Card C, Field 2) are other than zero. The unit may be either an input or an output unit or both, depending on the value assigned to ITER. The output file created on this unit is 80 column and the same file is used as input in a subsequent run. Therefore, the format an order need not concern the user.

<u>Unit 25</u>

If ISUS = 2, the file containing initial feasible solution must be provided on this unit. Format and order for this file are given under Field 3 of Card C for the option ISUS = 2 (page 13).

2.5. OUTPUTS FROM SSTAR:

The output from the SSTAR water management model appears on three separate output files. General output information, including any sensitivity analysis, is less than 80 columns in width and is directed to unit ITOUT. Output and results from the optimization subroutine QPTHOR are found on Unit 6, where 132 column record length is needed. Any requested map output is directed to unit IMAP, also of 132 column record length. Each of these output files are described in detail for a typical problem.

Unit ITOUT

This output listing indicates the number of individually constrained constant head cells, KCH. The number of constant- head subsystems, NCHSUB, and stream/aquifer subsystems, NSUB, are also noted in this file. The total number of constraints, K, is equal to NVAR + KCH + NCHSUB + NSUB, where NVAR is the total number of variable-head cells.

IfIPDM = 1 and ISUS is not equal zero,there will be a two line message at this point in the output file that indicates whether the coefficient matrix of the quadratic terms is positive definite or not.

If ISUS is not zero, the next line in the output file indicates the constant value of weighted sum of squares of the initially input (current or 'target') drawdowns in variable-head cells . This numerical value is the constant term in the quadratic objective function (Model 2) described in chapter four.

If ISUS is not 2, the following part of the output file is a note indicating the number of iterations used in subroutine GSIMEQ, and whether the total number of iterations, NIT, has been exceeded. Subroutine GSIMEQ uses the Gauss-Seidel iterative process to calculate the drawdown values which correspond to the lower limit on groundwater pumping in all cells. (Further description of this subroutine appears in the Description of Subroutines used in SSTAR.) Because this is an iterative method of simultaneous equation solution, an accuracy criteria is employed for determining when the process should be stopped.

The accuracy criteria used in subroutine GSIMEQ is the same criteria used in QPTHOR for determining whether any constraints have been violated by the initial feasible solution. Therefore, a solution created by GSIMEQ within the maximum number of iterations, is automatically accepted by QPTHOR. However, if the maximum number of iterations is exceeded before the accuracy criteria is satisfied, the initial feasible solution may be rejected by QPTHOR.

The accuracy criteria in both GSIMEQ and QPTHOR is a function of ACC (Card A, Field 2). The values of ACC in the range 0.001 - 0.002 have been satisfactory for most of the developmental simulations. The maximum number of iterations in GSIMEQ is defined by the integer NIT and has been internally set to 100. If this is exceeded and the solution rejected by QPTHOR it may be necessary to increase NIT. Under certain input conditions, such as a large value of reach transmissivity (above the order of E+09 ft^2/year), a degenerate situation may arise in which convergence in subroutine GSIMEQ is not guaranteed. If such a situation occurs, the accuracy term, ACC may have to be increased.

After a solution has been calculated in subroutine GSIMEQ, the corresponding recharge in the constant-head cells is calculated. This calculated recharge is that which supports the initial feasible solution. If the initial recharge in a constant-head cell is less than the input lower limit on recharge in that cell, the lower limit is decreased and set equal to the initial recharge. When this is necessary, a message is output to unit ITOUT indicating the magnitude of the change. When a recharge constraint is tight at the initial feasible solution, and the initial feasible solution represents minimum allowable groundwater pumping, further optimization is severely restricted.

In the specific case when ISUS = 2 (initial feasible solution supplied by the user through an input file), no call is made to subroutine GSIMEQ. In this case obviously no output from that subroutine described above, will be produced.

If ICHK = 1, the next portion of the output file is a print out of the final optimal values for all variables (including slack variables) and their bounds. If ICHK equals 0, this output is not produced.

If no sensitivity analysis is performed (ISP = 0), no additional output to unit ITOUT exists. If a sensitivity analysis is requested (ISP = 1), the results are directed to unit ITOUT. The results of the sensitivity analysis indicate the relationship of each decision variable to the value of the objective function. This is useful in determining the effect on the objective function due to a change in a limiting constraint.

The output listing contains three lines for each decision variable. A decision variable is any variable which is tight against either its lower bound or its upper bound at the optimal solution. The total number of decision variables is equal to NVAR.

The first line indicates the type of variable and its current value. The cell numbering system is that as discussed previously. The variable may represent drawdown or pumping in a variable-head cell, recharge in a

23

constant-head cell, total recharge in a constant-head subsystem, or total interflow in a stream/aquifer subsystem. If the variable is representative of drawdown, the value of the variable is equal to the drawdown at that cell. If however, the variable represents one of the slack variables, pumping, recharge, or total reach response, the given value of the variable is equal to the difference between the flux and the lower limit on that flux. For example, if the value of the variable representing pumping in cell 9 is equal to zero, than the actual value of pumping is computed as P-PMIN=0 or P=PMIN.

The second output line for each decision variable lists the constrained derivative of the objective function with respect to that particular decision variable, and the maximum change in the value of that decision variable for which the constrained derivative is applicable. The constrained derivative indicates the change in the value of the objective function for a unit change in the value of the decision variable. The maximum change in the decision variable indicates the range within which the constrained derivative applies, assuming that the decision variable is changed in the direction which improves the value of the objective function. A unit change in the decision variable in which the absolute value of the constrained derivative is the largest has the most effect on the value of the objective function.

The third output line for each decision variable indicates the state variable which becomes tight when the decision variable is changed by the maximum amount indicated in the second line. The variable numbering system applied to these state variables is common throughout the output and will be encountered again. For this reason it is now explained in detail.

The total number of variables, including slack variables, is equal to NVAR+K where K is the total number of inequality constraints as defined previously. The total number of variables is also expressed as NVAR + NVAR + KCH + NCHSUB + NSUB. The first NVAR variables are numbered according to the cell numbering system and represent the drawdown in cells 1 to NVAR. The next NVAR variables represent the groundwater pumping in cells 1 to NVAR and are designated by the integers NVAR+1 to 2*NVAR. The next KCH variables are those corresponding to the recharge in individually constrained constant-head cells and are numbered from 2*NVAR+1 to 2*NVAR+KCH. (The individually constrained constant-head cells are located as described in the constant-head cell numbering system.) The following NCHSUB variables are those representing the total recharge in each of the constant-head cell subsystems.

These variables are numbered from 2*NVAR+KCH+1 to 2*NVAR+KCH+NCHSUB. The final NSUB variables represent total interflow from the stream/aquifer subsystems and are numbered from 2*NVAR+KCH+NCHSUB+1 to 2*NVAR+KCH+NCHSUB+NSUB.

24

Unit 6

Unit 6 is designated by QPTHOR to receive the output from the optimization process. This output listing begins by indicating the number of variables in the objective function, NVAR, and the total number of inequality constraints, K. The information that follows is the upper and lower limit on each variable, including slack variables, and the value of each variable used as an initial feasible solution. The value used as an initial feasible solution must be within or equal to the upper or lower bounds. The variable numbering system is that as explained previously.

The initial value of the objective function is indicated followed by the optimal value of all system variables. Recall that the values listed for the slack variables are the differences between the flux and the lower limit on the flux. Finally, the optimal value of the objective function and the number of iterations required is output.

Before performing the optimization, all input values are modified such that all volumes are represented in units of millions of cubic feet. This is done in order that the matrices of coefficients are all of an order of one. The values of variables and limits listed in this output are therefore in units of millions of cubic feet and must be divided by 0.04356 to change them to acre feet.

Unit IMAP

The information on this unit is a listing of some input and output values on a cell by cell basis in map format. If IW = 1, the listing begins with a map of the cell numbering system followed by a map of the constant head cell numbering system. These maps are useful in locating a particular variable by i,j coordinates. Initial input elevations (current or target), corresponding drawdowns, bounds on the variables and initial saturated thicknesses are then printed in a map format.

The next parts of this output file are formulated in subroutine INFOUT and contain two main portions 1) information about the initial feasible solution and 2) information associated with the optimal solution. When ISUS is equal to 0 or 3, that is when subroutine GSIMEQ is called to generate the initial feasible solution, the first portion shows the results associated with drawdowns calculated by that subroutine. The second portion in this case contains the optimal solution either from LPMIN (ISUS = 0) or from TARGET (ISUS = 3). When ISUS = 2, the first portion contains information from the initial solution supplied by the user and the second portion shows the results of optimization by TARGET. When ISUS = 1, the first portion shows the results from optimization in LPMIN and the second portion contains the results from TARGET.

25

APPENDICES
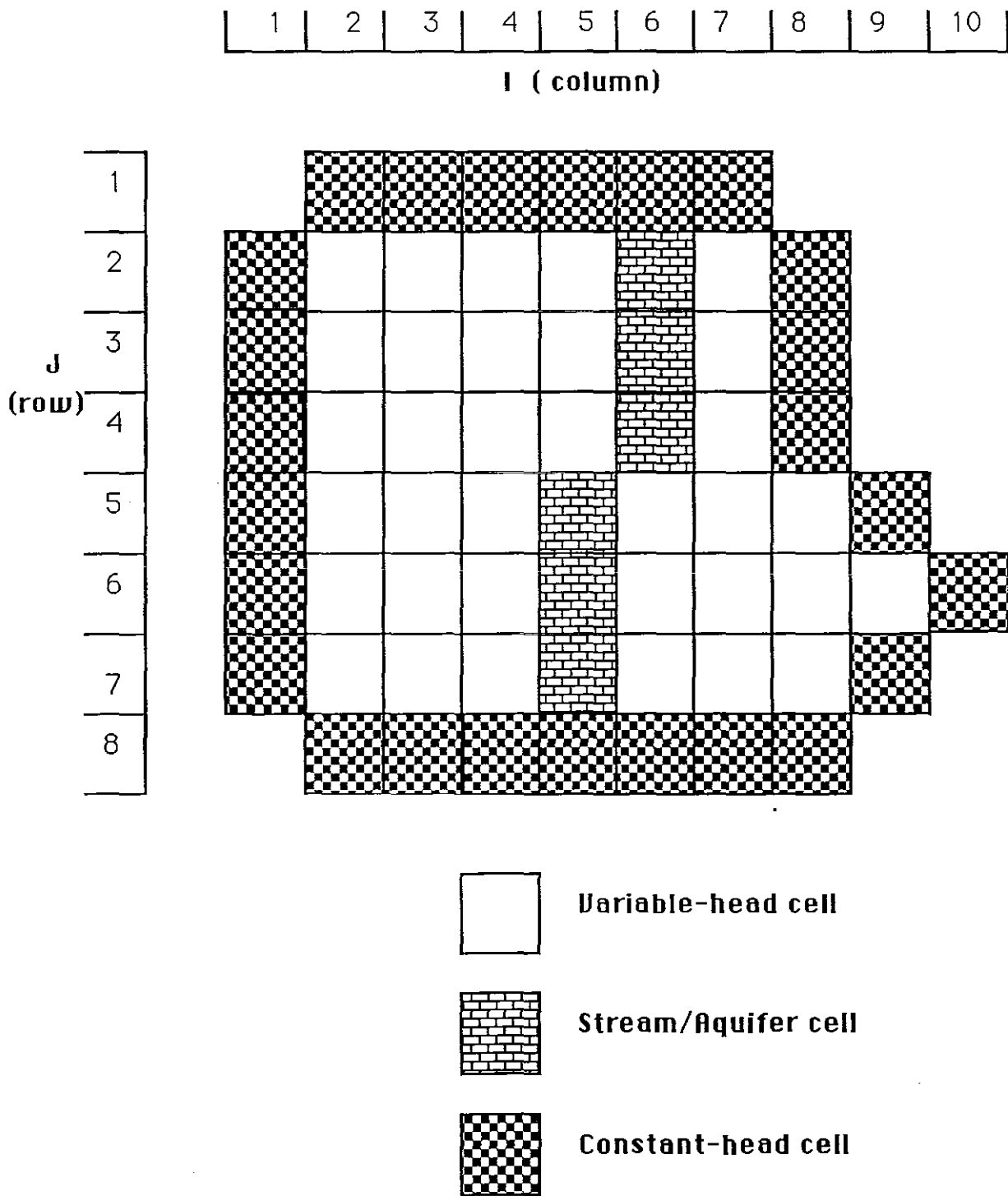
Figure 3.1. Cell Discretization For A Hypothetical Area.

Figure 3.2. Device Input Unit IN (File For004.dat)

```
98250.0      0.002              Card A
   1  10   8   65               Card B
   1   1   0   0   0            Card C
   0   1   1                    Card D
   1                            Card E
 -14049.0                       Card F
   2   7                        Card(s) G
   1   8
   1   8
   1   8
   1   8
   1   8
   1   8
   2   8
   5   7
   6   6
  25   0                        Card H
   1   2   0                    Card(s) I
   1   3   0
   1   4   0
   1   5   0
   1   6   0
   1   7   0
   2   1   0
   2   8   0
   3   1   0
   3   8   0
   4   1   0
   4   8   0
   5   1   0
   5   8   0
   6   1   0
   6   8   0
   7   1   0
   7   8   0
   8   2   0
   8   3   0
   8   4   0
   8   8   0
   9   5   0
   9   7   0
```

```
10   6   0
 6                                              Card K
 6   2   1    92.5   6.20E+07                   Card(s) L
 6   3   1    93.0   6.20E+07
 6   4   1    93.5   6.20E+07
 5   5   1    94.0   5.11E+05
 5   6   1    95.0   5.11E+05
 5   7   1    96.0   5.11E+05

 1  2 0   89.725    300.    35.    20.   -2000.    0.    0    0 Card(s)  M
 1  3 0   91.151    300.    21.    20.   -2000.    0.    0    0
 1  4 0   93.754    300.     4.    20.   -2000.    0.    0    0
 1  5 0   96.521    300.    15.    20.   -2000.    0.    0    0
 1  6 0   99.829    300.    28.    20.   -2000.    0.    0    0
 1  7 0  103.968    300.    30.    20.   -2000.    0.    0    0
 8  2 0  103.886    300.   -25.    20.   -2000.    0.    0    0
 8  3 0  104.891    300.    -7.    20.   -2000.    0.    0    0
 8  4 0  105.525    300.     8.    20.   -2000.    0.    0    0
 9  5 0  110.005    300.     2.    20.   -2000.    0.    0    0
 9  7 0  110.796    300.    15.    20.   -2000.    0.    0    0
10  6 0  112.648    300.     5.    20.   -2000.    0.    0    0
 2  1 0   87.774    300.    50.    20.   -2000.    0.    0    0
 3  1 0   87.296    300.    39.    20.   -2000.    0.    0    0
 4  1 0   88.064    300.    20.    20.   -2000.    0.    0    0
 5  1 0   89.568    300.     7.    20.   -2000.    0.    0    0
 6  1 0   92.319    300.    -4.    20.   -2000.    0.    0    0
 7  1 0   97.501    300.   -16.    20.   -2000.    0.    0    0
 2  8 0   98.848    300.    35.    20.   -2000.    0.    0    0
 3  8 0   94.379    300.    49.    20.   -2000.    0.    0    0
 4  8 0   96.176    300.    42.    20.   -2000.    0.    0    0
 5  8 0   97.960    300.    24.    20.   -2000.    0.    0    0
 6  8 0   99.052    300.    29.    20.   -2000.    0.    0    0
 7  8 0  101.249    300.    29.    20.   -2000.    0.    0    0
 8  8 0  105.462    300.    26.    20.   -2000.    0.    0    0
 2  5 1   93.644    300.    26.    20.       0.    0.    0  551.
 2  6 1   96.290    300.    29.    20.       0.    0.    0  573.
 4  3 1   88.274    300.    20.    20.       0.    0.    0  958.
 4  6 1   92.536    300.    28.    20.       0.    0.    0  414.
 4  7 1   94.010    300.    39.    20.       0.    0.    0  556.
 5  3 1   89.896    300.    23.    20.       0.    0.    0  891.
 5  4 1   91.918    300.    -6.    20.       0.    0.    0  908.
 5  6 1   93.531    300.    19.    20.       0.    0.    0  603.
 6  3 1   92.990    300.     8.    20.       0.    0.    0  813.
 6  4 1   96.079    300.     0.    20.       0.    0.    0  830.
```

6	7	1	95.852	300.	27.	20.	0.	0.	0	391.
6	6	1	95.210	300.	20.	20.	0.	0.	0	430.
7	3	1	100.750	300.	-2.	20.	0.	0.	0	682.
7	4	1	101.441	300.	4.	20.	0.	0.	0	752.
7	6	1	98.587	300.	19.	20.	0.	0.	0	478.
7	7	1	97.588	300.	28.	20.	0.	0.	0	2078.
8	6	1	106.633	300.	16.	20.	0.	0.	0	432.
8	7	1	105.452	300.	19.	20.	0.	0.	0	243.
9	6	1	111.862	300.	10.	20.	0.	0.	0	525.
2	2	1	86.387	300.	51.	20.	0.	0.	0	1490.
2	3	1	88.166	300.	17.	20.	0.	0.	0	1069.
2	4	1	90.948	300.	8.	20.	0.	0.	0	1156.
2	7	1	98.594	300.	25.	20.	0.	0.	0	1085.
3	2	1	86.322	300.	38.	20.	0.	0.	0	1234.
3	3	1	87.434	300.	11.	20.	0.	0.	0	1043.
3	4	1	89.594	300.	24.	20.	0.	0.	0	1199.
3	5	1	91.430	300.	39.	20.	0.	0.	0	1846.
3	6	1	92.650	300.	30.	20.	0.	0.	0	1414.
3	7	1	94.442	300.	40.	20.	0.	0.	0	1611.
4	4	1	89.917	300.	23.	20.	0.	0.	0	1034.
4	5	1	91.343	300.	38.	20.	0.	0.	0	1579.
5	2	1	88.659	300.	11.	20.	0.	0.	0	1577.
5	5	1	92.910	300.	13.	20.	0.	0.	0	1682.
6	2	1	90.073	300.	0.	20.	0.	0.	0	1245.
4	2	1	87.437	300.	10.	20.	0.	0.	0	2337.
5	7	1	94.979	300.	30.	20.	0.	0.	0	2256.
6	5	1	96.026	300.	9.	20.	0.	0.	0	2337.
7	5	1	100.600	300.	4.	20.	0.	0.	0	2018.
7	2	1	99.853	300.	-13.	20.	0.	0.	0	879.
8	5	1	106.041	300.	5.	20.	0.	0.	0	2078.

Figure 3.3.1. Output Unit ITOUT (File For007.dat)

KCH =   25

NCHSUB =   0   NSUB =   1

ITERATIONS =   16 IN SUBROUTINE GSIMEQ

***** EPD =   0.40515423E+00

Figure 3.3.2. Output Unit IMAP (File For009.dat)

VARIABLE CELL NUMBERING SYSTEM

```
          0.00    0.00    0.00    0.00    0.00    0.00
  0.00    1.00    2.00    3.00    4.00    5.00    6.00    0.00
  0.00    7.00    8.00    9.00   10.00   11.00   12.00    0.00
  0.00   13.00   14.00   15.00   16.00   17.00   18.00    0.00
  0.00   19.00   20.00   21.00   22.00   23.00   24.00    0.00
  0.00   25.00   26.00   27.00   28.00   29.00   30.00    0.00
  0.00   31.00   32.00   33.00   34.00   35.00   36.00    0.00
          0.00    0.00    0.00   37.00   38.00   39.00    0.00
                                  0.00   40.00    0.00
                                          0.00
```

CONSTANT HEAD CELL NUMBERING SYSTEM

```
          1.00    2.00    3.00    4.00    5.00    6.00
  7.00    0.00    0.00    0.00    0.00    0.00    0.00    8.00
  9.00    0.00    0.00    0.00    0.00    0.00    0.00   10.00
 11.00    0.00    0.00    0.00    0.00    0.00    0.00   12.00
 13.00    0.00    0.00    0.00    0.00    0.00    0.00   14.00
 15.00    0.00    0.00    0.00    0.00    0.00    0.00   16.00
 17.00    0.00    0.00    0.00    0.00    0.00    0.00   18.00
         19.00   20.00   21.00    0.00    0.00    0.00   22.00
                                 23.00    0.00   24.00
                                         25.00
```

INITIAL DRAWDOWNS (FT) FROM DATUM = 300 FT.

```
        210.28  208.85  206.25  203.48  200.17  196.03
212.23  213.61  211.83  209.05  206.36  203.71  201.41  201.15
212.70  213.68  212.57  210.41  208.57  207.35  205.56  205.62
211.94  212.56  211.73  210.08  208.66  207.46  205.99  203.82
210.43  211.34  210.10  208.08  207.09  206.47  205.02  202.04
207.68  209.93  207.01  203.92  203.97  204.79  204.15  200.95
202.50  200.15  199.25  198.56  199.40  201.41  202.41  198.75
        196.11  195.11  194.48  193.96  193.37  194.55  194.54
                                190.00  188.14  189.20
                                        187.35
```

UPPER BOUND ON DRAWDOWN TO PROVIDE MIN SAT THICK

```
          0.00    0.00    0.00    0.00    0.00    0.00
  0.00  229.00  263.00  272.00  254.00  251.00  255.00    0.00
  0.00  242.00  269.00  256.00  241.00  250.00  240.00    0.00
  0.00  270.00  260.00  257.00  242.00  252.00  241.00    0.00
  0.00  269.00  257.00  286.00  267.00  261.00  250.00    0.00
  0.00  280.00  272.00  280.00  271.00  260.00  253.00    0.00
  0.00  293.00  282.00  276.00  276.00  261.00  252.00    0.00
          0.00    0.00    0.00  275.00  264.00  261.00    0.00
                                  0.00  270.00    0.00
                                          0.00
```

32

INITIAL ELEVATIONS (FT)

```
         89.72   91.15   93.75    96.52    99.83  103.97
 87.77   86.39   88.17   90.95    93.64    96.29   98.59    98.85
 87.30   86.32   87.43   89.59    91.43    92.65   94.44    94.38
 88.06   87.44   88.27   89.92    91.34    92.54   94.01    96.18
 89.57   88.66   89.90   91.92    92.91    93.53   94.98    97.96
 92.32   90.07   92.99   96.08    96.03    95.21   95.85    99.05
 97.50   99.85  100.75  101.44   100.60    98.59   97.59   101.25
        103.89  104.89  105.53   106.04   106.63  105.45   105.46
                                 110.00   111.86  110.80
                                          112.65
```

INITIAL SATURATED THICKNESS (FT)

```
         54.72   70.15   89.75    81.52    71.83   73.97
 37.77   35.39   71.17   82.95    67.64    67.29   73.59    63.85
 48.30   48.32   76.43   65.59    52.43    62.65   54.44    45.38
 68.06   77.44   68.27   66.92    53.34    64.54   55.01    54.18
 82.57   77.66   66.90   97.92    79.91    74.53   64.98    73.96
 96.32   90.07   84.99   96.08    87.03    75.21   68.85    70.05
113.50  112.85  102.75   97.44    96.60    79.59   69.59    72.25
       128.89  111.89   97.53   101.04    90.63   86.45    79.46
                                108.00   101.86   95.80
                                         107.65
```

MINIMUM ALLOWABLE RECHARGE IN 100 ACRE-FEET

```
        -20.00  -20.00  -20.00   -20.00   -20.00  -20.00
-20.00    0.00    0.00    0.00     0.00     0.00    0.00   -20.00
-20.00    0.00    0.00    0.00     0.00     0.00    0.00   -20.00
-20.00    0.00    0.00    0.00     0.00     0.00    0.00   -20.00
-20.00    0.00    0.00    0.00     0.00     0.00    0.00   -20.00
-20.00    0.00    0.00    0.00     0.00     0.00    0.00   -20.00
-20.00    0.00    0.00    0.00     0.00     0.00    0.00   -20.00
        -20.00  -20.00  -20.00     0.00     0.00    0.00   -20.00
                                 -20.00     0.00  -20.00
                                           -20.00
```

MAXIMUM ALLOWABLE RECHARGE IN 100 ACRE-FEET

```
         0.00    0.00    0.00     0.00     0.00    0.00
 0.00    0.00    0.00    0.00     0.00     0.00    0.00     0.00
 0.00    0.00    0.00    0.00     0.00     0.00    0.00     0.00
 0.00    0.00    0.00    0.00     0.00     0.00    0.00     0.00
 0.00    0.00    0.00    0.00     0.00     0.00    0.00     0.00
 0.00    0.00    0.00    0.00     0.00     0.00    0.00     0.00
 0.00    0.00    0.00    0.00     0.00     0.00    0.00     0.00
         0.00    0.00    0.00     0.00     0.00    0.00     0.00
                                 0.00     0.00    0.00
                                          0.00
```

MINIMUM ALLOWABLE PUMPING IN ACRE-FEET

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	
					0.00		

MAXIMUM ALLOWABLE PUMPING IN ACRE-FEET

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	1490.00	1069.00	1156.00	551.00	573.00	1085.00	0.00
0.00	1234.00	1043.00	1199.00	1846.00	1414.00	1611.00	0.00
0.00	2337.00	958.00	1034.00	1579.00	414.00	556.00	0.00
0.00	1577.00	891.00	908.00	1682.00	603.00	2256.00	0.00
0.00	1245.00	813.00	830.00	2337.00	430.00	391.00	0.00
0.00	879.00	682.00	752.00	2018.00	478.00	2078.00	0.00
	0.00	0.00	0.00	2078.00	432.00	243.00	0.00
				0.00	0.00	0.00	
					0.00		

STREAM REACH LOCATIONS

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00
0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	
					0.00		

LOWER LIMIT ON TOTAL INTERFLOW IN REACH   1 = -14049.0   ACRE-FEET

OUTPUT FROM I.F.S.

DRAWDOWN VALUES FROM 300. DATUM.(FT)

```
        210.28  208.85  206.25  203.48  200.17  196.03
212.23  209.89  207.94  206.05  203.92  201.78  200.31  201.15
212.70  209.72  207.67  205.95  204.19  202.86  202.73  205.62
211.94  209.25  207.28  205.54  203.91  202.84  202.75  203.82
210.43  208.19  206.46  204.89  203.10  201.98  201.70  202.04
207.68  206.52  205.71  204.67  201.46  200.15  200.00  200.95
202.50  201.10  200.14  199.30  197.91  197.14  197.23  198.75
        196.11  195.11  194.48  193.92  193.51  193.46  194.54
                                190.00  189.95  189.20
                                        187.35
```

ELEVATIONS.(FT)

```
         89.72   91.15   93.75   96.52   99.83  103.97
 87.77   90.11   92.06   93.95   96.08   98.22   99.69   98.85
 87.30   90.28   92.33   94.05   95.81   97.14   97.27   94.38
 88.06   90.75   92.72   94.46   96.09   97.16   97.25   96.18
 89.57   91.81   93.54   95.11   96.90   98.02   98.30   97.96
 92.32   93.48   94.29   95.33   98.54   99.85  100.00   99.05
 97.50   98.90   99.86  100.70  102.09  102.86  102.77  101.25
        103.89  104.89  105.52  106.08  106.49  106.54  105.46
                                110.00  110.05  110.80
                                        112.65
```

GROUNDWATER PUMPING IN ACRE-FEET

```
         0.00    0.00    0.00    0.00    0.00    0.00
 0.00    4.07    7.78    7.73    5.65    4.09    1.57    0.00
 0.00    5.87    8.82    8.00    6.12    4.65    1.45    0.00
 0.00    5.79    6.96    7.54    6.19    4.44    1.31    0.00
 0.00    3.00    4.25    5.71    5.76    3.70    1.08    0.00
 0.00    0.92    1.77    3.88    4.02    2.51    0.68    0.00
 0.00    0.66    1.08    1.74    2.23    1.41    0.34    0.00
         0.00    0.00    0.00    0.77    0.57    0.00    0.00
                                0.00    0.01    0.00
                                        0.00
```

TOTAL REGIONAL GROUNDWATER PUMPING = 0.144115E+03

GW PUMPING AS % OF MAX ALLOWABLE PUMPING

```
         0.00    0.00    0.00    0.00    0.00    0.00
 0.00    0.27    0.73    0.67    1.03    0.71    0.14    0.00
 0.00    0.48    0.85    0.67    0.33    0.33    0.09    0.00
 0.00    0.25    0.73    0.73    0.39    1.07    0.24    0.00
 0.00    0.19    0.48    0.63    0.34    0.61    0.05    0.00
 0.00    0.07    0.22    0.47    0.17    0.58    0.17    0.00
 0.00    0.08    0.16    0.23    0.11    0.29    0.02    0.00
         0.00    0.00    0.00    0.04    0.13    0.00    0.00
                                0.00    0.00    0.00
                                        0.00
```

35

RECHARGE IN ACRE-FEET

	237.93	411.63	106.69	-37.21	-143.32	-1392.16	
146.94	0.00	0.00	0.00	0.00	0.00	0.00	-412.17
470.39	0.00	0.00	0.00	0.00	0.00	0.00	1067.71
594.29	0.00	0.00	0.00	0.00	0.00	0.00	185.47
704.59	0.00	0.00	0.00	0.00	0.00	0.00	-24.30
912.05	0.00	0.00	0.00	0.00	0.00	0.00	324.25
-865.50	0.00	0.00	0.00	0.00	0.00	0.00	610.60
	-1084.68	-1340.19	-1085.86	0.00	0.00	0.00	-518.10
				-915.43	0.00	-1040.19	
					-614.46		

TOTAL REGIONAL RECHARGE = -.370103E+04

TOTAL EXCITATION IN ACRE-FEET

	237.93	411.63	106.69	-37.21	-143.32	-1392.16	
146.94	4.07	7.78	7.73	5.65	4.09	1.57	-412.17
470.39	5.87	8.82	8.00	6.12	4.65	1.45	1067.71
594.29	5.79	6.96	7.54	6.19	4.44	1.31	185.47
704.59	3.00	4.25	5.71	26.17	24.93	17.27	-24.30
912.05	835.39	1100.99	1569.67	4.02	2.51	0.68	324.25
-865.50	0.66	1.08	1.74	2.23	1.41	0.34	610.60
	-1084.68	-1340.19	-1085.86	0.77	0.57	0.00	-518.10
				-915.43	0.01	-1040.19	
					-614.46		

STREAM/AQUIFER RESPONSE IN ACRE-FEET

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	20.41	21.23	16.19	0.00
0.00	834.47	1099.22	1565.80	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	
					0.00		

TOTAL REGIONAL S/A RESPONSE = 0.355732E+04

TOTAL INTERFLOW IN S/A SUBSYSTEM 1 =   3557.

36

STREAM ELEVATIONS

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	94.00	95.00	96.00	0.00
0.00	92.50	93.00	93.50	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	
					0.00		

RECHARGE AS % OF MAX. ALLOWABLE RECHARGE

	-11.90	-20.58	-5.33	1.86	7.17	69.61	
-7.35	0.00	0.00	0.00	0.00	0.00	0.00	20.61
-23.52	0.00	0.00	0.00	0.00	0.00	0.00	-53.39
-29.71	0.00	0.00	0.00	0.00	0.00	0.00	-9.27
-35.23	0.00	0.00	0.00	0.00	0.00	0.00	1.21
-45.60	0.00	0.00	0.00	0.00	0.00	0.00	-16.21
43.27	0.00	0.00	0.00	0.00	0.00	0.00	-30.53
	54.23	67.01	54.29	0.00	0.00	0.00	25.90
				45.77	0.00	52.01	
					30.72		

SATURATED THICKNESS (FT)

	54.72	70.15	89.75	81.52	71.83	73.97	
37.77	39.11	75.06	85.95	70.08	69.22	74.69	63.85
48.30	52.28	81.33	70.05	56.81	67.14	57.27	45.38
68.06	80.75	72.72	71.46	58.09	69.16	58.25	54.18
82.57	80.81	70.54	101.11	83.90	79.02	68.30	73.96
96.32	93.48	86.29	95.33	89.54	79.85	73.00	70.05
113.50	111.90	101.86	96.70	98.09	83.86	74.77	72.25
	128.89	111.89	97.52	101.08	90.49	87.54	79.46
				108.00	100.05	95.80	
					107.65		

OUTPUT FROM MAX PUMPING LINEAR O.F.

DRAWDOWN VALUES FROM 300. DATUM.(FT)

	210.28	208.85	206.25	203.48	200.17	196.03	
212.23	220.03	218.99	216.87	213.71	209.58	203.96	201.15
212.70	222.62	223.76	223.62	223.06	217.54	210.00	205.62
211.94	222.13	223.32	223.45	223.47	217.75	212.34	203.82
210.43	216.80	217.73	217.74	218.24	215.10	212.73	202.04
207.68	208.80	208.37	208.36	209.11	208.45	207.15	200.95
202.50	202.98	202.09	201.75	202.11	202.53	204.14	198.75
	196.11	195.11	194.48	195.60	196.15	196.04	194.54
				190.00	191.15	189.20	
					187.35		

ELEVATIONS.(FT)

	89.72	91.15	93.75	96.52	99.83	103.97	
87.77	79.97	81.01	83.13	86.29	90.42	96.04	98.85
87.30	77.38	76.24	76.38	76.94	82.46	90.00	94.38
88.06	77.87	76.68	76.55	76.53	82.25	87.66	96.18
89.57	83.20	82.27	82.26	81.76	84.90	87.27	97.96
92.32	91.20	91.63	91.64	90.89	91.55	92.85	99.05
97.50	97.02	97.91	98.25	97.89	97.47	95.86	101.25
	103.89	104.89	105.52	104.40	103.85	103.96	105.46
				110.00	108.85	110.80	
					112.65		

GROUNDWATER PUMPING IN ACRE-FEET

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	1490.02	1069.00	1114.38	550.97	573.02	0.00	0.00
0.00	1233.99	1042.99	1199.03	1846.04	1413.98	72.85	0.00
0.00	2336.95	958.07	1033.97	1578.99	413.99	556.00	0.00
0.00	1577.01	891.01	907.98	1682.03	602.99	2256.00	0.00
0.00	1244.93	812.97	829.99	4.00	2.54	390.99	0.00
0.00	879.04	226.79	0.09	2.23	-0.05	2078.02	0.00
	0.00	0.00	0.00	-0.01	0.59	243.00	0.00
				0.00	525.02	0.00	
					0.00		

TOTAL REGIONAL GROUNDWATER PUMPING = 0.336414E+05

GW PUMPING AS % OF MAX ALLOWABLE PUMPING

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	100.00	100.00	96.40	99.99	100.00	0.00	0.00
0.00	100.00	100.00	100.00	100.00	100.00	4.52	0.00
0.00	100.00	100.01	100.00	100.00	100.00	100.00	0.00
0.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
0.00	99.99	100.00	100.00	0.17	0.59	100.00	0.00
0.00	100.00	33.25	0.01	0.11	-0.01	100.00	0.00
	0.00	0.00	0.00	0.00	0.14	100.00	0.00
				0.00	100.00	0.00	
					0.00		

RECHARGE IN ACRE-FEET

	-769.38	-1348.80	-2000.01	-1676.02	-1365.58	-2000.01	
-689.94	0.00	0.00	0.00	0.00	0.00	0.00	-976.90
-935.19	0.00	0.00	0.00	0.00	0.00	0.00	252.47
-1514.03	0.00	0.00	0.00	0.00	0.00	0.00	-994.31
-851.41	0.00	0.00	0.00	0.00	0.00	0.00	-1748.95
433.75	0.00	0.00	0.00	0.00	0.00	0.00	-796.85
-1343.76	0.00	0.00	0.00	0.00	0.00	0.00	-493.96
	-1594.32	-1811.10	-2000.02	0.00	0.00	0.00	-1000.03
				-1594.08	0.00	-1836.89	
					-898.08		

TOTAL REGIONAL RECHARGE = -.295534E+05

TOTAL EXCITATION IN ACRE-FEET

	-769.38	-1348.80	-2000.01	-1676.02	-1365.58	-2000.01	
-689.94	1490.02	1069.00	1114.38	550.97	573.02	0.00	-976.90
-935.19	1233.99	1042.99	1199.03	1846.04	1413.98	72.85	252.47
-1514.03	2336.95	958.07	1033.97	1578.99	413.99	556.00	-994.31
-851.41	1577.01	891.01	907.98	1595.87	531.92	2194.56	-1748.95
433.75	135.15	-354.43	-761.80	4.00	2.54	390.99	-796.85
-1343.76	879.04	226.79	0.09	2.23	-0.05	2078.02	-493.96
	-1594.32	-1811.10	-2000.02	-0.01	0.59	243.00	-1000.03
				-1594.08	525.02	-1836.89	
					-898.08		

STREAM/AQUIFER RESPONSE IN ACRE-FEET

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	-86.16	-71.07	-61.45	0.00
0.00	-1109.78	-1167.40	-1591.79	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	
					0.00		

TOTAL REGIONAL S/A RESPONSE = -.408765E+04

TOTAL INTERFLOW IN S/A SUBSYSTEM   1 =   -4088.

STREAM ELEVATIONS

	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	94.00	95.00	96.00	0.00
0.00	92.50	93.00	93.50	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	
					0.00		

RECHARGE AS % OF MAX. ALLOWABLE RECHARGE

	38.47	67.44	100.00	83.80	68.28	100.00	
34.50	0.00	0.00	0.00	0.00	0.00	0.00	48.85
46.76	0.00	0.00	0.00	0.00	0.00	0.00	-12.62
75.70	0.00	0.00	0.00	0.00	0.00	0.00	49.72
42.57	0.00	0.00	0.00	0.00	0.00	0.00	87.45
-21.69	0.00	0.00	0.00	0.00	0.00	0.00	39.84
67.19	0.00	0.00	0.00	0.00	0.00	0.00	24.70
	79.72	90.55	100.00	0.00	0.00	0.00	50.00
				79.70	0.00	91.84	
					44.90		

SATURATED THICKNESS (FT)

	54.72	70.15	89.75	81.52	71.83	73.97	
37.77	28.97	64.01	75.13	60.29	61.42	71.04	63.85
48.30	39.38	65.24	52.38	37.94	52.46	50.00	45.38
68.06	67.87	56.68	53.55	38.53	54.25	48.66	54.18
82.57	72.20	59.27	88.26	68.76	65.90	57.27	73.96
96.32	91.20	83.63	91.64	81.89	71.55	65.85	70.05
113.50	110.02	99.91	94.25	93.89	78.47	67.86	72.25
	128.89	111.89	97.52	99.40	87.85	84.96	79.46
				108.00	98.85	95.80	
					107.65		