# DOCUMENTATION OF A NUMERICAL CODE FOR THE SIMULATION OF VARIABLE DENSITY GROUND-WATER FLOW IN THREE DIMENSIONS

By Logan K. Kuiper

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WILLIAM P. CLARK, Secretary

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Dallas L. Peck, Director

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For additional information write to:

Project Chief
U.S. Geological Survey
Southwest Tower, 3rd Floor
211 East 7th Street
Austin, Texas 78701

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## CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

| Multiply | By | To obtain |
|---|---|---|
| cubic foot ($ft^3$) | 0.02832 | cubic meter ($m^3$) |
| foot per day (ft/d) | 0.3048 | meter per day (m/d) |
| pound, avoirdupois | 453.6 | gram (g) |

# DOCUMENTATION OF A NUMERICAL CODE FOR THE SIMULATION OF VARIABLE DENSITY GROUND-WATER FLOW IN THREE DIMENSIONS

By Logan K. Kuiper

## *ABSTRACT*

*This report documents a numerical code for the simulation of variable density time dependant ground-water flow in three dimensions. The ground-water density, although variable in space, is assumed to be approximately constant in time and known. The Integrated Finite Difference grid elements in the code follow the geologic strata in the modeled area. If appropriate, the determination of hydraulic head in confining beds can be deleted to decrease computation time. The strongly implicit procedure (SIP), successive over-relaxation (SOR), and eight different preconditioned conjugate gradient (PCG) methods are used to solve the approximating equations.*

*The use of the computer program that performs the calculations in the numerical code is emphasized. Detailed instructions are given for using the computer program, including input data formats. An example simulation and Fortran listing of the program are included.*

## INTRODUCTION

This report documents a numerical code for the simulation of variable density time dependant ground-water flow in three dimensions. The ground-water density, although variable in space, is assumed to be approximately constant in time and known. The Integrated Finite Difference grid elements in the code are six sided and rectangular when viewed from the vertical direction. The sides of these grid elements are planar, but their top and bottom surfaces follow the curvature of the geologic strata in the modeled area.

The strongly implicit procedure (SIP), successive over-relaxation (SOR), and eight different preconditioned conjugate gradient methods (PCG) (Kuiper, written commun., 1984) are used to solve the approximating equations.

The ground-water flow equation with constant density is used for most ground-water flow studies. In many problems the variation in ground-water density $\rho$ is sufficiently small that it can be neglected. For certain situations, however, it is necessary to treat $\rho$ as a function of water pressure, salt concentration, and temperature.

In some cases, particularly in a confined aquifer, the pressure at a point may change considerably with time, even though the density, temperature, and salt concentration of the water change very little. This is possible, since water density is more weakly dependent upon pressure than it is upon temperature and salt concentration. Density changes that occur due to thermal and salt transport are much slower than those that occur due to pressure changes. Thus if one is interested in the simulation of pressure for a short time period, it is a permissible approximation to regard the density as being time independent and to use the ground-water flow equatiton by itself without the solute transport or heat conduction equation. In this case, the density $\rho(x,y,z)$ is regarded as being time independent and is determined either by measurement, model callbration, or other procedures, much the same as the hydraulic conductivity. After a certain time period, depending upon the circumstances, pressure changes may pass to a state of quasi-equilibrium. This may occur in a time period which is sufficiently small that density changes, due to thermal and salt transport, are insignificant. A good approximation to this quasi-equilibrium solution is the solution of the steady state ground-water flow equation, again with density $\rho(x,y,z)$ independent of time. Numerical solutions of this type, although valid only for the restricted conditions given above, are far less expensive in terms of computional cost than are those for more general situations which also solve the coupled solute transport and/or heat condition equations. In this report, as with Bennett (1980) and Weiss (1982), ground-water density $\rho$ is assumed to be a known function of spatial position.

## THEORETICAL DEVELOPMENT

The basic development of the numerical code documented in this report has been presented by Kuiper (1983), and will not be presented here. Approximating equations (17) and (28) of Kuiper (1983), for steady-state flow, are:

$$F \cong A_x \hat{K}'_{uu} \left[ \frac{\Delta h}{\ell} + \frac{B}{\ell \rho_0} \right] + \cdots \quad (M/T) \qquad (1)$$

$$F_z \cong (\Delta x_i \Delta y_j)\, \hat{K}'_{ww} \left[ \frac{\Delta h}{b'} + \frac{\rho_{i,j,k}\, b_{i,j,k} + \rho_{i,j,k+1}\, b_{i,j,k+1}}{2b'\rho_0} \right] (M/T) \qquad (2)$$

Equation (1) gives an approximation to the flow into the side of a grid element i,j,k from a horizontally adjacent grid element i+1,j,k. The quantity $\ell$ is the distance in the i direction between the center of grid element i,j,k and grid element i+1,j,k, $\Delta h$ is the difference in the pressure head h between the two grid element centers, $A_x$ is an approximation to the area of the common side shared by the two grid elements, and $\hat{K}'_{uu}$ is the weighted harmonic mean of the hydraulic conductivity for the two grid elements. The quantity B is an approximation to the intergral of $\rho \Delta z$ from the center of grid element i,j,k to the center of grid element i+1,j,k. The fluid density is $\rho$ and $\Delta z$ is the increment of vertical distance z, measured positive upwards. In equation (2), $F_z$ is an approximation to the flow downward into the top of grid element i,j,k from grid element i,j,k+1. The terms in equation (2) are completely analogous to those in equation (1). The vertical distance between the two grid element centers is $b'$, and $b_{i,j,k}$ and $b_{i,j,k+1}$ are the vertical thicknesses of grid elements i,j,k and i,j,k+1 respectively. Note that the harmonic mean has been taken of the hydraulic conductivity rather than transmissivity.

With the substitutions $h' = h+z$ and $\rho' = \rho - \rho_0$, the terms in the brackets in equations (1) and (2) remain the same except that fresh-water head $h'$ replaces pressure head $h$, and $\rho'$ replaces $\rho$. With this alteration, multiplication by -1, and division by $\rho_0 = 1\ gm/cm^3$, equations (1) and (2) may be written in matrix form as:

$$Mh' = \hat{q} \qquad (L^3/T) \qquad (3)$$

Matrix M has seven diagonals corresponding to the i,j,k-1, i,j-1,k, i-1,j,k, i,j,k, i+1,j,k, i,j+1,k, i,j,k+1 grid element locations. Component i,j,k of vector $\hat{q}$ includes the sum of all sources of mass (divided by $\rho_0$) that arise in grid element i,j,k. Such sources of mass include ground-water pumping from wells, as a negative quantity, and also the dissolution of solutes from the porous media. From equation (1), and since $K = K'/\rho_0$, the i+1,j,k location diagonal of matrix M is equal to the quantity $-A_x\hat{K}_{xx}/\ell$, where the notations $K_{uu}$, $K_{vv}$, and $K_{ww}$ (Kuiper, 1983) are replaced by $K_{xx}$, $K_{yy}$, and $K_{zz}$ in this report. Similar equalities pertain to the i-1,j,k, i,j-1,k, and i,j+1,k diagonals. The second term in equation (1), with $\hat{K}'_{uu}$ replaced by $\hat{K}_{uu}$, is part of vector $\hat{q}$. The i,j,k+1 diagonal of matrix M is equal to the quantity $-(\Delta x_i \Delta y_j)\ \hat{K}_{zz}/b$ from equation (2). The i,j,k-1 diagonal is equal to the i,j,k-1 location equivalent of this same quantity. The second term in (2) with $\hat{K}'_{ww}$ replaced by $\hat{K}_{ww}$ is part of vector $\hat{q}$. The center diagonal of M is equal to the negative of the sum of the six off-center diagonals.

Equation (3) is modified for time dependant flow. Component i,j,k of matrix equation (3) expresses the conservation of mass for grid element i,j,k. Using the backward difference for the time derivative, $[(dV)S_s(\rho/\rho_0)/\Delta t](h')^{n-1}$, for grid element i,j,k, is added to the i,j,k component of mass recharge vector $\hat{q}$. The dV, $S_s$, and $\rho$, are the volume, specific storage, and water density for grid element i,j,k. The $\Delta t$ is the time interval between times n and n-1. The expression $[(dV)S_s(\rho/\rho_0)/\Delta t]$ is added to the center diagonal of matrix M.

For any grid element, the computer model allows for mass discharge which, when the hydraulic head H is greater than some chosen value $H_e$, increases linearly with h'. When such discharge is taking place, vector $\hat{q}$ and the center diagonal of matrix $M$ receive additional terms, as with the addition of time dependancy.

## MODEL APPLICATION

### Grid Elements

Figure 1 shows a side view example of the grid element system, and figure 2 shows a top view.

In figures 1 and 2, the modeled region lies within the total volume taken up by grid elements I,J,K for $2 \leq I \leq 10$, $2 \leq J \leq 5$; and $2 \leq K \leq 6$. There are: nine columns numbered I = 2, 3,... , 10; four rows numbered J = 2, 3, 4, 5; and five layers numbered K = 2, 3,... , 6. In the computer program, grid elements are not identified using I, J, K, but rather by a single subscript:

$$IJ = I + (NI10)(J-2) + (NIJ10)(K-2)$$

where NIJ10 = (NI10)(NJ10). NI10, NJ10, and NK10 are the total number of columns, rows, and layers in the modeled region. In the example in figures 1 and 2, NI10 = 9, NJ10 = 4, and NK10 = 5. IJ has the values 2, 3,... , 181. Confining bed grid elements are identified by

$$IJLB = I + (NI10)(J-2) + (NIJ10)(KLB-2)$$

where KLB denotes confining bed layer. In figure 1, KLB has the values 7 and 8. IJLB has the values 182, 183,... , 253.

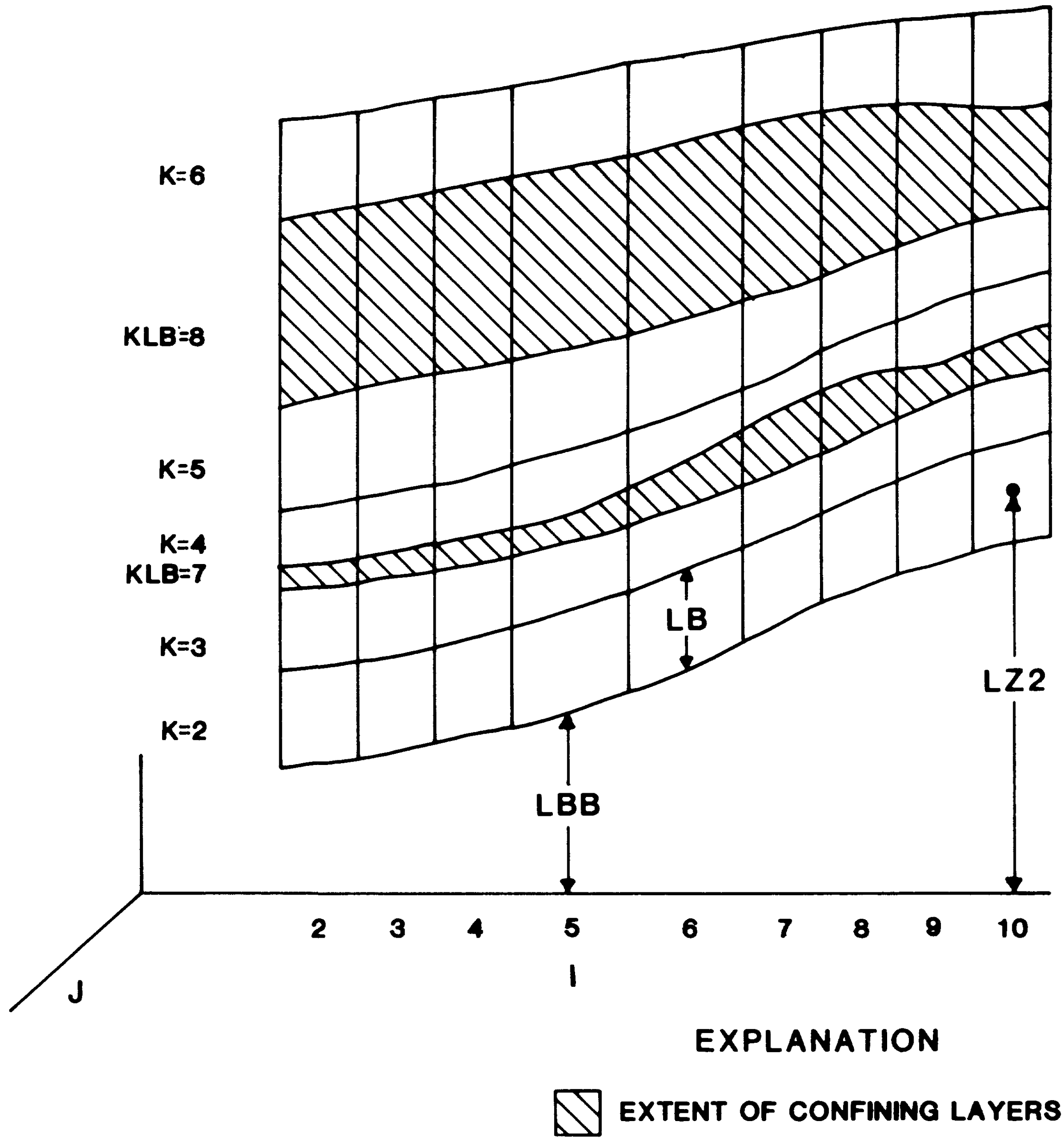


Figure 1.--Side view of grid elements.

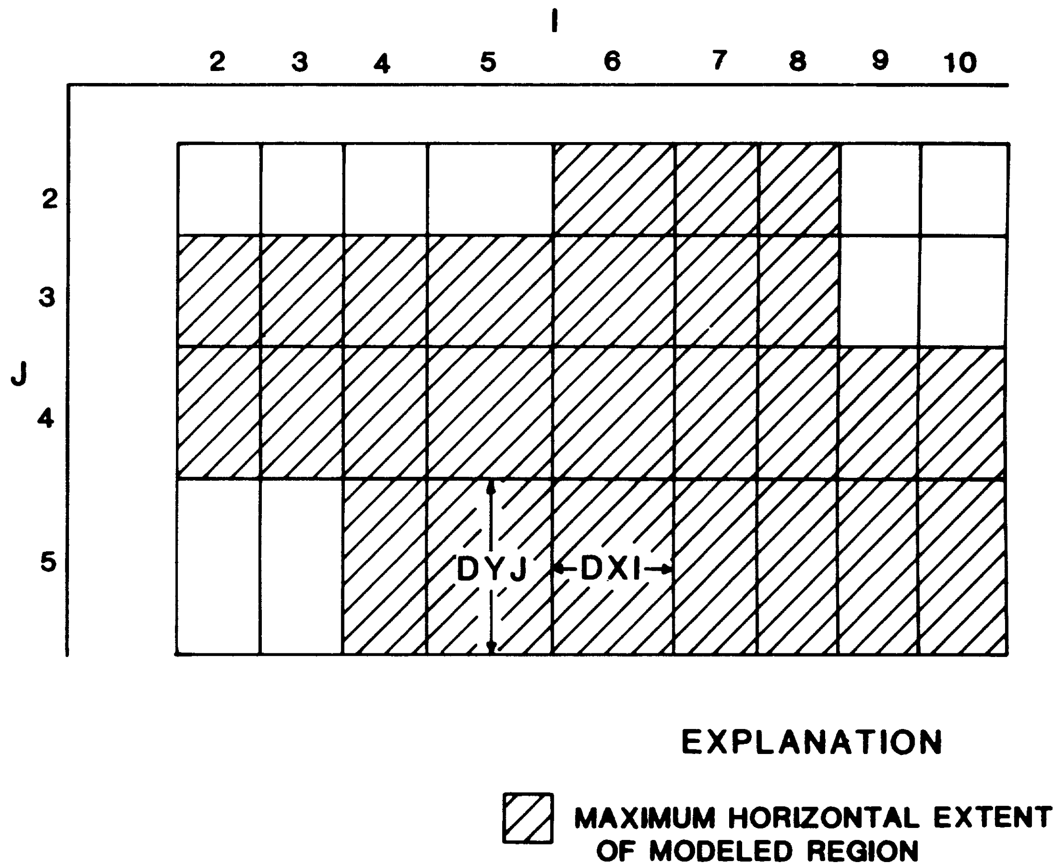


Figure 2.--Top view of grid elements.

The solution procedure in the numerical code assumes that no flow can pass through the boundary surface surrounding the modeled region. By fixing the rate of water withdrawal or injection from grid elements adjacent to the boundary surface, specified flow boundary conditions can be simulated. By fixing the hydraulic head in grid elements adjacent to the boundary, specified hydraulic head boundary conditions can be simulated.

In the computer program, grid elements, and confining bed grid elements, which lie outside of the modeled region, are flagged with NT=0. When a grid element has NT=0, it is dropped from the calculations in the solution procedure, thus reducing the computation time. Figure 2 shows the maximum horizontal extent of the modeled region. Because the modeled region may have different values of I and J for each layer, some of the grid elements or confining bed grid elements, which lie in the cross-hatched area in figure 2, lie outside of the modeled region.

For the computer program, values of $\rho'$ may have any value outside of the modeled region. Values for LB and LBB in figure 1, in the cross-hatched area in figure 2, even when outside of the modeled region, should have values such that the computer program, when summing values of LB and LBB, obtains the correct elevations for LZ2 in figure 1 for the grid elements and confining bed grid elements within the modeled region. Values for LB, and LBB, may have any value outside of the cross-hatched area in figure 2.

When a layer, or confining bed layer, pinches out, LB is set to zero, and a non-zero value for $K_{zz}$ (see page D-2) is used. This prescription for LB and $K_{zz}$ causes a pinched-out grid element or confining bed grid element to offer no resistance to the flow of water through the elements' top and bottom surfaces, but prevents any flow through the elements' sides.

## Fresh-Water Head

In the development by Kuiper (1983), the approximating equations (1) and (2) are written using pressure head $h = p/\rho_0 g$, where p is pressure, $\rho_0 = 1\ gm/cm^3$, and g is the acceleration of gravity. When equations (1) and (2) are altered using fresh-water head $h' = h+z$ and $\rho' = \rho - \rho_0$, and then divided by $\rho_0$, they become equation (3).

When a cased well extends to a point at elevation z and at which the ground water has pressure p and density $\rho$, the water rises inside the well bore a distance $p/\rho g = h\,\rho_0/\rho$. Since the hydraulic head H is the elevation of the formation water in the well bore:

$$H = \frac{h}{\frac{\rho}{\rho_0}} + z$$

or

$$H = \frac{h'-z}{\left(\frac{\rho'}{\rho_0} + 1\right)} + z \qquad (4)$$

The computer program solves matrix equation (3) written with fresh-water head h' as the unknown. Any fixed hydraulic head values (MHD values in the computer program) are first converted to fixed h' values, using equation (4) evaluated at the center of the grid element, before the solution procedure is started. After a solution is obtained, the newly found h' values (XX values in the computer program) are converted to hydraulic head values, using equation (4), before they are printed. Hydraulic head values are input into the computer program and are also obtained as output, even though fresh-water head h' is used in the solution procedure.

## Confining Beds

Confining bed grid elements, by definition, have zero hydraulic conductivity in the I and J directions, and thus do not allow any water to pass through their sides. Their specific storage is zero, and they do not have any wells, or any sources or sinks of mass of any type.

Figure 1 shows two confining beds, between the K = 3 and K = 4 layers and also between layers K = 5 and K = 6. The vertical dimension and $\rho'$ for confining bed and regular grid elements are input in the computer program using the data sets LB and LRO respectively. For the example in figures 1 and 2, 180 values of LB (IJ) and LRO (IJ) for IJ = 2, 3,... , 181 are read in. In addition, 72 values of LB (IJLB) and LRO(IJLB) for IJLB = 182, 183,... , 253 are read in. The LB(IJ) and LB(IJLB) values are read in as one continuous array of 252 values, with the confining bed grid elements following the regular grid elements. In like manner, LRO(IJLB) values follow LRO(IJ) values. This same procedure is used to read in values for NT(IJ) and NT(IJLB), which are needed for the computation of hydraulic conductivity.

When more than one confining bed exists between two aquifer layers, they must be combined into one effective confining bed with the z component of K equal to $(K_{zz})_{eff}$, and with the same total vertical dimension LB, by using:

$$\frac{(K_{zz})_{eff}}{LB} = \left[ \sum_{i=1}^{n} \left( \frac{b}{K_{zz}} \right)_i \right]^{-1} \qquad (5)$$

The number of adjacent confining beds is n. Confining bed i has vertical dimension $b_i$, and $(K_{zz})_i$ for the z component of K. The total thickness, or vertical dimension, of the adjacent confining beds is $\sum_{i=1}^{n} b_i = LB$. The ground-water density $\rho_{eff}$, for the effective confining bed, is found using:

$$(LB)\ \rho_{eff} = \sum_{i=1}^{n} \rho_i\ b_i \qquad (6)$$

## Recharge

Component IJ of mass recharge vector $\hat{q}$ in equation (3), with units ($L^3/T$), includes the sum of all sources of mass (divided by $\rho_0$) that occur in grid element IJ. Such sources of mass include ground-water pumping from wells, as a negative quantity, and also the dissolution of solutes from the porous media. Vector $\hat{q}$ is denoted by the quantities YQ(IJ) in the computer program. The user must specify the mass recharge rates YQ(IJ), one for each grid element IJ, but may also specify mass recharge rates Q2(I,J,K) with which one must give the associated locations I, J, and K. If values for Q2(I,J,K,) are specified, the computer program adds these values to those given for YQ(IJ).

## Head Dependant Discharge

For any grid element the computer model allows for mass discharge which, when the hydraulic head H is greater than some chosen value $H_e$, increases linearly with H. The rate of mass discharge ($L^3/T$) from a grid element is given by $Aa(H-H_e)$ when $H>H_e$, and is zero when $H<H_e$. H is the hydraulic head in the grid element and A is the area of the grid element, ((DXI(I) X (DYJ(J)). In the computer program, XXE(IJ) is $H_e$, measured relative to the center of the grid element. ALN(IJ), with units (1/T) specifies the quantity a.

The discharge may be used for a variety of purposes. It lends itself readily to evaporation which is sometimes assumed to begin when the hydraulic head rises to within a certain distance from ground surface. It can also be used to simulate discharge into a stream. In this case Q2(or YQ) would also be used, to arrive at a net discharge of $Aa(H-H_e)-Q2$ for $H>H_e$, and Q2 for $H<H_e$. By choosing $H_e$ to be less than any H that could possibly exist in the grid element being considered, the net discharge becomes $Aa(H-H_e)-Q2 = Aa[H-(H_e+Q2/Aa)]$. $H_e$ and Q2 should be chosen such that $H_e+Q2/Aa$ is equal to the stream elevation.

## SOLUTION METHODS

### Strongly Implicit Procedure

The strongly implicit procedure (SIP) for the solution of equation (3) uses the basic iterative equations (10), (14), and (15) of Weinstein and others (1969). In the numerical code, Weinstein's equation (10) is used with $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_m$ where

$$(1-\alpha_m) = (1-\alpha_{max})^{m/C-1} \qquad m = 0, 1, \ldots, (C-1)$$

C is the number of iteration parameters in a cycle, and is denoted by LENGTH in the computer program. In the computer program, one may choose $(1-\alpha_{max})$ to be WMAX by reading in a non-zero value for WMAX, or let the program calculate a value:

$$(1-\alpha_{max}) = (XYFC)\ (XY) \tag{7}$$

where

$$XY = \left(\frac{\pi^2}{2}\right)\frac{1}{NCNT} \sum_{IJ} \min\left[\frac{1}{(NI10)^2\ (1+XM(IJ))},\ \frac{1}{(NJ10)^2\ (1+YM(IJ))},\ \frac{1}{(NK10)^2\ (1+ZM(IJ))}\right] \tag{8}$$

where

$$XM = \frac{B+H+Z+S}{D+F} \qquad (9)$$

$$YM = \frac{D+F+Z+S}{B+H} \qquad (10)$$

$$ZM = \frac{D+F+B+H}{Z+S} \qquad (11)$$

where Z, B, D, F, H, and S are the diagonals i,j,k-1, i,j-1,k, i-1,j,k, i+1,j,k, i,j+1,k, and i,j,k+1 diagonals in the matrix M, using the notation in the computer program. The sum in IJ is over all the grid elements in the modeled region except those that have fixed head. NCNT is the number of such grid elements. The factor XYFC in equation (7) may be varied from 1.0 in an attempt to accelerate the convergence of SIP. Weinstein's equation (15) is modified by multiplying the right hand side by $\beta'$ (Trescott and Larson, 1977). This iteration parameter, called HMAX in the computer program, may also be varied from 1.0 to accelerate convergence. For a given problem, the best choice for XYFC, and HMAX will depend a great deal upon whether one is using direction reversal in the J direction, the J and K directions, or only the K direction, corresponding to L9 = 1, 2, and 3 in the computer program. It will also depend upon the value used for LENGTH, the number of iteration parameters.

Increasing HMAX or decreasing XYFC usually tends to accelerate convergence unless instability arises. In the case of instability one should either decrease HMAX, increase XYFC, or do both. The best choice for the SIP parameters L9, LENGTH, HMAX, and XYFC will depend upon the particular problem being solved. Generally speaking, problems with a large number of grid elements for which the head is fixed, tend to be more stable and allow values of HMAX > 1.0

The user of the computer program is encouraged to experiment somewhat with selecting L9, LENGTH, HMAX, and XYFC, particularly with L9, HMAX, and XYFC. Good starting values are LENGTH = 5, HMAX = 1.0, and XYFC = 1.0. HMAX will usually have values between 0.5 and 1.5, and XYFC between 0.01 and 100. If one uses WMAX, and thus bypasses equations (7) through (11) and the use of XYFC, its value will usually lie between 0.000001 and 0.1. Decreasing WMAX usually tends to accelerate convergence unless instability arises.

## Successive Over-Relaxation

The successive over-relaxation method (SOR) repeatedly finds values for the unknown variable XX at node points spaced along a single line with the adjacent values of the unknown XX taken to be known.

An 8 by 10 2-dimensional example is as follows. Values are first found at J=1, I=1 to 8, then J=2, I=1 to 8, etc., etc. The 8 equations for XX(I=1 to 8,J) contain values for XX(I=1 to 8,J-1) and XX(I=1 to 8,J+1), which are treated as known quantities. After a sweep is made across the solution area finding values along the 10 rows, a sweep is made finding values along the 8 columns: First I=1, for J=1 to 10, then I=2, for J=1 to 10, etc.

If the solution region is 3-dimensional, values would probably also be found in the K- direction.

The computer program allows one to omit calculating values in any one or two of the I, J, and K directions. The program omits the directions specified by NSKP1 and NSKP2. Directions I, J, and K correspond to 1, 2, and 3. For example: NSKP1=0 and NSKP2=1 causes the I direction to be skipped. Setting NSKP1=2 and NSKP1=3 causes both the J and K directions to be skipped.

Two relaxation parameters, RELX1 and RELX2, are used. Over-relaxation corresponds to these parameters having values greater than 1.0 and under-relaxation to values less than 1.0. RELX1 is applied after each single line of values is found, in each of the I, J, and K directions. RELX2 is applied after a full set (up to 3 if all of the I, J, and K directions are used, i.e., NSKP1=NSKP2=0) of sweeps is made over the solution region. Over-relaxed or under-relaxed values for XX are calculated using values of XX just prior to the last full set of sweeps, and the newly calculated XX values which were produced by the last full set of sweeps. The actual relaxation parameter used is RELX3 where:

RELX3 = 1.0 when ICNT = 1-5

= RELX2 when ICNT = 6-20

= RELX2 - COEF(INCT - 20) when ICNT $\geq$ 21

ICNT is the count of the number of full sets of sweeps, and is output as the number of "iterations used" by the computer program. COEF is selected to decrease RELX3 from RELX2 sufficiently fast to counter the possibly destabilizing effect of large values for RELX3 near convergence.

## Preconditioned Conjugate Gradient

The preconditioned conjugate gradient (PCG) methods (Hageman and Young, 1981; Kershaw, 1978; Kuiper, 1981; Kuiper, written commun., 1984) are easier to use than SIP or SOR because they require very few convergence parameters only ITMAX, ERR, and XX10 need to be selected.

PCG methods solve nonlinear problems differently than SIP and SOR. For this reason the computer program uses the PCG methods differently, with regard to water discharge from a grid element when $H > H_e$, than it uses SIP or SOR. When using the PCG methods $Aa(H - H_e)$ (see the head dependant discharge section) is evaluated as $Aa(H^n - H_e)$, during the iterations finding the solution for $XX^{n+1}$, h' at time step n+1. For SIP and SOR however $Aa(H - H_e)$ is evaluated as $Aa(H^{n+1} - H_e)$. For this reason the PCG methods may give slightly different results. They will give the same results as SIP, or SOR, when such water discharge from a grid element does not occur.

For ISOR = 2, 3,... , 9 the PCG methods: incomplete Cholesky congugate gradient types 1,2, and 3, ICCG(1), ICCG(2), and ICCG(3); Richardson, RFCG; point Jacobi congugate gradient, Pt. J. CG; block Jacobi congugate gradient, Blk. J. CG; SIP conjugate gradient, SIPCG; and symmetric factorization procedure congugate gradient, SFPCG are used. These eight methods are described by Kuiper (written commun., 1984). Usually the ICCG, SIPCG, and SFPCG methods perform better than the others. In general the PCG methods are much faster than either SIP (Kuiper, written commun., 1984) or SOR.

## Convergence

In the computer program, iteration is terminated when either

$$\max_{\text{(over IJ)}} \left| XX^{ICNT} - XX^{(ICNT-1)} \right| +$$

$$\max_{\text{(over IJ)}} \left| XX^{(ICNT-1)} - XX^{(ICNT-2)} \right| < ERR \qquad (L) \qquad (12)$$

or

$$\max_{\text{(over IJ)}} \left| [M]XX^{ICNT} - YQ \right| < XX10 \qquad (L^3/T) \qquad (13)$$

or ICNT $\geq$ ITMAX. ICNT is the iteration counter, and ITMAX is the maximum number of iterations. In the first iteration stop, inequality (12), ERR should be chosen sufficiently small that any further decrease fails to produce any real and desirable increased accuracy in the answers for hydraulic head.

In the second iteration stop, inequality (13), [M], XX, and YQ denote matrix M, h', and vector $\hat{q}$ in equation (3). This maximum residual error iteration stop, is in general strongly preferred to the use of (12), since (12) does not guarantee that the errors in the components of $XX^{ICNT}$ are less than ERR, in fact they may be much larger. On the other hand, using (13) places the limit XX10 on the maximum error of the equations being solved, namely those of matrix equation (3).

Users may wish to set IWRT = 1 in order to obtain a convergence watching output from the computer program. For each iteration, this output prints fresh-water head XX at three locations of one's choice: IJ = NW1, NW2, and NW3. Also printed for each iteration are the maximum change in XX:

$$\max_{\text{(over IJ)}} \left| XX^{ICNT} - XX^{(ICNT-1)} \right|$$

the location I,J,K at which this maximum change occurred, $XX(I,J,K)^{ICNT}$, and the maximum residual error

$$\max_{\text{(over IJ)}} \left| [M]XX^{ICNT} - YQ \right|$$

If a clear idea of the convergence process is desired, XX(NW1), XX(NW2), and XX(NW3), the maximum change in XX, and the maximum residual error, should be graphed as functions of the iteration counter ICNT.

If one wishes to use iteration stop (12), ERR should be given an appropriate value and XX10 should be set to zero. Set ERR = 0 and choose an appropriate value for XX10 if (13) is to be used. In general, however, iteration terminates when (12), or (13), or ICNT $\geq$ ITMAX, or certain internal stops are satisfied.

## Computation Time

The amount of computation needed for one iteration is proportional to the number of elements in the modeled region of the problem being solved. Thus it is appropriate that the amount of time needed for computation be set equal to:

$$(\text{CPU time}) = (\theta)\ (\text{number of grid elements})(\text{number of iterations}) \quad (14)$$

The quantity θ is CPU time per node iteration, and is in effect defined by equation (14). For a desired solution accuracy, as determined by XX10 or ERR, the number iterations should be minimized by proper selection of the parameters L9, LENGTH, HMAX, and XYFC, for SIP and the parameters RELX1, RELX2, and COEF, for SOR. The PCG methods do not have any parameters that affect the number of iterations required to obtain a given accuracy. The quantity θ has a different fixed value for each of the ten solution methods, SIP, SOR, and the eight PCG methods. It cannot be changed by the computer program user, but when using SOR it is proportional to the number of sweeps taken per iteration.

# WATER DENSITY CALCULATIONS

Values of water density can be entered for each grid element, or values of density can be calculated for those grid elements for which values for pressure, molality, and temperature are entered. The same option pertains to the confining bed grid elements. Calculations of density in the model are limited to temperatures between 0° C and 75° C.

When LLRO = 0, only the values entered for LRO(IJ) = $(\rho'/\rho_0)_{I,J,K}$ and LRO(IJLB) = $(\rho'/\rho_0)_{I,J,KLB}$, where $\rho' = \rho - \rho_0$, are used. When LLRO = 1, read-in values for LRO(IJ) and LRO(IJLB) are replaced by calculated values, whenever such values are available. These calculated values are determined and made available only for those IJ or IJLB for which the pressure is specified to be greater than zero. A blank or zero is entered in the pressure data array when no calculation of LRO is desired and the read-in value for LRO is to be used. $\rho/\rho_0$ is determined using the method of Potter and Brown (1977):

$$(\rho/\rho_0) = \frac{1000 + M_2 m}{\frac{1000}{(\rho_w/\rho_0)} + A_0 m + B_0 m^{3/2} + C_0 m^2} + \delta(P, m, T) \qquad (15)$$

where $\rho_w$ is the density of pure water at the temperature and pressure of the ground-water sample, $M_2$ = 58.488 is the molecular weight of NaCl, and m is molality of the ground-water sample. Equation (15) for $\rho/\rho_0$ approximates data for NaCl solutions and is assumed to be an adequate approximation to $\rho/\rho_0$ for ground water.

Values for the parameters $A_o$, $B_o$, and $C_o$ (Potter and Brown, p. 35, 1977) are: $A_o$ = 12.43, 16.62, 18.00, 18.18; $B_o$ = 3.07, 1.773, 1.66, 1.19; and $C_o$ = -.02, .098, .002, .12; for water temperature T equal to 0, 25, 50, and 75° C. $A_o$, $B_o$, and $C_o$ are approximated by third order polynomial interpolation for $0 \leq T \leq 75°$ C. These polynomials, one for each of the parameters $A_o$, $B_o$, and $C_o$, are exact at T = 0, 25, 50, and 75° C. With $\delta = 0$, equation (15) is solved for $\rho_w$ with $\rho$ taken from Potter's table 1 with m = 1 and 6, giving $(\rho_w)_{m=1}$ and $(\rho_w)_{m=6}$. The value taken for $\rho_w$ for use in (15) is $\hat{\rho}_w = [(\rho_w)_{m=1} + (\rho_w)_{m=6}]/2$. This is done for T = 0, 25, 50, and 75° C, giving four values for $\hat{\rho}_w$ from which $\hat{\rho}_w(T)$ is obtained using a third order interpolation polynomial as described above. The term $\delta$ is pressure, molality, and temperature dependent, and is a small pertubation to the main term in equation (15):

$$\delta(P,m,T) = \frac{am+b}{10^5}(P/bar) \qquad \text{for } 0 \leq P \leq 100 \text{ bar}$$

(16)

$$\delta(P,m,T) = \frac{am+b}{10^3} + \left[\frac{.84(x-1)+3.75}{10^5}\right] [(P/bar)-100] \qquad \text{for } 100 \text{ bar} \leq P$$

where a = -.75(x-1) + .25, and b = 3.5(x-1) + 2, where x = T/25° C and P is pressure. For $P \leq 500$ bar, $m \leq 6$, and $0 \leq T \leq 75°$ C, equations (15) and (16) fit the tabular data for $\rho$ of Potter and Brown (1977) to within the allowable error tolerances they specify.

Pressure P is given by $P = \rho g \ell'$, where $\ell'$ is the length of the column of water with density $\rho$ that would exist in a well bore extending to the center of the grid element in which $\rho$ is to be determined. Thus equation (15), along with equation (16), becomes an equation to be solved for $\rho$ once $\ell'$, m, and T have been specified. This can be done readily with several iterations of equation (15) using $\rho = \rho^{n+1}$ left of the equality and $\rho = \rho^n$ in $\delta$, with n the iteration number.

## UNITS

The user may use any consistent set of units for all variables except: $\ell'$, used to give water pressure $P = \rho g \ell'$ for calculating water density $\rho$, must be in feet; water temperature T, also used for calculating water density $\rho$, must be in degrees celsius. Hydraulic conductivity K has units (L/T). Thus, for example, if the length and time units were chosen to be feet and days respectively, then K would be expressed in ft/d. Specific storage has units (1/L). All mass flow rates, such as the mass recharge rates YQ or Q2, and also those through grid element sides, express the mass of water moving per unit time divided by $\rho_0 = 1\ gm/cm^3$, and consequently have units $(L^3/T)$. For example, a value of 50 $ft^3/d$ for the mass flow rate through a particular grid element side means that the mass of water passing though the side per day is equal to the mass of 50 $ft^3$ of a fluid with density 1 $gm/cm^3$, or approximately (50) (62.43) pounds. This would correspond to less than 50 $ft^3$ of water if the density of the water exceeds $\rho_0$. Suppose a well pumps (from a grid element) at a volumetric rate of 1000 $ft^3/d$, as measured in the field and suppose that the density of the water pumped is $\rho$. Then the rate at which mass is being removed is $(1000\ ft^3/d)\rho$. Thus the value to be used for YQ or Q2 is $-(1000\ ft^3/d)(\rho/\rho_0)$. The minus sign occurs because YQ and Q2 are defined to be positive for recharge. Thus, field measured volumetric flow rates need to be multiplied by $(\rho/\rho_0)$ to arrive at the mass flow rates used in the computer program. This situation arises because the basic flow equations as solved in the computer program conserve mass rather than volume.

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# ATTACHMENT A

# COMPUTER PROGRAM

This section explains the Fortran computer program. It should be used in conjuction with the Fortran program listing in Attachment E.

## Main program (MAN0080 - MAN7690)

| | Explanation of program |
|---|---|
| 0080-0180 | The array variables DD, BB, ZZ, SV, XXS, ALN, XXE, XXSTR, YQ1, DT, E2, F2, G2, VV, XX, YQ, MHD, and LZ2 have a dimension size equal to the total number of grid elements plus 2: [(NI10)(NJ10)(NK10)+2]. The array variables LB, LRO, and NT, have a dimension size equal to the total number of grid elements and confining bed grid elements plus 2: [[(NI10)(NJ10)(NK15)]+2]. The dimension size of array variable LBB is [(NI10)(NJ10)+2]. The dimension size of these array variables should be adjusted by the computer program user in the main program as well as in the subroutines. The dimension size of the other array variables are probably sufficiently large and can be left at the values shown.<br><br>The use of the IMPLICIT REAL*8 statement is optional. Removing this statement will decrease the storage requirement of the computer program but may cause certain outputs, such as water flow rates, to become less accurate. The user should try deleting the IMPLICIT REAL*8 statement to see whether any decrease in accuracy is experienced. In general, the use of the statement is recommended. |

| | |
|---|---|
| 0200-0230 | Data for use in the determination of water density from water pressure, molality and temperature. |
| 0240-0250 | Initialize MAQ1 to 0. |
| 0270-0370 | Read group I data. |
| 0380-0530 | Determine various integer parameters related to the number of grid elements and confining bed grid elements. |
| 0570-0630 | Read and write MHD. |
| 0640-1050 | If LLRO = 1 read $\ell'$, m, T, and determine $\rho$ for those grid elements having $\ell'>0$. Temporarily place $\rho$ in LB. |
| 1060-1110 | Read and write LRO. These written values will have been determined from $\ell'$, m, and T, if LLRO = 1 and $\ell'>0$. |
| 1120-1170 | Read and write LBB. |
| 1180-1230 | Read and write LB. |
| 1240-1340 | If IEVP = 1, read and write XXE(IJ) and ALN(IJ). |
| 1350-1410 | Read and write initial hydraulic head. |
| 1420-1450 | Read and write SV. |
| 1460-1510 | If IKZZ = 1, read XKZZ. |
| 1520-1550 | Remove pinched-out nodes when appropriate. |
| 1560-1770 | Read and write FCNT, DDK, BBK, and NT. |
| 1790-1830 | Read and write MAQ1, if there are any confining beds. |
| 1840-2010 | Read and write DXI and DYJ. |
| 2020-2060 | Read and write NI, NJ, NK, and Q2. |
| 2090-2180 | Initialize various arrays to zero. |

| | |
|---|---|
| 2210-2760 | Determine LZ2 and initial or fixed XX, put recharge rates Q2 into YQ. If IEVP = 1, modify XXE and ALN. |
| 2800-2890 | If ILZ2 = 0, calculate and print the elevation of the top of the uppermost grid element layer. |
| 2910-3440 | Determine the quantities DD, BB, and ZZ. |
| 3470-4240 | Add variable density contributions to YQ, put into YQ1. |
| 4260-4370 | If SIP is being used (ISOR = 0), determine XY and the iteration parameters WS(I). Write the various SIP convergence parameters, and also the iteration parameters WS(I). |
| 4400-4410 | If SOR is being used (ISOR = 1), write the various SOR convergence parameters. |
| 4430-4440 | If PCG is being used (ISOR $\geq$ 2), write ITMAX, ERR, and XX10. |
| 4460-4480 | Enter DO loop for pumping intervals. Write pumping interval number IPINT. Read data for this pumping interval. |
| 4510-4700 | Read and write recharge rates YQ for this pumping interval. Add YQ1 to YQ, put into YQ. Calculated budgets. |
| 4740-4780 | Set TOTIME = 0. Enter DO loop for time intervals INT = 1, NINT. Write INT, DELT, and TOTIME. |
| 4830-4880 | Write NU1, NU2, and NU3, when IWR1 = 1. |
| 4900-4920 | Begin SIP, SOR, or PCG iterations. Write data for watching the convergence of SIP, SOR, or PCG, when IWR1 = 1. |
| 4930 | Write ICNT, ER5, SRZ, SUMRZ. |
| 4950-4960 | Save XX in XXS for use during the next time statement. |

| | |
|---|---|
| 4970-6460 | If LFLOW = 1, determine and possibly print the four types of flow rate data. |
| 6480-6640 | Determine hydraulic head from XX = h' = pressure head h) + z. Write out hydraulic head. Write XX = h', if IWRTXX = 1. |
| 6680-6820 | If IPDD = 1 print drawdowns for this pumping interval. |
| 6840-7080 | Formats. |
| 7690 | Stop. |

<u>Subroutine RDWRT</u>

This subroutine performs the reading and writing of group II array data (see Attachment B.) IT15 is 1 for data sets 1-9, and 2 for data set 10. ICRO is always 0 except ICRO = 1 when LLRO = 1, in which case values for LRO are computed from water pressure, molality, and temperature. NK1115 is equal to NK11 or NK15 corresponding to the data set having values for grid elements only (NK1115 = NK11), or for both grid elements and confining bed grid elements (NK1115 = NK15). NT is used as a temporary storage location for data being read in. After returning to the main program the array data in NT is usually placed into another variable.

The dimension size of the array variables should be the same as in the main program and should be adjusted by the computer program user.

<u>Subroutine SOR</u>

This subroutine performs the successive over-relaxation method SOR.

The dimension size of the array variables should be the same as in the main program and should be adjusted by the computer program user.

## Subroutine SIP

This subroutine performs the strongly implicit procedure SIP.

The dimension size of the array variables should be the same as in the main program and should be adjusted by the computer program user.

## Subroutine PCG

This subroutine performs the preconditioned conjugate gradient (PCG) methods.

The dimension size of the array variables should be the same as in the main program and should be adjusted by the computer program user.

In addition, D2S and E22 need to be dimensioned, unless SIPCG and SFPCG are not going to be used, in which case the indicated deletions in the subroutine should be made.

## ATTACHMENT B

## DATA DECK INSTRUCTIONS

Group I: Model dimensions and options, parameters related to the use of SIP, SOR, or PCG

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 0 | 1-10 | G10.0 | ISOR | ISOR = 0, 1, and 2 through 9 correspond to the use of SIP, SOR, and the 8 PCG methods, ICCG(1), ICCG(2), ICCG(3), RFCG, Pt. J. CG, Blk. J. CG, SIPCG, and SFPCG; and the use of cards 1a, 1b, and 1c, respectively. ISOR = 2-4, and 8-9 are usually preferred choices. |
| 1a | 1-10 | G10.0 | L9 | 1, 2, and 3 for J, J and K, and K only direction reversal in SIP. |
| | 11-20 | G10.0 | LENGTH | Number of SIP iteration parameters. LENGTH = 5 is a common choice. |
| | 21-30 | G10.0 | HMAX | SIP parameter $\beta'$. Increasing $\beta'$ usually causes faster convergence unless instability arises. Values of .5 - 1.3 are usually used. |

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
| --- | --- | --- | --- | --- |
| | 31-40 | G10.0 | XYFC | This factor is multiplied by XY before it is used for $(1-\alpha_{max})$ in SIP. First choice for XYFC is 1.0. Decreasing XYFC usually tends to cause faster convergence unless instability arises. |
| | 41-50 | G10.0 | WMAX | When not zero, WMAX is used for $(1-\alpha_{max})$. When zero, it is not used and $(1-\alpha_{max})$ is set equal to (XYFC) X (XY). Usually $0.000001 < WMAX < 0.1$, if used. Decreasing WMAX usually tends to cause faster convergence unless instability arises. Non-zero values of WMAX are not usually used, thus allowing the computer program to select XY. |
| | 51-60 | G10.0 | ITMAX | |
| | 61-70 | G10.0 | ERR | |
| | 71-80 | G10.0 | XX10 | |
| 1b | 1-10 | G10.0 | NSKP1 | See the Successive over-relaxation section of the text NSKP1, NSKP2, RELX1, RELX2, and COEF. |
| | 11-20 | G10.0 | NSKP2 | |
| | 21-30 | G10.0 | RELX1 | |
| | 31-40 | G10.0 | RELX2 | |
| | 41-50 | G10.0 | COEF | |
| | 51-60 | G10.0 | ITMAX | |
| | 61-70 | G10.0 | ERR | |
| | 71-80 | G10.0 | XX10 | |

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 1c | 1-10 | G10.0 | ITMAX | |
| | 11-20 | G10.0 | ERR | |
| | 21-30 | G10.0 | XX10 | |

For cards 1a, 1b, and 1c, ITMAX is the maximum allowed number of iterations for SIP, SOR, and the 8 PCG methods. Iteration terminates at iteration count n when the sum of the maximum change in fresh-water head h' between iterations n-1 and n, plus the change between iterations n-2 and n-1, is less than ERR. Iteration also terminates when the maximum residual error is less than XX10.

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 2 | 1-10 | I10 | NI10 | Number of columns in modeled area. |
| | 11-20 | I10 | NJ10 | Number of rows in modeled area. |
| | 21-30 | I10 | NK10 | Number of layers in modeled area. |
| | 31-40 | I10 | NK4 | Number of intervening confining beds. |
| 3 | 1-40 | I4<br>3I4<br>3I4<br>3I4 | IWRT<br>NU1(I),I=1,3<br>NU2(I),I=1,3<br>NU3(I),I=1,3 | Set IWRT to 1 if you want to watch the convergence of fresh-water head h' = XX, at the three locations:<br>I = NU1(1), J = NU1(2), K = NU1(3);<br>I = NU2(1), J = NU2(2), K = NU2(3); and<br>I = NU3(1), J = NU3(2), K = NU3(3). |

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
| --- | --- | --- | --- | --- |
| 4 | 1-10 | I10 | NPINT | Number of pumping intervals. |
| | 11-20 | I10 | IPDD | If IPDD = 1, the drawdown (decrease in hydraulic head H) during a pumping interval is printed. |
| | 21-30 | I10 | LLRO | If LLRO = 0, read-in values for LRO are used. If LLRO = 1, read-in values for LRO are replaced by values for LRO calculated from water pressure, molality, and temperature, when such calculated values are available. Calculated values are made available only for those IJ or IJLB for which the pressure is specified to be greater than zero. |
| | 31-40 | I10 | IWRTXX | If IWRTXX = 1, freshwater head h' = (pressure head h) + z is printed along with the hydraulic head. If IWRTXX = 0, it is not printed. If IWRTXX = 2, only h' is printed. |
| | 41-50 | I10 | IPRNT | Setting IPRNT = 0 causes IWRT and LFLOW to be set to zero, and the printing of hydraulic and fresh-water head deleted, for all time intervals except the last. |

| CARD | COLUMN | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| | 51-60 | I10 | ILZ2 | If ILZ2 = 0, the elevation of the top of the uppermost grid element layer is printed. |
| | 61-70 | I10 | IEVP | If IEVP $\neq$ 1, data sets 5 and 6 are not read. If IEVP = 1 these data sets are read, and the head dependant discharge option is available. |
| | 71-80 | I10 | IKZZ | If IKZZ $\neq$ 1, data set 9 is not read. If IKZZ = 1, data set 9, XKZZ = $K_{zz}$ is read. In this case $K_{zz}$ is specified by XKZZ rather than by NT from data set 10. |

| CARD | COLUMN | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 5 | 1-10 | I10 | LFLOW | Four types of flow rate data are available: 1) the flow rate out of each grid element in the negative I, J, and K directions, 2) the flow rate out of fixed head (MHD = 0) grid elements, 3) head dependant discharge flow rates from grid elements having such discharge, 4) total flow rate budgets for sets of grid elements having the same I, the same J, and the same K. All flow rates are in units of mass divided by $\rho_0 = 1\ gm/cm^3$ per unit time ($L^3/T$). See the Units section of the text. Set LFLOW = 1 if you want any flow rate data, set LFLOW = 0 if no flow rate data is desired. Set LFLO(i) = 0 if you do not want type i flow rate data. For i = 1, set LFLO(1) = 1, 2, 3, for type 1 flow rate data in the negative I, J, and K directions respectively. If LFLO(1) = 4 all directions are given. Set LFLO(2) = 1 if you want type 2 flow rate data. Set LFLO(3) = 1 if you want type 3 flow rate data. Set LFLO(4) = 1, 2, 3, for the budgets of sets of grid elements having the same I, J, and K respectively. IF LFLO(4) = 4 budgets are given for I, J, and K. Corresponding to the integers 1, 2, and 3 in the first column of output the second column gives I, J, and K respectively. |
| | 11-20 | I10 | LFLO(1) | |
| | 21-30 | I10 | LFLO(2) | |
| | 31-40 | I10 | LFLO(3) | |
| | 41-50 | I10 | LFLO(4) | |

| CARD | COLUMN | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 6,7... | 1-80 | 20I4 | IPH(K)<br>K=2,NK11 | Set IPH(K) = 1 if you want: hydraulic head or freshwater head, flow rate data, or drawdown for layer K. Set IPH(K) = 0 if you do not want these quantities for layer K. The layers are numbered K = 2 through K = NK11 = NK10+1. |

Group II: Array data

Each of the following data sets consists of a format card, one or more parameter cards and, if the data set contains variable data, a set of data cards. A single parameter card and corresponding set of data cards (for layers with variable data), are required for each layer.

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| Format card | 1-4<br>5-40<br>41-80 | I4<br>9A4<br>10A4 | | Place the desired Fortran read format in columns 5-40, and the write format in lines 41-80. When writing with an I format, place a zero in column 4. When writing with a non-integer type format, place a 1 in column 4. |
| Para-meter cards. | 1-10<br>11-10 | G10.0<br>G10.0 | FCNT<br>IVAR | If IVAR = 0, values of the array are given the value FCNT, and no data cards are read. If IVAR = 1, values for the array are set equal to FCNT multiplied by the values read from the data cards following this card. |

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| | 21-30 | G10.0 | IPRN | If IPRN = 0, the input data for this layer are printed. If IPRN = 1, the input data for this layer are not printed. If IPRN = 2, only parameter card data for the layer is printed. |
| | 31-40 | G10.0 | DDK | Multiplication factor for hydraulic conductivity in the I direction (data set 10 only). |
| | 41-50 | G10.0 | BBK | Multiplication factor for hydraulic conductivity in the J direction (data set 10 only). |

When data cards are used for a layer, start each row on a new card. First, row J = 2, the first row of the layer, is read from as many cards as is necessary. Then, starting with a new card, row J = 3 is read, then row J = 4, and so forth, until the last row of the layer, J = NJ11 = NJ10+1, is read.

DATA CARDS:

| DATA SET | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 1 | 1-80 | Variable | MHD | When MHD(IJ) $\neq$ 0 the hydraulic head for grid element IJ is fixed at the value specified. When MHD(IJ) = 0, the head for grid element IJ is not fixed. There are NK10 layers of MHD values. Values given are truncated after the first decimal place. |

| DATA SET | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 2 | 1-80 | Variable | LRO | LRO(IJ) = $(\rho'/\rho_0)$. $\rho = \rho' + \rho_0$ is the water density for grid element IJ. LRO(IJLB) = $(\rho'/\rho_0)$, where $\rho = \rho' + \rho_0$ is the water density for confining bed grid element IJLB. Values given are truncated after the fifth decimal place. |
| 3 | 1-80 | Variable | LBB | LBB is the elevation of the base of the lowermost K = 2 layer. LBB values exist only for this layer. |
| 4 | 1-80 | Variable | LB | LB(IJ) is the vertical dimension of grid element IJ. LB(IJLB) is the vertical dimension of confining bed grid element IJLB. There are NK10 layers of LB(IJ) values followed by NK4 layers cf LB(IJLB) values. |
| 5 | 1-80 | Variable | XXE | The rate of water discharge $(L^3/T)$ from a grid element is given by $Aa(H-H_e)$ when $H>H_e$ and is zero when $H<H_e$. H is the hydraulic head in the grid element and A is the area of the grid element, ((DXI(I)) X (DYJ(J)). XXE(IJ) of data set 5 is $H_e$, measured relative to the center of the grid element IJ. ALN(IJ) of data set 6 specifies the quantity a. When no discharge is desired, XXE(IJ) should be given a large value and the quantity a should be zero. If IEVP $\neq$ 1, data sets 5 and 6 are not read. |
| 6 | 1-80 | Variable | ALN | |

| DATA SET | COLUMNS | FORMAT | VARIABLE | DEFINITION |
| --- | --- | --- | --- | --- |
| 7 | 1-80 | Variable | Initial hydraulic head | Fixed hydraulic head values MHD $\neq$ 0 override values given for the initial hydraulic head. |
| 8 | 1-80 | Variable | SV | SV(IJ) specifies specific storage $S_s$ of grid element IJ. |
| 9 | 1-80 | Variable | XKZZ | When this data set is read, IKZZ = 1, $K_{zz}$(IJ) = XKZZ(IJ) rather than NT(IJ) in data set 10. Use of this data set allows one to vary the x, y, and z components of the hydraulic conductivity independently. |
| 10 | 1-80 | Variable | NT | $K_{xx}$(IJ) = NT(IJ) X (DDK(K)), $K_{yy}$(IJ) = NT(IJ) X (BBK(K)), $K_{zz}$(IJ) = NT(IJ) where $K_{xx}$(IJ), $K_{yy}$(IJ), and $K_{zz}$(IJ) denote the x, y, and z components of K, the hydraulic conductivity for grid element IJ. There are values of NT(IJ), DDK(K), and BBK(K), for NK10 layers. These are followed by values of NT(IJLB) for NK4 confining bed layers. DDK and BBK are not needed for confining bed layers. |

When LLRO = 1, data sets 1a-c are required. If LLRO = 0, they should be omitted. These data sets are used to calculate water density from the pressure, dissolved solids concentration, and temperature of the water. They are placed between data set 1 for MHD and data set 2 for LRO.

| DATA SET | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 1a | 1-80 | Variable | $\ell'$ | Water pressure, in feet, defined as the length of the column of water that would exist in a well bore extending to the center of the grid element. If pressure is zero, then LRO from data set 2 is used. |
| 1b | 1-80 | Variable | m | Dissolved solids concentration, expressed as molality. Values given are truncated after the second decimal point. |
| 1c | 1-80 | Variable | T | Temperature, in degrees Centigrade. Values given are truncated after the first decimal point. |

There are values of $\ell'$, m, and T for NK10 layers, followed by values for NK4 confining bed layers. See the WATER DENSITY CALCULATIONS section of the text for more detail.

## Group III: Additional array data

Except for LBB, the data sets of group II are 3-dimensional arrays corresponding to the three cartesian directions I, J, and K. The data sets of group III (except for Q2) are 1-dimensional arrays corresponding to only one of the cartesian directions I, J, or K.

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 1 | 1-80 | 20I4 | MAQ1 | MAQ1(K) = 0 except when a confining bed lies between layers K-1 and K, in which case MAQ1(K) = 1. There are NK10 values for MAQ1(K) for K = 2,... , (NK10+1). If there are no confining beds (NK4 = 0), omit this data set. Values for MAQ1(K) are printed when NK4>0. |
| 2-parameter card | 1-10 | G10.0 | FDXI | If MDXI1 = 0, DXI(I) is set to FDXI and no data cards are read. |
| | 11-20 | G10.0 | FDYJ | If MDYJ1 = 0, DYJ(J) is set to FDYJ and no data cards are read. |
| | 21-30<br>31-40<br>41-50 | G10.0<br>G10.0<br>G10.0 | MDXI1<br>MDYJ1<br>MD2 | If MDXI1 = 1, DXI(I) is read from data cards that follow the parameter card. If MDYJ1 = 1, DYJ(J) is read from data cards that follow the parameter card and also any data cards for DXI(K) when they are present. |
| 2-Data cards | 1-80<br>1-80 | 8G10.0<br>8G10.0 | DXI(I)<br>DYJ(J) | There are NI10 values of DXI(I) for I = 2,... , (NI10+1), and NJ10 values of DYJ(J) for J = 2,.... , (NJ10+1). If MD2 = 0 the input data for this data set are printed. If MD2 = 1 the input data are not printed. |

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 3-parameter card | 1-10 | I10 | NWEL | Number of grid elements to receive recharge. |
| 3-data cards | 1-80 | 4(3I3, E11.3) | NI, NJ NK, and Q2 | Q2 is the recharge rate ($L^3/T$) into the grid element located at I = NI, J = NJ, and K = NK. Four values of NJ, NK, and Q2 are read in per card. If there is no recharge, set NWEL to 1, choose any location, and use Q2 = 0. Values for NI, NJ, NK, and Q2 are always printed. The recharge specified with this data set is added to the recharge YQ of data set 1 of group IV. Either or both methods for specifying recharge may be used. However, Q2 is read only once, and is the same for each pumping interval, whereas YQ is different for each pumping interval. |

GROUP IV: Array data for pumping intervals

Many pumping intervals are allowed. Each pumping interval requires data related to the time intervals used, and the recharge. The total recharge ($L^3/T$) used in the computer model is Q2 + YQ. Q2 is read in only once, in group III data, but YQ is read in group IV data and changes with each pumping interval.

For each pumping interval a time interval card is followed by series of cards for YQ with exactly the same format as group II data. The format, parameter, and data cards used are the same as those for group II data sets (See Group II: Array data). When a layer has variable YQ, the usual case, data cards are needed (See Group II: Array data):

The time interval card has the following format:

| CARD | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| Time interval | 1-10 | G10.0 | NINT | Number of time intervals desired. |
| | 11-20 | G10.0 | DTO | Duration of the first time interval. |
| | 21-30 | G10.0 | TFAC | The ratio of the duration of a time interval divided by the duration of the preceding time interval. |
| | 31-40 | G10.0 | TOT | If TOT $\neq$ 0, DTO is calculated such that the duration of the pumping interval, the sum of the NINT time intervals, is TOT. |

DATA CARDS:

| DATA SET | COLUMNS | FORMAT | VARIABLE | DEFINITION |
|---|---|---|---|---|
| 1 | 1-80 | Variable | YQ | YQ(IJ) along with Q2(I,J,K), specifies the recharge rate ($L^3/T$) into grid element IJ. |

## ATTACHMENT C

## EXAMPLE APPLICATION

This section presents an example steady state application of the computer program. The input data is shown on page C-3 and the resulting program output is shown on page C-6.

The hypothetical problem simulated has: 3 layers corresponding to K = 2, 3, and 4; 5 rows corresponding to J = 2, 3, 4, 5, and 6; and 25 columns corresponding to I = 2, 3, 4,... , 26. A confining bed appears in the output as layer five (KLB = 5).

Proceeding through the computer program output on page C-6, we see that fixed hydraulic head MHD is fixed at: 645.6 ft (the length unit chosen is feet) at location I = 2, J = 2, K = 2; at 747.8 ft at location I = 26, J = 2, K = 2; at 748.8 ft at location I = 2, J = 6, K = 2; and at 750.3 ft at location I = 26, J = 6, K = 2. It is also fixed at 600.0 ft at all 125 locations in layer K = 4. We now proceed to the next data set, the water pressure as measured by the length $\ell'$ of water column that would exist in a well bore extending to the center of the grid element. Eighteen non-zero values for $\ell'$ are shown in layer K = 3, rows two and four. Values for LRO are calculated at these 18 locations. Values for molality m = 1.0-6.0, and temperature T = 25-75°C occur at these same 18 locations, on page C-7. The next data set shown is LRO = $[(\rho/\rho_0)-1]$. Eighteen of these LRO values were calculated from $\ell'$, m, and t, at locations with $\ell'>0$. The remaining values for LRO, all but two of which are zero, are those read as the data set LRO. The next data set is base elevation, LBB, which has non-zero values in rows five and six. The next data set is the z dimension, LB, of the grid elements and confining bed grid elements. The grid elements have uniform values for LB of 200, 235, and 120 ft for K = 2, 3, and 4. The confining bed grid elements all have LB = 60 ft. Following this are initial hydraulic head, and specific storage.

The next data set is K, the hydraulic conductivity. Shown also are $K_{xx}/K_{zz}$ and $K_{yy}/K_{zz}$. In layer two: $K_{zz}$ = 5 ft/d, $K_{xx}/K_{zz}$ = 1, and $K_{yy}/K_{zz}$ = 1. In layers three and four: $K_{zz}$ = 12 and 20 ft/d, and $K_{xx}/K_{zz}$ = $K_{yy}/K_{zz}$ = 1. For the confining bed, KLB = 5, $K_{zz}$ = 0.01 ft/d. Zeros are shown for $K_{xx}/K_{zz}$ and $K_{yy}/K_{zz}$, but are not used. The next data set is MAQ1(K). The 1, for layer four, indicates that layer four is underlain by a confining bed. The next data set shows the X (I direction) and Y (J direction) dimensions of the grid elements: DXI(I) = 8000 ft for I = 2, 3,... , 26 DYJ(J) = 10000 ft for J = 2, 3,... , 6. The next data set shows the recharge rates Q2 to grid elements: I = 10, J = 4, K = 3 and I = 20, J = 4, K = 3. The next data set shows the elevation of the top of the uppermost grid element layer, as calculated from values for LB and LBB. The next section lists the values that were chosen for the PCG(7) convergence parameters. The next section gives the pumping interval and YQ, data set 1 of group IV. The next section gives the time interval number, the duration of the time interval, and the total amount of time elapsed in the current pumping interval. It also follows the solution as it proceeds to convergence. Note the behavior of XX(I = 5, J = 3, K = 2), XX(I = 10, J = 3, K = 2) and XX(I = 15, J = 3, K = 2) as they converge to their final values. Note that the maximum residual error decreases uniformly as iteration proceeds. The next output gives the water flow rate in the negative I, J, and K directions out of each grid element and shows that the dense water, which exists in some of the grid elements, is sinking. The flow of water adjacent to such elements is similar to that adjacent to a heavy object sinking in a fluid. The next two sections give: water flow rates out of fixed head (MHD = 0) grid elements total flow rate budgets for sets of grid elements having the same I, the same J, and the same K, respectively. The last data set printed is hydraulic head H. Because IWRTXX = 1, fresh-water head XX = h' = (pressure head h) + z is also printed. H and XX are related by equation 4 in the text. Because IPDD = 0, no drawdown values are printed. Because IPH(K) is equal to 0, 1, and 0, for K = 2, 3, and 4, water flow rates and head are given only for layer K = 3.

```
       8
      100         0         40
       25         5          3          1
  1    5    3    2   10    3    2  15    3    2
       1          0          1          1          0          0          0          0
       1          4          1          0          4
  0    1    0
```

Group I

```
 0(1068.0)                          (I12,15I8/(12X,15I8))
      .1          1          0
   6456
0
                                7478
0
0
0
0
0
0
0
0
0
   7488
0
                                7503
       0          0          0
     600          0          0
```

Group II

MHD

```
 0(1366.0)                          (I12,15I8/(12X,15I8))
       0          0          0
       1          1          0
  4000  1000    1    1    1    1    1    1
0
0
0
  4000  1000  1000  2000  2000  3000  3000  3000  4000  3000
0
0
0
0
0
       0          0          0
       0          0          0
```

LENGTH ℓ'

```
0(20G4.0)                                   (I12,20I6/(12X,20I6))
           0          0          0
         .01          1          0
 500 100 100 100 100 600 600 600
0
0
0
 500 100 100 200 200 300 500 600 400 500
0
0
0
0
0
           0          0          0
           0          0          0
```

Molality m

```
0(20G4.0)                                   (I12,20I6/(12X,20I6))
           0          0          0
          .1          1          0
 250 375 250 500 750 250 500 750
0
0
0
 250 500 500 500 500 400 250 250 250 250
0
0
0
0
0
           0          0          0
           0          0          0
```

Temperature T

```
0(13G6.0)                                   (I12,15I8/(12X,15I8))
           0          0          0
       1.D-5          1          0
     0      0 10000 10000 10000 10000 10000 10000 10000 10000
0
0
0
0
0
0
0
0
0
           0          0          0
           0          0          0
```

LRO

```
    0(13G6.0)                                     (I12,15I8/(I2X,15I8))
              1          1          0
0
0
0
0                                                                                        LBB
0
0
     7      7      7      7      7      5      5      5      6      6      5      4
     6      7      7      4      3      2      0      3      4      5      6      7
     7      8     12     12     13     14     17     22     22     22     22     23
    23     33     33     33     33     33     31     32     33     34     35
-------------------------------------------------------------------------------------
           0
         200          0          0                                                   LB
         235
         120
          60
-------------------------------------------------------------------------------------
           0
           0          0          0                                                   Initial Hydraulic head
           0          0          0
           0          0          0
-------------------------------------------------------------------------------------
           0
           1          0          0
           1          0          0                                                   Specific storage  SV
           1          0          0
-------------------------------------------------------------------------------------
           0
           5          0          0          1          1                             Hydraulic conductivity
          12          0          0          1          1
          20          0          0          1          1                             Kxx, Kyy, Kzz
         .01          0          0          0          0
-------------------------------------------------------------------------------------
   0   0   1                                                                         MAQ1              Group III
-------------------------------------------------------------------------------------
        8000      10000          0          0          0                             DXI,DYJ
-------------------------------------------------------------------------------------
           2                                                                         NWEL
 10   4    3    -1.D+5  20   4   3     -1.D+5                                        NI,NJ,NK,Q2
-------------------------------------------------------------------------------------
           1      1.D40        1.0          0                                                          Group IV
-------------------------------------------------------------------------------------
           0
           0          0          0                                                   Recharge rate YQ
           0          0          0
           0          0          0
-------------------------------------------------------------------------------------
```

FIXED HYDRAULIC HEAD

```
LAYER   ROW
  2         0. 1000D+00
         2    6456      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0   7478
         3       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         4       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         5       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         6    7488      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0   7503
  3         0 0000D+00
  4         0 6000D+03
```

LENGTH IN FEET OF WATER COLUMN IN WELL BORE

```
LAYER   ROW
  2         0. 0000D+00
  3         0 1000D+01
         2    4000   1000      1      1      1      1      1      1      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         3       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         4    4000   1000   1000   2000   2000   3000   3000   3000   4000   3000      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         5       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
         6       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                 0      0      0      0      0      0      0      0      0      0
  4         0. 0000D+00
  5         0. 0000D+00
```

MOLALITY

```
LAYER   ROW
   2         0 0000D+00
   3         0 1000D-01
          2   500   100   100   100   100   600   600   600     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          3     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          4   500   100   100   200   200   300   500   600   400   500     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          5     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          6     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
   4         0. 0000D+00
   5         0. 0000D+00
```

TEMPERATURE DEGREES CENTIGRADE

```
LAYER   ROW
   2         0. 0000D+00
   3         0. 1000D+00
          2   250   375   250   500   750   250   500   750     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          3     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          4   250   500   500   500   500   400   250   250   250   250     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          5     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
          6     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
                0     0     0     0     0
   4         0. 0000D+00
   5         0. 0000D+00
```

(DENSITY OF WATER RHO, IN GRAMS PER CUBIC CENTIMETER)-1 0

```
LAYER   ROW
  2          0 0000D+00
  3          0. 1000D-04
        2   17066   3260   3620   2589   1257  19287  18010  16771  10000  10000      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        3       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        4   17066   2742   2742   6375   6375  10208  16934  19666  14128  16934      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        5       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        6       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
  4          0. 0000D+00
  5          0. 0000D+00
```

BASE ELEVATION

```
LAYER   ROW
  2          0. 1000D+01
        2       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        3       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        4       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                0      0      0      0      0      0      0      0      0      0
        5       7      7      7      7      7      5      5      5      6      6      5      4      0      6      7
                7      4      3      2      0      3      4      5      6      7
        6       7      8     12     12     13     14     17     22     22     22     22     23      0     23     33
               33     33     33     33     31     32     33     34     35      0
```

Z DIMENSION OF GRID ELEMENTS

```
LAYER   ROW
  2          0. 2000D+03
  3          0. 2350D+03
  4          0. 1200D+03
  5          0 6000D+02
```

INITIAL HYDRAULIC HEAD

| LAYER | ROW |
|---|---|
| 2 | 0 0000D+00 |
| 3 | 0 0000D+00 |
| 4 | 0 0000D+00 |

SPECIFIC STORAGE

| LAYER | ROW |
|---|---|
| 2 | 0. 1000D+01 |
| 3 | 0. 1000D+01 |
| 4 | 0. 1000D+01 |

HYDRAULIC CONDUCTIVITY

| LAYER | ROW | | |
|---|---|---|---|
| 2 | 0. 5000D+01 | 0. 1000D+01 | 0. 1000D+01 |
| 3 | 0. 1200D+02 | 0. 1000D+01 | 0. 1000D+01 |
| 4 | 0. 2000D+02 | 0. 1000D+01 | 0. 1000D+01 |
| 5 | 0. 1000D-01 | 0. 0000D+00 | 0. 0000D+00 |

LAYERS UNDERLAIN BY A CONFINING BED HAVE 1, OTHER LAYERS 0

| | |
|---|---|
| 2 | 0 |
| 3 | 0 |
| 4 | 1 |

X AND Y DIMENSIONS OF GRID ELEMENTS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 |
| 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 | 8000. 0 |
| 8000. 0 | | | | | | | | | | | |
| 10000. 0 | 10000. 0 | 10000. 0 | 10000. 0 | 10000. 0 | | | | | | | |

RECHARGE RATES Q2 (L*L*L/T)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10 | 4 | 3 | -0. 100D+06 | 20 | 4 | 3 | -0. 100D+06 |

THE ELEVATION OF THE TOP OF THE UPPERMOST GRID ELEMENT LAYER

| LAYER | ROW | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | | | | | | | | | | | | | | |
| | 2 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 |
| | | 615 | 615 | 615 | 615 | 615 | | | | | | | | | | | | | | | |
| | 3 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 |
| | | 615 | 615 | 615 | 615 | 615 | | | | | | | | | | | | | | | |
| | 4 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 |
| | | 615 | 615 | 615 | 615 | 615 | | | | | | | | | | | | | | | |
| | 5 | 622 | 622 | 622 | 622 | 622 | 620 | 620 | 620 | 621 | 621 | 620 | 619 | 615 | 621 | 622 | 622 | 619 | 618 | 617 | 615 |
| | | 618 | 619 | 620 | 621 | 622 | | | | | | | | | | | | | | | |
| | 6 | 622 | 623 | 627 | 627 | 628 | 629 | 632 | 637 | 637 | 637 | 637 | 638 | 615 | 638 | 648 | 648 | 648 | 648 | 648 | 646 |
| | | 647 | 648 | 649 | 650 | 615 | | | | | | | | | | | | | | | |

[illegible] CONVERGENCE PARAMETERS CHOSEN

| ITMAX | ERR | XX10 |
|---|---|---|
| 100 | 0.000D+00 | 0.400D+02 |

PUMPING INTERVAL= 1

RECHARGE RATE YQ (L*L*L/T)

| LAYER | ROW | |
|---|---|---|
| | 2 | 0.0000D+00 |
| | 3 | 0.0000D+00 |
| | 4 | 0.0000D+00 |

TOTAL YQ RECHARGE RATE TO MODELED REGION= 0.0000D+00
TOTAL Q2 RECHARGE RATE TO MODELED REGION= -0.2000D+06
TOTAL RECHARGE RATE TO MODELED REGION= -0.2000D+06

TIME INTERVAL NUMBER 1 DURATION = 0.1000D+41 TOTAL ELAPSED TIME = 0.1000D+41

WATCHING CONVERGENCE

I,J,K, IS THE LOCATION AT WHICH THE MAXIMUM CHANGE IN XX OCCURED.
MAXIMUM RESIDUAL ERROR = THE MAXIMUM OVER ALL THE GRID ELEMENTS OF THE DIFFERENCE BETWEEN THE WATER FLOW RATE INTO AND OUT OF EACH GRID ELEMENT

| | I | J | K | XX(I,J,K) | CHANGE IN XX(I,J,K) | MAX RESIDUAL ERROR | XX AT I= 5 J= 3 K= 2 | XX AT I= 10 J= 3 K= 2 | XX AT I= 15 J= 3 K= 2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 | 6 | 3 | 0.0000000D+00 | 0.0000000D+00 | 0.2022506D+10 | 0.0000000D+00 | 0.0000000D+00 | 0.0000000D+00 |
| 2 | 26 | 6 | 3 | 0.7653667D+03 | 0.7653667D+03 | 0.4619078D+08 | 0.3788751D+03 | 0.3702612D+03 | 0.3685258D+03 |
| 3 | 9 | 4 | 2 | 0.6298676D+03 | 0.2566925D+03 | 0.3049345D+07 | 0.6043369D+03 | 0.6001787D+03 | 0.5967501D+03 |
| 4 | 2 | 4 | 3 | 0.6110648D+03 | 0.3628884D+02 | 0.1107198D+07 | 0.6027578D+03 | 0.6042555D+03 | 0.5999280D+03 |
| 5 | 2 | 4 | 2 | 0.6334332D+03 | 0.2339734D+01 | 0.1666597D+06 | 0.6021166D+03 | 0.6043710D+03 | 0.6000251D+03 |
| 6 | 2 | 4 | 3 | 0.6138748D+03 | 0.4709476D+00 | 0.8400994D+04 | 0.6019399D+03 | 0.6043525D+03 | 0.6000190D+03 |
| 7 | 3 | 3 | 2 | 0.6032022D+03 | 0.5954329D-01 | 0.4948052D+03 | 0.6019073D+03 | 0.6043471D+03 | 0.6000168D+03 |
| 8 | 2 | 5 | 3 | 0.6226189D+03 | 0.6021821D-02 | 0.1169914D+03 | 0.6019047D+03 | 0.6043465D+03 | 0.6000167D+03 |
| 9 | 3 | 3 | 2 | 0.6031991D+03 | 0.4581165D-03 | 0.1903306D+02 | 0.6019049D+03 | 0.6043465D+03 | 0.6000168D+03 |

ITERATIONS USED = 9 MAXIMUM CHANGE IN XX BETWEEN LAST 2 ITERATIONS = 0.458D-03
MAXIMUM RESIDUAL ERROR FOR GRID ELEMENTS NOT HAVING FIXED HYDRAULIC HEAD = 0.190D+02 TOTAL = -0.288D+01

## WATER FLOW RATE IN NEGATIVE I DIRECTION

| LAYER | ROW | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | |
| | 2 | 0.000D+00 | -0.594D+05 | -0.145D+05 | -0.327D+04 | 0.677D+04 | 0.317D+05 | 0.669D+04 | -0.505D+04 | -0.145D+05 | -0.100D+05 |
| | | -0.200D+05 | -0.628D+04 | -0.131D+04 | -0.276D+03 | -0.611D+02 | -0.213D+02 | -0.301D+02 | -0.693D+02 | -0.885D+02 | 0.254D+03 |
| | | 0.742D+03 | 0.331D+04 | 0.163D+05 | 0.818D+05 | 0.415D+06 | | | | | |
| | 3 | 0.000D+00 | -0.131D+05 | -0.452D+04 | -0.352D+02 | 0.227D+04 | 0.793D+04 | 0.395D+04 | -0.267D+03 | -0.530D+04 | -0.254D+04 |
| | | -0.862D+04 | -0.303D+04 | -0.825D+03 | -0.204D+03 | -0.536D+02 | -0.380D+02 | -0.113D+03 | -0.402D+03 | -0.104D+04 | 0.113D+04 |
| | | 0.725D+03 | 0.143D+04 | 0.517D+04 | 0.180D+05 | 0.480D+05 | | | | | |
| | 4 | 0.000D+00 | -0.272D+05 | -0.824D+04 | 0.366D+04 | 0.380D+04 | 0.100D+05 | 0.129D+05 | 0.302D+04 | -0.181D+05 | 0.467D+04 |
| | | -0.239D+05 | -0.769D+04 | -0.145D+04 | -0.285D+03 | -0.689D+02 | -0.777D+02 | -0.356D+03 | -0.194D+04 | -0.109D+05 | 0.110D+05 |
| | | 0.213D+04 | 0.103D+04 | 0.227D+04 | 0.606D+04 | 0.112D+05 | | | | | |
| | 5 | 0.000D+00 | -0.516D+05 | -0.187D+05 | -0.408D+04 | -0.297D+03 | 0.182D+04 | 0.251D+04 | 0.616D+03 | -0.252D+04 | -0.434D+03 |
| | | -0.473D+04 | -0.171D+04 | -0.467D+03 | -0.117D+03 | -0.334D+02 | -0.334D+02 | -0.112D+03 | -0.402D+03 | -0.104D+04 | 0.113D+04 |
| | | 0.730D+03 | 0.145D+04 | 0.525D+04 | 0.183D+05 | 0.488D+05 | | | | | |
| | 6 | 0.000D+00 | -0.417D+06 | -0.823D+05 | -0.162D+05 | -0.308D+04 | -0.307D+03 | 0.251D+03 | 0.580D+02 | -0.330D+03 | -0.235D+03 |
| | | -0.666D+03 | -0.347D+03 | -0.126D+03 | -0.395D+02 | -0.134D+02 | -0.116D+02 | -0.280D+02 | -0.687D+02 | -0.879D+02 | 0.256D+03 |
| | | 0.753D+03 | 0.336D+04 | 0.166D+05 | 0.831D+05 | 0.422D+06 | | | | | |

## WATER FLOW RATE IN NEGATIVE J DIRECTION

| LAYER | ROW | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | |
| | 2 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 |
| | | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 |
| | | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | | | | | |
| | 3 | -0.417D+05 | -0.120D+05 | -0.564D+04 | -0.357D+04 | -0.646D+04 | -0.217D+05 | -0.235D+05 | -0.204D+05 | -0.145D+05 | -0.974D+04 |
| | | -0.244D+04 | -0.364D+03 | -0.555D+02 | -0.933D+01 | -0.451D+01 | -0.152D+02 | -0.685D+02 | -0.281D+03 | -0.889D+03 | -0.328D+03 |
| | | -0.339D+03 | -0.154D+04 | -0.866D+04 | -0.494D+05 | -0.284D+06 | | | | | |
| | 4 | 0.156D+05 | 0.659D+04 | 0.422D+04 | 0.658D+04 | 0.756D+04 | 0.891D+04 | 0.146D+05 | 0.167D+05 | 0.858D+04 | 0.132D+05 |
| | | 0.344D+04 | 0.458D+03 | 0.569D+02 | 0.538D+01 | -0.441D+01 | -0.298D+02 | -0.185D+03 | -0.117D+04 | -0.748D+04 | -0.119D+04 |
| | | -0.291D+03 | -0.547D+03 | -0.240D+04 | -0.101D+05 | -0.336D+05 | | | | | |
| | 5 | 0.212D+05 | 0.444D+04 | -0.227D+04 | -0.693D+04 | -0.955D+04 | -0.147D+05 | -0.210D+05 | -0.224D+05 | -0.126D+05 | -0.157D+05 |
| | | -0.459D+04 | -0.760D+03 | -0.129D+03 | -0.220D+02 | 0.726D+00 | 0.290D+02 | 0.185D+03 | 0.117D+04 | 0.748D+04 | 0.119D+04 |
| | | 0.295D+03 | 0.564D+03 | 0.247D+04 | 0.103D+05 | 0.344D+05 | | | | | |
| | 6 | 0.282D+06 | 0.481D+05 | 0.743D+04 | -0.335D+03 | -0.212D+04 | -0.348D+04 | -0.492D+04 | -0.528D+04 | -0.388D+04 | -0.375D+04 |
| | | -0.115D+04 | -0.280D+03 | -0.619D+02 | -0.125D+02 | 0.378D+00 | 0.144D+02 | 0.683D+02 | 0.281D+03 | 0.890D+03 | 0.329D+03 |
| | | 0.344D+03 | 0.157D+04 | 0.881D+04 | 0.503D+05 | 0.289D+06 | | | | | |

## WATER FLOW RATE OUT GRID ELEMENT BOTTOM

| LAYER | ROW | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | |
| | 2 | -0.172D+06 | -0.295D+05 | 0.345D+04 | 0.561D+03 | -0.338D+05 | 0.630D+05 | 0.294D+05 | 0.344D+05 | 0.302D+04 | 0.310D+05 |
| | | -0.187D+05 | -0.164D+04 | -0.346D+03 | -0.730D+02 | -0.126D+02 | 0.848D+01 | 0.382D+02 | 0.107D+03 | 0.194D+03 | -0.569D+02 |
| | | -0.791D+03 | -0.406D+04 | -0.202D+05 | -0.102D+06 | -0.265D+07 | | | | | |
| | 3 | -0.477D+05 | -0.153D+05 | -0.111D+05 | -0.128D+05 | -0.142D+05 | -0.371D+05 | -0.448D+05 | -0.456D+05 | -0.318D+05 | -0.312D+05 |
| | | -0.409D+04 | -0.108D+04 | -0.261D+03 | -0.589D+02 | -0.586D+01 | 0.317D+02 | 0.144D+03 | 0.541D+03 | 0.156D+04 | 0.450D+03 |
| | | -0.267D+03 | -0.168D+04 | -0.679D+04 | -0.246D+05 | -0.726D+05 | | | | | |
| | 4 | 0.612D+05 | -0.217D+05 | -0.203D+04 | 0.222D+05 | 0.104D+05 | 0.225D+05 | 0.541D+05 | 0.708D+05 | 0.141D+05 | 0.814D+05 |
| | | -0.277D+05 | -0.179D+04 | -0.349D+03 | -0.671D+02 | 0.102D+01 | 0.778D+02 | 0.430D+03 | 0.234D+04 | -0.130D+05 | 0.228D+04 |
| | | 0.183D+03 | -0.835D+03 | -0.308D+04 | -0.907D+04 | -0.202D+05 | | | | | |
| | 5 | -0.915D+05 | -0.298D+05 | -0.113D+05 | -0.984D+04 | -0.955D+04 | -0.140D+05 | -0.213D+05 | -0.238D+05 | -0.174D+05 | -0.190D+05 |
| | | -0.231D+04 | -0.611D+03 | -0.149D+03 | -0.332D+02 | -0.140D+00 | 0.329D+02 | 0.144D+03 | 0.541D+03 | 0.156D+04 | 0.449D+03 |
| | | -0.273D+03 | -0.171D+04 | -0.690D+04 | -0.250D+05 | -0.738D+05 | | | | | |
| | 6 | -0.266D+07 | -0.103D+06 | -0.208D+05 | -0.478D+04 | -0.174D+04 | -0.144D+04 | -0.168D+04 | -0.174D+04 | -0.141D+04 | -0.118D+04 |
| | | -0.522D+03 | -0.178D+03 | -0.531D+02 | -0.140D+02 | -0.744D+00 | 0.107D+02 | 0.384D+02 | 0.106D+03 | 0.193D+03 | -0.600D+02 |
| | | -0.805D+03 | -0.413D+04 | -0.205D+05 | -0.103D+06 | -0.270D+07 | | | | | |

WATER FLOW RATES OUT OF FIXED HEAD GRID ELEMENTS

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 2 | 0.244D+06 | 26 | 2 | 2 | 0.290D+07 | 2 | 6 | 2 | 0.291D+07 | 26 | 6 | 2 | 0.295D+07 | 2 | 2 | 4 | -0.710D+05 |
| 3 | 2 | 4 | -0.624D+05 | 4 | 2 | 4 | -0.212D+04 | 5 | 2 | 4 | -0.590D+04 | 6 | 2 | 4 | -0.523D+05 | 7 | 2 | 4 | 0.110D+06 |
| 8 | 2 | 4 | 0.646D+05 | 9 | 2 | 4 | 0.642D+05 | 10 | 2 | 4 | 0.131D+05 | 11 | 2 | 4 | 0.508D+05 | 12 | 2 | 4 | -0.300D+05 |
| 13 | 2 | 4 | -0.625D+04 | 14 | 2 | 4 | -0.132D+04 | 15 | 2 | 4 | -0.278D+03 | 16 | 2 | 4 | -0.476D+02 | 17 | 2 | 4 | 0.327D+02 |
| 18 | 2 | 4 | 0.146D+03 | 19 | 2 | 4 | 0.408D+03 | 20 | 2 | 4 | 0.742D+03 | 21 | 2 | 4 | -0.216D+03 | 22 | 2 | 4 | -0.302D+04 |
| 23 | 2 | 4 | -0.155D+05 | 24 | 2 | 4 | -0.770D+05 | 25 | 2 | 4 | -0.386D+06 | 26 | 2 | 4 | -0.195D+07 | 2 | 3 | 4 | -0.919D+05 |
| 3 | 3 | 4 | -0.425D+05 | 4 | 3 | 4 | -0.254D+05 | 5 | 3 | 4 | -0.253D+05 | 6 | 3 | 4 | -0.338D+05 | 7 | 3 | 4 | -0.638D+05 |
| 8 | 3 | 4 | -0.787D+05 | 9 | 3 | 4 | -0.777D+05 | 10 | 3 | 4 | -0.577D+05 | 11 | 3 | 4 | -0.481D+05 | 12 | 3 | 4 | -0.156D+05 |
| 13 | 3 | 4 | -0.411D+04 | 14 | 3 | 4 | -0.993D+03 | 15 | 3 | 4 | -0.223D+03 | 16 | 3 | 4 | -0.210D+02 | 17 | 3 | 4 | 0.122D+03 |
| 18 | 3 | 4 | 0.550D+03 | 19 | 3 | 4 | 0.207D+04 | 20 | 3 | 4 | 0.599D+04 | 21 | 3 | 4 | 0.172D+04 | 22 | 3 | 4 | -0.102D+04 |
| 23 | 3 | 4 | -0.641D+04 | 24 | 3 | 4 | -0.259D+05 | 25 | 3 | 4 | -0.940D+05 | 26 | 3 | 4 | -0.275D+06 | 2 | 4 | 4 | 0.828D+05 |
| 3 | 4 | 4 | -0.385D+05 | 4 | 4 | 4 | -0.743D+04 | 5 | 4 | 4 | 0.356D+05 | 6 | 4 | 4 | 0.213D+05 | 7 | 4 | 4 | 0.433D+05 |
| 8 | 4 | 4 | 0.997D+05 | 9 | 4 | 4 | 0.131D+06 | 10 | 4 | 4 | 0.113D+06 | 11 | 4 | 4 | 0.139D+06 | 12 | 4 | 4 | -0.358D+05 |
| 13 | 4 | 4 | -0.681D+04 | 14 | 4 | 4 | -0.133D+04 | 15 | 4 | 4 | -0.255D+03 | 16 | 4 | 4 | 0.500D+01 | 17 | 4 | 4 | 0.298D+03 |
| 18 | 4 | 4 | 0.164D+04 | 19 | 4 | 4 | 0.897D+04 | 20 | 4 | 4 | 0.501D+05 | 21 | 4 | 4 | 0.873D+04 | 22 | 4 | 4 | 0.698D+03 |
| 23 | 4 | 4 | -0.318D+04 | 24 | 4 | 4 | -0.117D+05 | 25 | 4 | 4 | -0.346D+05 | 26 | 4 | 4 | -0.770D+05 | 2 | 5 | 4 | -0.301D+06 |
| 3 | 5 | 4 | -0.106D+06 | 4 | 5 | 4 | -0.356D+05 | 5 | 5 | 4 | -0.202D+05 | 6 | 5 | 4 | -0.191D+05 | 7 | 5 | 4 | -0.260D+05 |
| 8 | 5 | 4 | -0.355D+05 | 9 | 5 | 4 | -0.378D+05 | 10 | 5 | 4 | -0.283D+05 | 11 | 5 | 4 | -0.266D+05 | 12 | 5 | 4 | -0.877D+04 |
| 13 | 5 | 4 | -0.233D+04 | 14 | 5 | 4 | -0.566D+03 | 15 | 5 | 4 | -0.125D+03 | 16 | 5 | 4 | 0.716D+00 | 17 | 5 | 4 | 0.127D+03 |
| 18 | 5 | 4 | 0.551D+03 | 19 | 5 | 4 | 0.207D+04 | 20 | 5 | 4 | 0.599D+04 | 21 | 5 | 4 | 0.171D+04 | 22 | 5 | 4 | -0.104D+04 |
| 23 | 5 | 4 | -0.651D+04 | 24 | 5 | 4 | -0.263D+05 | 25 | 5 | 4 | -0.955D+05 | 26 | 5 | 4 | -0.280D+06 | 2 | 6 | 4 | -0.197D+07 |
| 3 | 6 | 4 | -0.390D+06 | 4 | 6 | 4 | -0.794D+05 | 5 | 6 | 4 | -0.182D+05 | 6 | 6 | 4 | -0.663D+04 | 7 | 6 | 4 | -0.547D+04 |
| 8 | 6 | 4 | -0.642D+04 | 9 | 6 | 4 | -0.663D+04 | 10 | 6 | 4 | -0.539D+04 | 11 | 6 | 4 | -0.450D+04 | 12 | 6 | 4 | -0.199D+04 |
| 13 | 6 | 4 | -0.678D+03 | 14 | 6 | 4 | -0.201D+03 | 15 | 6 | 4 | -0.519D+02 | 16 | 6 | 4 | -0.151D+01 | 17 | 6 | 4 | 0.422D+02 |
| 18 | 6 | 4 | 0.148D+03 | 19 | 6 | 4 | 0.407D+03 | 20 | 6 | 4 | 0.739D+03 | 21 | 6 | 4 | -0.228D+03 | 22 | 6 | 4 | -0.307D+04 |
| 23 | 6 | 4 | -0.158D+05 | 24 | 6 | 4 | -0.783D+05 | 25 | 6 | 4 | -0.392D+06 | 26 | 6 | 4 | -0.199D+07 | | | | |

TOTAL RECHARGE TO MODELED REGION= -0.2000D+06
TOTAL FLOW FROM FIXED HEAD GRID ELEMENTS INTO MODELED REGION= 0.2001D+06
TOTAL HEAD DEPENDANT DISCHARGE FROM MODELED REGION 0.0000D+00

| | | RECHARGE | FLOW FROM FIXED HEADS | HEAD DEPENDANT DISCHARGE | FLOW IN BOTTOM | FLOW IN TOP | FLOW OUT BOTTOM | FLOW OUT TOP |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 0.000D+00 | 0.813D+06 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.813D+06 |
| 1 | 3 | 0.000D+00 | -0.640D+06 | 0.000D+00 | 0.813D+06 | 0.000D+00 | 0.000D+00 | 0.173D+06 |
| 1 | 4 | 0.000D+00 | -0.150D+06 | 0.000D+00 | 0.173D+06 | 0.103D+05 | 0.000D+00 | 0.335D+05 |
| 1 | 5 | 0.000D+00 | -0.341D+05 | 0.000D+00 | 0.335D+05 | 0.155D+05 | 0.103D+05 | 0.457D+04 |
| 1 | 6 | 0.000D+00 | -0.906D+05 | 0.000D+00 | 0.457D+04 | 0.102D+06 | 0.155D+05 | 0.415D+03 |
| 1 | 7 | 0.000D+00 | 0.578D+05 | 0.000D+00 | 0.415D+03 | 0.437D+05 | 0.102D+06 | 0.000D+00 |
| 1 | 8 | 0.000D+00 | 0.437D+05 | 0.000D+00 | 0.000D+00 | 0.901D+04 | 0.437D+05 | 0.903D+04 |
| 1 | 9 | 0.000D+00 | 0.732D+05 | 0.000D+00 | 0.903D+04 | 0.000D+00 | 0.901D+04 | 0.732D+05 |
| 1 | 10 | -0.100D+06 | 0.343D+05 | 0.000D+00 | 0.732D+05 | 0.104D+05 | 0.000D+00 | 0.179D+05 |
| 1 | 11 | 0.000D+00 | 0.110D+06 | 0.000D+00 | 0.179D+05 | 0.000D+00 | 0.104D+05 | 0.118D+06 |
| 1 | 12 | 0.000D+00 | -0.921D+05 | 0.000D+00 | 0.118D+06 | 0.000D+00 | 0.000D+00 | 0.258D+05 |
| 1 | 13 | 0.000D+00 | -0.202D+05 | 0.000D+00 | 0.258D+05 | 0.000D+00 | 0.000D+00 | 0.566D+04 |
| 1 | 14 | 0.000D+00 | -0.441D+04 | 0.000D+00 | 0.566D+04 | 0.000D+00 | 0.000D+00 | 0.125D+04 |
| 1 | 15 | 0.000D+00 | -0.934D+03 | 0.000D+00 | 0.125D+04 | 0.000D+00 | 0.000D+00 | 0.312D+03 |
| 1 | 16 | 0.000D+00 | -0.644D+02 | 0.000D+00 | 0.312D+03 | 0.000D+00 | 0.000D+00 | 0.246D+03 |
| 1 | 17 | 0.000D+00 | 0.622D+03 | 0.000D+00 | 0.246D+03 | 0.000D+00 | 0.000D+00 | 0.867D+03 |
| 1 | 18 | 0.000D+00 | 0.304D+04 | 0.000D+00 | 0.867D+03 | 0.000D+00 | 0.000D+00 | 0.390D+04 |
| 1 | 19 | 0.000D+00 | 0.139D+05 | 0.000D+00 | 0.390D+04 | 0.000D+00 | 0.000D+00 | 0.178D+05 |
| 1 | 20 | -0.100D+06 | 0.636D+05 | 0.000D+00 | 0.178D+05 | 0.186D+05 | 0.000D+00 | 0.000D+00 |
| 1 | 21 | 0.000D+00 | 0.117D+05 | 0.000D+00 | 0.000D+00 | 0.688D+04 | 0.186D+05 | 0.000D+00 |
| 1 | 22 | 0.000D+00 | -0.745D+04 | 0.000D+00 | 0.000D+00 | 0.143D+05 | 0.688D+04 | 0.000D+00 |
| 1 | 23 | 0.000D+00 | -0.474D+05 | 0.000D+00 | 0.000D+00 | 0.617D+05 | 0.143D+05 | 0.000D+00 |
| 1 | 24 | 0.000D+00 | -0.219D+06 | 0.000D+00 | 0.000D+00 | 0.281D+06 | 0.617D+05 | 0.000D+00 |
| 1 | 25 | 0.000D+00 | -0.100D+07 | 0.000D+00 | 0.000D+00 | 0.128D+07 | 0.281D+06 | 0.000D+00 |
| 1 | 26 | 0.000D+00 | 0.128D+07 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.128D+07 | 0.000D+00 |
| 2 | 2 | 0.000D+00 | 0.785D+06 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.000D+00 | 0.785D+06 |
| 2 | 3 | 0.000D+00 | -0.958D+06 | 0.000D+00 | 0.785D+06 | 0.251D+06 | 0.000D+00 | 0.772D+05 |
| 2 | 4 | -0.200D+06 | 0.519D+06 | 0.000D+00 | 0.772D+05 | 0.104D+06 | 0.251D+06 | 0.250D+06 |
| 2 | 5 | 0.000D+00 | -0.105D+07 | 0.000D+00 | 0.250D+06 | 0.936D+06 | 0.104D+06 | 0.343D+05 |
| 2 | 6 | 0.000D+00 | 0.901D+06 | 0.000D+00 | 0.343D+05 | 0.000D+00 | 0.936D+06 | 0.000D+00 |
| 3 | 2 | 0.000D+00 | 0.901D+07 | 0.000D+00 | 0.000D+00 | 0.513D+06 | 0.000D+00 | 0.952D+07 |
| 3 | 3 | -0.200D+06 | 0.000D+00 | 0.000D+00 | 0.952D+07 | 0.106D+07 | 0.513D+06 | 0.987D+07 |
| 3 | 4 | 0.000D+00 | -0.881D+07 | 0.000D+00 | 0.987D+07 | 0.000D+00 | 0.106D+07 | 0.000D+00 |

HYDRAULIC HEAD

| LAYER | ROW | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | | | | | | | | | |
| | 2 | 580.5 | 599.3 | 594.4 | 596.3 | 601.8 | 566.4 | 570.7 | 572.2 | 584.1 | 581.5 | 602.3 | 600.5 | 600.1 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 600.0 | 599.9 | 600.0 | 600.2 | 601.2 | 605.8 | 629.0 | 746.7 | | | | | |
| | 2 | 625.4 | 608.5 | 604.4 | 603.5 | 605.4 | 614.4 | 616.3 | 614.9 | 610.8 | 607.9 | 602.3 | 600.5 | 600.1 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 600.0 | 599.9 | 600.0 | 600.2 | 601.2 | 605.8 | 629.0 | 746.7 | | | | | |
| | 3 | 606.9 | 603.2 | 601.9 | 601.9 | 602.5 | 604.8 | 605.9 | 605.8 | 604.3 | 603.6 | 601.2 | 600.3 | 600.1 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 599.8 | 599.5 | 599.9 | 600.1 | 600.5 | 601.9 | 607.1 | 620.7 | | | | | |
| | 3 | 606.9 | 603.2 | 601.9 | 601.9 | 602.5 | 604.8 | 605.9 | 605.8 | 604.3 | 603.6 | 601.2 | 600.3 | 600.1 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 599.8 | 599.5 | 599.9 | 600.1 | 600.5 | 601.9 | 607.1 | 620.7 | | | | | |
| | 4 | 570.6 | 598.4 | 596.1 | 587.6 | 588.6 | 581.8 | 569.7 | 564.7 | 572.2 | 567.2 | 602.7 | 600.5 | 600.1 | 600.0 | 600.0 |
| | | 600.0 | 599.9 | 599.3 | 596.2 | 599.3 | 599.9 | 600.2 | 600.9 | 602.6 | 605.8 | | | | | |
| | 4 | 613.8 | 606.1 | 603.8 | 604.8 | 605.9 | 608.7 | 612.4 | 613.3 | 608.1 | 609.5 | 602.7 | 600.5 | 600.1 | 600.0 | 600.0 |
| | | 600.0 | 599.9 | 599.3 | 596.2 | 599.3 | 599.9 | 600.2 | 600.9 | 602.6 | 605.8 | | | | | |
| | 5 | 622.6 | 608.0 | 602.7 | 601.5 | 601.4 | 602.0 | 602.7 | 602.8 | 602.1 | 602.0 | 600.7 | 600.2 | 600.0 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 599.8 | 599.6 | 599.9 | 600.1 | 600.5 | 602.0 | 607.2 | 621.0 | | | | | |
| | 5 | 622.6 | 608.0 | 602.7 | 601.5 | 601.4 | 602.0 | 602.7 | 602.8 | 602.1 | 602.0 | 600.7 | 600.2 | 600.0 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 599.8 | 599.6 | 599.9 | 600.1 | 600.5 | 602.0 | 607.2 | 621.0 | | | | | |
| | 6 | 747.7 | 629.3 | 606.0 | 601.4 | 600.5 | 600.4 | 600.5 | 600.5 | 600.4 | 600.3 | 600.1 | 600.1 | 600.0 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 600.0 | 599.9 | 600.0 | 600.2 | 601.2 | 605.9 | 629.5 | 749.2 | | | | | |
| | 6 | 747.7 | 629.3 | 606.0 | 601.4 | 600.5 | 600.4 | 600.5 | 600.5 | 600.4 | 600.3 | 600.1 | 600.1 | 600.0 | 600.0 | 600.0 |
| | | 600.0 | 600.0 | 600.0 | 599.9 | 600.0 | 600.2 | 601.2 | 605.9 | 629.5 | 749.2 | | | | | |

## ATTACHMENT D

## DEFINITION OF PROGRAM VARIABLES

ALN, XXE — The rate of water discharge ($L^3/T$) from a grid element is given by $Aa(H-H_e)$ when $H>H_e$ and is zero when $H<H_e$. H is the hydraulic head in the grid element and A is the area of the grid element, (DXI(I)) X (DYJ)). XXE(IJ) of data set 5 is $H_e$, measured relative to the center of the grid element. ALN(IJ) of data set 6 specifies the quantity a.

BBK — See FCNT

DDK — See FCNT

DTO — Duration of the first time interval.

DXI,DYJ — DXI(I) is the I direction horizontal dimension of the grid elements in column I. DYJ(J) is the J direction horizontal dimension of the grid elements in row J.

ERR, XX10 — Iteration terminates when

$$\max_{\text{(over IJ)}} \left| XX^{ICNT} - XX^{(ICNT-1)} \right| + \max_{\text{(over IJ)}} \left| XX^{(ICNT-1)} - XX^{(ICNT-2)} \right| < ERR,$$

the maximum residual error

$$\max_{\text{(over IJ)}} \left| [M]\ XX^{ICNT} - YQ \right| < XX10, \text{ or } ICNT \geq ITMAX.$$

FCNT,NT, DDK,BBK — $K_{xx}(IJ) = (NT(IJ)\ X\ (DDK(K))$,
$K_{yy}(IJ) = (NT(IJ)\ X\ (BBK(K))$,
$K_{zz}(IJ) = (NT(IJ)$,
where $K_{xx}(IJ)$, $K_{yy}(IJ)$, and $K_{zz}(IJ)$ denote the x, y, and z components of K, the hydraulic conductivity for grid element IJ. NT = 0 is used as a flag to the computer program that the grid element lies outside the modeled region. NT is also used as a dummy variable for reading various data sets.

HMAX — SIP parameter $\beta'$ (Trescott and Larson, 1977).

I — Positional locator along a row, also column number.

ICNT — Iteration counter in the solution procedure.

ICT — In SIP, a repeating counter for iteration parameter number.

IEVP — If IEVP $\neq$ 1, data sets 5 and 6 are not read. If IEVP = 1, these data sets are read, and the head dependant discharge option is available.

IJ — Single subscript replacement for I,J,K corresponding to grid element I,J,K.

IJKM1 — Replacement for I,J,K-1, or for I,J,K+1 when the K direction is reversed in SIP.

IJKP1 — Replacement for I,J,K+1, or for I,J,K-1 when the K direction is reversed in SIP.

IJLB — IJ for confining bed grid elements.

IJM1K — Replacement for I,J-1,K, or for I,J+1,K when the J direction is reversed in SIP.

IJP1K — Replacement for I,J+1,K, or for I,J-1,K when the J direction is reversed in SIP.

ILZ2 — If ILZ2 = 0, the elevation of the top of the uppermost grid element layer is printed.

IKZZ — If IKZZ $\neq$ 1, data set 9 is not read. If IKZZ = 1, data set 9, XKZZ = $K_{zz}$ is read. In this case $K_{zz}$ is specified by XKZZ rather than by NT from data set 10.

IM1JK — Single subscript replacement for I-1,J,K

IP1JK — Single subscript replacement for I+1,J,K

IPDD — If IPDD = 1, the drawdown (decrease in hydraulic head H) during a pumping interval is printed.

| | |
|---|---|
| IPH(K), K=2, NK11 | Set IPH(K) = 1 if you want: hydraulic head or fresh-water head, flow rate data, or drawdown, for layer K. Set IPH(K) = 0 if you do not want these quantities for layer K. The layers are numbered K=2 through K = NK11 = NK10+1. |
| IPRNT | Setting IPRNT = 0 causes IWRT and LFLOW to be set to zero, and the printing of hydraulic and fresh-water head deleted, for all time intervals except the last. |
| ITMAX | Maximum number of iterations allowed. |
| IWRT NU1(I), I=1,3 NU2(I), I=1,3 NU3(I), I=1,3 | Set IWRT to 1 if you want to watch the convergence of fresh-water head h' - XX, at the three locations: I = NU1(1), J = NU1(2), K = NU1(3) I = NU2(1), J = NU2(2), K = NU2(3) and I = NU3(1), J = NU3(2), K = NU3(3). |
| IWRTXX | If IWRTXX = 1, fresh-water head h' = (pressure head h) + z is printed along with the hydraulic head. If IWRTXX = 0, it is not printed. If IWRTXX = 2, only h' is printed. |
| J | Positional locator along a colunm, also row number. |
| K | Layer number. |
| KOUT | The total number of confining beds between layer 2 and layer K. Only one effective confining bed is allowed between any two layers. If there are more than two confining beds, they are combined into one effective confining bed in accordance with equation 5 in the text. |
| L9 | In SIP, L9 is: 1 for J direction reversal, 2 for J and K direction reversal, and 3 for K direction reversal. |
| LB | LB(IJ) is the vertical dimension of grid element IJ. |
| LBB | Elevation of the base of the lowermost layer, K = 2. |

| | |
|---|---|
| LENGTH | Number of iteration parameters in SIP. |
| LFLOW<br>LFLO(1)<br>LFLO(2)<br>LFLO(3)<br>LFLO(4) | Four types of flow rate data are available: 1) the flow rate out of each grid element in the negative I, J, and K directions, 2) the flow rate out of fixed head (MHD = 0) grid elements, 3) head dependant discharge flow rates from grid elements having such discharge, 4) total flow rate budgets for sets of grid elements having the same I, the same J, and the same K. All flow rates are in units of mass divided by $\rho_0 = 1$ gm/cm$^3$ per unit time ($L^3/T$). See the Units section of the text. Set LFLOW = 1 if you want any flow rate data, set LFLOW = 0 if no flow rate data is desired. Set LFLO(i) = 0 if you do not want type i flow rate data. For i = 1, set LFLO(1) = 1, 2, 3, for type 1 flow rate data in the negative I,J, and K directions respectively. If LFLO(1) = 4 all directions are given. Set LFLO(2) = 1 if you want type 2 flow rate data. Set LFLO(3) = 1 if you want type 3 flow rate data. Set LFLO(4) = 1, 2, 3, for the budgets of sets of grid elements having the same I, J, and K respectively. If LFLO(4) = 4 budgets are given for I, J, and K. Corresponding to the integers 1, 2, and 3 in the first column of output the second column gives I, J, and K respectively. |
| LLRO | If LLRO = 0, read-in values for LRO are used. If LLRO = 1, read-in values for LRO are replaced by values for LRO calculated from water pressure, molality, and temperature, when such calculated values are available. Calculated values are made available only for those IJ or IJLB for which the pressure is specified to be greater than zero. |
| LRO | LRO(IJ) = $(\rho'/\rho_0)$. $\rho = \rho' + \rho_0$ is the water density for grid element IJ. LRO(IJLB) = $(\rho'/\rho_0)$, where $\rho = \rho' + \rho_0$ is the water density for confining bed grid element IJLB. Values given are truncated after the fifth decimal place. |
| LZ2 | LZ2(IJ) = M, where the integer M divided by 10 is the elevation of node point IJ located at the center of grid element IJ. |

| | |
|---|---|
| MAQ1 | MAQ1(K) = 0 except when a confining bed lies between layers K-1 and K, in which case MAQ1(K) = 1. |
| MHD | When MHD(IJ) $\neq$ 0 the hydraulic head for grid element IJ is fixed at the value specified. When MHD(IJ) = 0, the head for grid element IJ is not fixed. There are NK10 layers of MHD values. Values given are truncated after the first decimal place. |
| NI10 | Number of columns in the modeled area. |
| NJ10 | Number of rows in the modeled area. |
| NK10 | Number of layers in the modeled area. |
| NK4 | Number of intervening confining beds. |
| NI | See Q2. |
| NINT | Number of time intervals desired in the current pumping interval. |
| NJ | See Q2. |
| NK | See Q2. |
| NNN | Total number of grid elements plus 2: [(NI10) X (NJ10) X (NK10)] + 2. |
| NPINT | Number of pumping intervals. |
| NSKP1, NSKP2, RELX1, RELX2, COEF | See the Successvie over-relaxation section of the text for these. |
| NT | See FCNT. |
| NU1 | See IWRT. |
| NU2 | See IWRT. |
| NU3 | See IWRT. |

NWEL — Number of grid elements with pumping wells.

Q2,NI, NJ,NK,YQ — YQ(IJ) + Q2(NI,NJ,NK) is the recharge rate ($L^3/T$) into the grid element located at I=NI, J=NJ, and K=NK.

SRZ — SRZ is the maximum residual error $\max_{(over\,IJ)} \left| [M]XX^{ICNT}-YQ \right|$ with units ($L^3/T$). For each grid element in the modeled region that does not have fixed hydraulic head, the computer program seeks to satisfy the conservation of mass, i.e. mass in equals mass out. The maximum residual error is the maximum over these grid elements, of the difference between mass in and mass out.

SUMRZ — SUMRZ is the sum, over all the grid elements in the modeled region not having fixed hydraulic head, of the members of residual vector $[M]X^{ICNT}-YQ$. In the computer output, SUMRZ is printed following the value printed for maximum residual error SRZ, and is denoted by "total." Both SRZ and SUMRZ are a measure of the accuracy of the solution found.

SV — SV specifies specific storage $S_s$.

TFAC — The ratio of the duration of a time interval divided by the duration of the preceding time interval.

TOT — If TOT = 0, DTO is calculated such that the duration of the pumping, the sum of the NINT time intervals, is TOT.

WMAX — In SIP, (XYFC) X (XY) is used for ($1-\alpha_{max}$) (Weinstein and others, 1969) when WMAX = 0. When WMAX = 0, ($1-\alpha_{max}$) = WMAX is used.

XX — Fresh-water head h' = (pressure head h) + z.

XXS — The value of XX for the previous time step.

XY — See equation (8) in text.

XYFC — See WMAX.

YQ — See Q2.

## ATTACHMENT E

## PROGRAM LISTING

```
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON WS,HMAX,RELX1,RELX2,COEF,ERR,XX10,DELT,ER5,SRZ,SUMRZ
     1,XX,DT,VV,E2,F2,G2,YQ,NIJ10,NI11,NJ11,NK11,NNN,NSKP1
     2,NSKP2,ITMAX,ICNT,IEVP,IWR1,NW1,NW2,NW3,N320,NUM4
     3,L9,LENGTH,NK1115,IT01,IT15,ICRO,DDK,BBK
     4,NT,DD,BB,ZZ,XXE,XXS,ALN,SV
     5,NI10,NJ10,NK10,NI12,NJ12,NK12,LB,MHD
      REAL*4 DD(377),BB(377),ZZ(377),SV(377),YQ(377),XXS(377)
     1,Q2(300),DDK(50),BBK(50),NT(502)
     2,DXI(250),DYJ(250),ALN(377),XXE(377),XXSTR(377),YQ1(377)
     3,XKZZ(377)
      INTEGER*2 LRO(502),IPH(50),LFLO(4),I7(5),J7(5),K7(5)
     1,NI(300),NJ(300),NK(300),MAQ1(50),NU1(3),NU2(3),NU3(3)
      DIMENSION DT(377),E2(377),F2(377),G2(377),VV(377),XX(377)
     1,WS(10),MHD(377),LZ2(377),LB(502),LBB(127)
     2,AOC(4),BOC(4),COC(4),DOC(4)
     3,SUMF(3,250),SUNF(3,250),SQ2(3,250),SG2(3,250),SYQ(3,250)
     4,SVV(3,250)
      PI=3.1415926
      DATA AOC/12.43,4.19,-1.405,.268333/,BOC/3.07,-1.297,.592,
     1-.256833/,
     2COC/-.02,.118,-.107,.0713333/,DOC/1.000117,-.0030861,-.0029377,
     3.0002689/
      DO 10 I=1,50
10    MAQ1(I)=0
C  READ IN GROUP I DATA
      READ(5,2000) ISOR
      IF(ISOR.EQ.0) READ(5,2000) L9,LENGTH,HMAX,XYFC,WMAX,ITMAX,ERR,XX10
      IF(ISOR.EQ.1) READ(5,2000) NSKP1,NSKP2,RELX1,RELX2,
     1COEF,ITMAX,ERR,XX10
      IF(ISOR.GE.2) READ(5,2000) ITMAX,ERR,XX10
      READ(5,2020) NI10,NJ10,NK10,NK4
      READ(5,2003) IWRT,(NU1(I),I=1,3),(NU2(I),I=1,3),(NU3(I),I=1,3)
      READ(5,2020) NPINT,IPDD,LLRO,IWRTXX,IPRNT,ILZ2,IEVP,IKZZ
      READ(5,2020) LFLOW,(LFLO(I),I=1,4)
      NK11=NK10+1
      READ(5,2003) (IPH(K),K=2,NK11)
      NUM4=ISOR-1
      NI11=NI10+1
      NJ11=NJ10+1
      NK15=NK11+NK4
      NI12=NI10+2
      NJ12=NJ10+2
      NK12=NK10+2
      NIJ10=NI10*NJ10
      NIJK10=NIJ10*NK10
      NNN=NIJK10+2
      N315=NIJ10+1
      N320=NIJK10+1
      N325=NIJ10*(NK10+NK4)+1
      NW1=NU1(1)+NI10*(NU1(2)-2)+NIJ10*(NU1(3)-2)
      NW2=NU2(1)+NI10*(NU2(2)-2)+NIJ10*(NU2(3)-2)
      NW3=NU3(1)+NI10*(NU3(2)-2)+NIJ10*(NU3(3)-2)
C  READ IN AND PRINT ARRAYS MHD,LRO,LBB,LB,XXE,ALN,XX,SV,FCNT,
C                           DDK,BBK,NT,MAQ1,DXI,DYJ,Q2,NI,NJ,NK
C  GROUP II
      WRITE(6,5000)
      NK1115=NK11
      IT15=1
      ICRO=0
```

```
      CALL RDWRT                                                        MAN00610
      DO 20  IJ=2,N320                                                  MAN00620
20    MHD(IJ)=NT(IJ)*10                                                 MAN00630
      IF(LLRO.EQ.0) GO TO 80                                            MAN00640
C  DETERMINE WATER DENSITIES FROM PRESSURE, MOLALITY, AND TEMPERATURE   MAN00650
      C624=.0298912D0                                                   MAN00660
      WRITE(6,4997)                                                     MAN00670
      NK1115=NK15                                                       MAN00680
      CALL RDWRT                                                        MAN00690
      DO 30   IJ=2,N325                                                 MAN00700
30    LB(IJ)=NT(IJ)                                                     MAN00710
      WRITE(6,4998)                                                     MAN00720
      CALL RDWRT                                                        MAN00730
      DO 40   IJ=2,N325                                                 MAN00740
40    LRO(IJ)=NT(IJ)*100                                                MAN00750
      WRITE(6,4999)                                                     MAN00760
      CALL RDWRT                                                        MAN00770
      DO 70   IJ=2,N325                                                 MAN00780
      PO=LB(IJ)*C624                                                    MAN00790
      IF(PO.GT.0) GO TO 50                                              MAN00800
      LB(IJ)=-30000                                                     MAN00810
      GO TO 70                                                          MAN00820
50    XM=LRO(IJ)/100.D0                                                 MAN00830
      X=NT(IJ)/25.D0                                                    MAN00840
      X3=X*(X-1)                                                        MAN00850
      X4=X3*(X-2)                                                       MAN00860
      AO=AOC(1)+AOC(2)*X+AOC(3)*X3+AOC(4)*X4                            MAN00870
      BO=BOC(1)+BOC(2)*X+BOC(3)*X3+BOC(4)*X4                            MAN00880
      CO=COC(1)+COC(2)*X+COC(3)*X3+COC(4)*X4                            MAN00890
      DO=DOC(1)+DOC(2)*X+DOC(3)*X3+DOC(4)*X4                            MAN00900
      XM32=XM*DSQRT(XM)                                                 MAN00910
      DE=1000+58.448DO*XM                                               MAN00920
      DG=DE/(1000/DO+AO*XM+BO*XM32+CO*XM*XM)                            MAN00930
      AMB=(-(X-1)*.75+.25)*XM+((X-1)*3.5+2)                             MAN00940
      RHO=1                                                             MAN00950
      R84=1.OD-5*(.84*(X-1)+3.75)                                       MAN00960
      DO 60 L3=1,3                                                      MAN00970
      P=PO*RHO                                                          MAN00980
      DLT=AMB*1.D-5*P                                                   MAN00990
      IF(P.GT.100) DLT=AMB*1.D-3+R84*(P-100)                            MAN01000
60    RHO=DG+DLT                                                        MAN01010
      LB(IJ)=(RHO-1)*1.D5                                               MAN01020
70    CONTINUE                                                          MAN01030
C  WATER DENSITIES ARE NOW DETERMINED                                   MAN01040
80    CONTINUE                                                          MAN01050
      WRITE(6,5002)                                                     MAN01060
      NK1115=NK15                                                       MAN01070
      ICRO=LLRO                                                         MAN01080
      CALL RDWRT                                                        MAN01090
      DO 90  IJ=2,N325                                                  MAN01100
90    LRO(IJ)=NT(IJ)*1.D+5                                              MAN01110
      WRITE(6,5003)                                                     MAN01120
      NK1115=2                                                          MAN01130
      ICRO=0                                                            MAN01140
      CALL RDWRT                                                        MAN01150
      DO 100 IJ=2,N315                                                  MAN01160
100   LBB(IJ)=NT(IJ)                                                    MAN01170
      WRITE(6,5004)                                                     MAN01180
      NK1115=NK15                                                       MAN01190
      CALL RDWRT                                                        MAN01200
      DO 110 IJ=2,N325                                                  MAN01210
```

```
110   LB(IJ)=NT(IJ)                                              MANO1220
      LB(1)=1                                                    MANO1230
      IF(IEVP.NE.1) GO TO 140                                    MANO1240
      WRITE(6,8000)                                              MANO1250
      NK1115=NK11                                                MANO1260
      CALL RDWRT                                                 MANO1270
      DO 120  IJ=2,N320                                          MANO1280
120   XXE(IJ)=NT(IJ)*10                                          MANO1290
      WRITE(6,8001)                                              MANO1300
      CALL RDWRT                                                 MANO1310
      DO 130  IJ=2,N320                                          MANO1320
130   ALN(IJ)=NT(IJ)                                             MANO1330
140   CONTINUE                                                   MANO1340
      WRITE(6,5052)                                              MANO1350
      NK1115=NK11                                                MANO1360
      CALL RDWRT                                                 MANO1370
      DO 150  IJ=2,N320                                          MANO1380
150   XX(IJ)=NT(IJ)*10                                           MANO1390
      XX(1)=0                                                    MANO1400
      XX(NNN)=0                                                  MANO1410
      WRITE(6,5054)                                              MANO1420
      CALL RDWRT                                                 MANO1430
      DO 160  IJ=2,N320                                          MANO1440
160   SV(IJ)=NT(IJ)                                              MANO1450
      IF(IKZZ.EQ.0) GO TO 167                                    MANO1460
      WRITE(6,5060)                                              MANO1470
      CALL RDWRT                                                 MANO1480
      DO 166 IJ=2,N320                                           MANO1490
166   XKZZ(IJ)=NT(IJ)                                            MANO1500
167   CONTINUE                                                   MANO1510
      WRITE(6,5005)                                              MANO1520
      NK1115=NK15                                                MANO1530
      IT15=2                                                     MANO1540
      CALL RDWRT                                                 MANO1550
C   ***** REMOVE PINCHED OUT NODES WHEN APPROPRIATE *****        MANO1560
      DO 165 I=2,NI11                                            MANO1570
      DO 165 J=2,NJ11                                            MANO1580
      IJIJ=I+NI10*(J-2)                                          MANO1590
      DO 165 K=2,NK11                                            MANO1600
      IJ=IJIJ+NIJ10*(K-2)                                        MANO1610
      IF(LB(IJ).NE.0) GO TO 165                                  MANO1620
      IF((K.EQ.2).OR.(K.EQ.NK11)) GO TO 164                      MANO1630
      IT5=0                                                      MANO1640
      KM1=K-1                                                    MANO1650
      DO 161 K1=2,KM1                                            MANO1660
      IJ1=IJIJ+NIJ10*(K1-2)                                      MANO1670
161   IF(LB(IJ1).NE.0) IT5=IT5+1                                 MANO1680
      IT6=0                                                      MANO1690
      KP1=K+1                                                    MANO1700
      DO 162 K2=KP1,NK11                                         MANO1710
      IJ2=IJIJ+NIJ10*(K2-2)                                      MANO1720
162   IF(LB(IJ2).NE.0) IT6=IT6+1                                 MANO1730
      IF((IT5*IT6).GT.0) GO TO 165                               MANO1740
164   NT(IJ)=0                                                   MANO1750
165   CONTINUE                                                   MANO1760
C   ****** DONE ******                                           MANO1770
C   GROUP III                                                    MANO1780
      IF(NK4.EQ.0) GO TO 170                                     MANO1790
      READ(5,2003) (MAG1(K),K=2,NK11)                            MANO1800
      WRITE(6,5010)                                              MANO1810
      WRITE(6,4002) (K,MAG1(K),K=2,NK11)                         MANO1820
```

```
170   CONTINUE
      READ(5,2000) FDXI,FDYJ,MDXI1,MDYJ1,MD2
      IF(MDXI1.EQ.1) READ(5,2000) (DXI(I),I=2,NI11)
      IF(MDYJ1.EQ.1) READ(5,2000) (DYJ(J),J=2,NJ11)
      IF(MDXI1.EQ.1) GO TO 190
      DO 180 I=2,NI11
180   DXI(I)=FDXI
190   IF(MDYJ1.EQ.1) GO TO 210
      DO 200 J=2,NJ11
200   DYJ(J)=FDYJ
210   IF(MD2.NE.0) GO TO 220
      WRITE(6,5001)
      WRITE(6,3010) (DXI(I),I=2,NI11)
      WRITE(6,3010) (DYJ(I),I=2,NJ11)
220   CONTINUE
      DXI(1)=1
      DYJ(1)=1
      DXI(NI12)=1
      DYJ(NJ12)=1
      WRITE(6,5055)
      READ(5,2020) NWEL
      NWEL=NWEL+1
      READ(5,2007) (NI(N),NJ(N),NK(N),Q2(N),N=2,NWEL)
      WRITE(6,3007) (NI(N),NJ(N),NK(N),Q2(N),N=2,NWEL)
C  READ IN AND PRINTING OF ARRAYS NOW COMPLETE
C  INITIALIZE VARIOUS ARRAYS TO ZERO
      DO 230  IJ=1,NNN
      DD(IJ)=0
      BB(IJ)=0
      ZZ(IJ)=0
      DT(IJ)=0
      E2(IJ)=0
      F2(IJ)=0
      G2(IJ)=0
      YQ(IJ)=0
230   VV(IJ)=0
C  DETERMINE LZ2 AND INITIAL OR FIXED XX, PUT RECHARGE RATES Q2 INTO YQ.
C  IF IEVP=1, MODIFY XXE AND ALN.
      SUMQ2=0
      DO 231 IDBZ=1,3
      DO 231 N=1,250
231   SQ2(IDBZ,N)=0
      KOUT=0
      DO 280 K=2,NK11
      KOUT=KOUT+MAQ1(K)
      DO 280 J=2,NJ11
      DO 280 I=2,NI11
      DXY=DXI(I)*DYJ(J)
      IJF=I+NI10*(J-2)
      IJ=IJF+NIJ10*(K-2)
      LBIJ=LB(IJ)
      KLB=NK11+KOUT
      IJLB=IJF+NIJ10*(KLB-2)
      DTIJ=LRO(IJ)*1.OD-5
      SV(IJ)=SV(IJ)*DXY*LBIJ
C  DETERMINE LZ2
      IJKM1=IJ-NIJ10
      IF(K.EQ.2) GO TO 240
      LZ2(IJ)=LZ2(IJKM1)+5*(LBIJ+LB(IJKM1))+10*MAQ1(K)*LB(IJLB)
      GO TO 250
240   LZ2(IJ)=LBIJ*5+10*(LBB(IJ)+MAQ1(K)*LB(IJLB))
```

```
250   CONTINUE
C     DETERMINE INITIAL OR FIXED XX
      XXMHD=XX(IJ)
      MHDIJ=MHD(IJ)
      IF(MHDIJ.NE.0) XXMHD=MHDIJ
      LZ2IJ=LZ2(IJ)
      X=((XXMHD-LZ2IJ)*(DTIJ+1)+LZ2IJ)*.1D0
      IF(NT(IJ).EQ.0.0) X=0.0
      XX(IJ)=X
      XXSTR(IJ)=X
      XXS(IJ)=X
      IX=0
      IF(MHDIJ.NE.0) IX=1
      IF(NT(IJ).EQ.0.0) IX=2
      MHD(IJ)=IX
C  IF IEVP=1, MODIFY XXE AND ALN
      IF(IEVP.NE.1) GO TO 260
      XXE(IJ)=(XXE(IJ)*(DTIJ+1)+LZ2IJ)*.1D0
      ALN(IJ)=ALN(IJ)*DXY/(DTIJ+1)
260   CONTINUE
C  PUT PUMPING RATES Q2 INTO YQ
      YQIJ=0
      DO 270 N=2,NWEL
      IF(.NOT.((I.EQ.NI(N)).AND.((J.EQ.NJ(N)).AND.(K.EQ.NK(N)))))
     1GO TO 270
      YQIJ=Q2(N)
270   CONTINUE
      YQ(IJ)=YQIJ
      SQ2(1,I)=SQ2(1,I)+YQIJ
      SQ2(2,J)=SQ2(2,J)+YQIJ
      SQ2(3,K)=SQ2(3,K)+YQIJ
      SUMQ2=SUMQ2+YQIJ
280   CONTINUE
C  LZ2, XX, AND YQ=Q2 ARE NOW DETERMINED.
C  IF ILZ2=0, CALCULATE AND PRINT THE ELEVATION OF THE TOP OF THE
C  UPPERMOST GRID ELEMENT LAYER.
      IF(ILZ2.NE.0) GO TO 310
      WRITE(6,8002)
      WRITE(6,6000)
      WRITE(6,4002) NK11
      DO 300 J=2,NJ11
      DO 290 I=2,NI11
      IJ=I+NI10*(J-2)+NIJ10*(NK11-2)
290   LBB(I)=LZ2(IJ)*.1D0+LB(IJ)*.5D0+.1
300   WRITE(6,3004) J,(LBB(I),I=2,NI11)
310   CONTINUE
C  DETERMINE THE QUANTITIES DD, BB, AND ZZ
      KOUT=0
      DO 320 K=2,NK11
      MAQ1K=MAQ1(K)
      KOUT=KOUT+MAQ1K
      KLB=NK11+KOUT
      DO 320 J=2,NJ11
      DO 320 I=2,NI11
      IJF=I+NI10*(J-2)
      IJ=IJF+NIJ10*(K-2)
      IJLB=IJF+NIJ10*(KLB-2)
      IM1JK=IJ-1
      IJM1K=IJ-NI10
      IJKM1=IJ-NIJ10
      IF(IJM1K.LT.1) IJM1K=1
```

```
      IF(IJKM1.LT 1) IJKM1=1
      DXII=DXI(I)
      DYJJ=DYJ(J)
      DXIM1=DXI(I-1)
      DYJM1=DYJ(J-1)
      BO=LB(IJ)
      LBIM1=LB(IM1JK)
      LBIJM=LB(IJM1K)
      BDD=(LBIM1*DXII+BO*DXIM1)/(DXII+DXIM1)
      BBB=(LBIJM*DYJJ+BO*DYJM1)/(DYJJ+DYJM1)
      WDD=LBIM1*BO
      WBB=LBIJM*BO
      IF(WDD.EQ.0.0D00) BDD=0
      IF(WBB.EQ.0.0 ) BBB=0
      B4=LB(IJKM1)
      CO=NT(IJ)
      CD=NT(IM1JK)
      CB=NT(IJM1K)
      CZ=NT(IJKM1)
      CO1=CO
      CZ1=CZ
      IF(IKZZ.EQ.0) GO TO 319
      CO1=XKZZ(IJ)
      CZ1=XKZZ(IJKM1)
319   CONTINUE
      IF(I.EQ.2) CD=0
      IF(J.EQ.2) CB=0
      IF(K.EQ.2) CZ=0
      IF(K.EQ.2) CZ1=0
      DD(IJ)=-DYJJ*2*DDK(K)*BDD*CD*CO/(DXII*CD+DXIM1*CO+1.D-30)
      BB(IJ)=-DXII*2*BBK(K)*BBB*CB*CO/(DYJJ*CB+DYJM1*CO+1.D-30)
      CC=NT(IJLB)
      IF(MAQ1K.EQ.0) CC=1
      ALP=.5D0*(BO*CC*CZ1+B4*CC*CO1)+MAQ1K*LB(IJLB)*CO1*CZ1
      CCC=CO1*CC*CZ1
      ZZIJ=1.DO
      IF(ALP.NE.0.0) ZZIJ=CCC/ALP
      IF(CCC.EQ.0.0) ZZIJ=0
      ZZ(IJ)=-DXI(I)*DYJ(J)*ZZIJ
320    CONTINUE
C  THE QUANTITIES DD, BB, AND ZZ, ARE NOW  DETERMINED.
C  ADD VARIABLE DENSITY CONTRIBUTIONS TO YQ, PUT INTO YQ1.
      SUX=0
      NCNT=0
      NI2=NI10*NI10
      NJ2=NJ10*NJ10
      NK2=NK10*NK10
      KOUT=0
      DO 350 K=2,NK11
      KOUT=KOUT+MAQ1(K)
      KLB=NK11+KOUT
      DO 350 J=2,NJ11
      DO 340 I=2,NI11
      IJF=I+NI10*(J-2)
      IJ=IJF+NIJ10*(K-2)
      IF(MHD(IJ).GE.1) GO TO 340
      NCNT=NCNT+1
      IJLB=IJF+NIJ10*(KLB-2)
      IJLB1=IJLB+NIJ10
      IP1JK=IJ+1
      IM1JK=IJ-1
```

```
      IJP1K=IJ+NI10                                                     MAN03660
      IJM1K=IJ-NI10                                                     MAN03670
      IJKP1=IJ+NIJ10                                                    MAN03680
      IJKM1=IJ-NIJ10                                                    MAN03690
      IF(IJM1K.LT.1) IJM1K=1                                            MAN03700
      IF(IJKM1.LT.1) IJKM1=1                                            MAN03710
      IF(IJP1K.GT.NNN) IJP1K=NNN                                        MAN03720
      IF(IJKP1.GT.NNN) IJKP1=NNN                                        MAN03730
      IF(IJLB1.GT.N325) IJLB1=N325                                      MAN03740
      DD1=DD(IJ)                                                        MAN03750
      DD2=DD(IP1JK)                                                     MAN03760
      BB1=BB(IJ)                                                        MAN03770
      BB2=BB(IJP1K)                                                     MAN03780
      ZZ1=ZZ(IJ)                                                        MAN03790
      ZZ2=ZZ(IJKP1)                                                     MAN03800
      IF((WMAX.NE.0.0).OR.(ISOR.NE.0.0)) GO TO 330                      MAN03810
      D1=(BB1+BB2+ZZ1+ZZ2)/(DD1+DD2-1.D-30)                             MAN03820
      B1=(DD1+DD2+ZZ1+ZZ2)/(BB1+BB2-1.D-30)                             MAN03830
      Z1=(DD1+DD2+BB1+BB2)/(ZZ1+ZZ2-1.D-30)                             MAN03840
      IF(D1.GT.1.D+9) D1=0                                              MAN03850
      IF(B1.GT.1.D+9) B1=0                                              MAN03860
      IF(Z1.GT.1.D+9) Z1=0                                              MAN03870
      D1=1/(NI2*(1+D1))                                                 MAN03880
      B1=1/(NJ2*(1+B1))                                                 MAN03890
      Z1=1/(NK2*(1+Z1))                                                 MAN03900
      X=D1                                                              MAN03910
      IF(B1.LT.X) X=B1                                                  MAN03920
      IF(Z1.LT.X) X=Z1                                                  MAN03930
      SUX=SUX+X                                                         MAN03940
330   CONTINUE                                                          MAN03950
      BO=LB(IJ)                                                         MAN03960
      B4=LB(IJKM1)                                                      MAN03970
      B5=LB(IJKP1)                                                      MAN03980
      BTO=LRO(IJ)*1.D-5                                                 MAN03990
      BT4=LRO(IJKM1)*1.D-5                                              MAN04000
      BT5=LRO(IJKP1)*1.D-5                                              MAN04010
      BTDD=LRO(IM1JK)*1.D-5                                             MAN04020
      BTFF=LRO(IP1JK)*1.D-5                                             MAN04030
      BTBB=LRO(IJM1K)*1.D-5                                             MAN04040
      BTHH=LRO(IJP1K)*1.D-5                                             MAN04050
      X=(.5DO*(BTO*BO+BT4*B4)+MAG1(K)*(LRO(IJLB)*1.0D-5)*LB(IJLB))*ZZ1  MAN04060
     1-(.5DO*(BTO*BO+BT5*B5)+MAG1(K+1)*(LRO(IJLB1)*1.0D-5)*LB(IJLB1))   MAN04070
     2*ZZ2+YG(IJ)                                                       MAN04080
      LZO=LZ2(IJ)                                                       MAN04090
      DXII=DXI(I)                                                       MAN04100
      DXIM1=DXI(I-1)                                                    MAN04110
      DXIP1=DXI(I+1)                                                    MAN04120
      DYJJ=DYJ(J)                                                       MAN04130
      DYJM1=DYJ(J-1)                                                    MAN04140
      DYJP1=DYJ(J+1)                                                    MAN04150
      BTOX=BTO*DXII                                                     MAN04160
      BTOY=BTO*DYJJ                                                     MAN04170
      YG1(IJ)=X-(((BTDD*DXIM1+BTOX)/(DXIM1+DXII))*DD1*(LZ2(IM1JK)-LZO)  MAN04180
     1          +((BTFF*DXIP1+BTOX)/(DXIP1+DXII))*DD2*(LZ2(IP1JK)-LZO)  MAN04190
     2          +((BTBB*DYJM1+BTOY)/(DYJM1+DYJJ))*BB1*(LZ2(IJM1K)-LZO)  MAN04200
     3          +((BTHH*DYJP1+BTOY)/(DYJP1+DYJJ))*BB2*(LZ2(IJP1K)-LZO)  MAN04210
     4)*.1DO                                                            MAN04220
340   CONTINUE                                                          MAN04230
350   CONTINUE                                                          MAN04240
C  YG1 NOW DETERMINED                                                   MAN04250
      IF(ISOR.NE.0) GO TO 370                                           MAN04260
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      XY= 5DO*PI*PI*SUX/NCNT
C  XY IS NOW DETERMINED
      XY=XYFC*XY
      IF(WMAX.NE.0.0) XY=WMAX
C  DETERMINE ITERATION PARAMETERS WS(I)
      DO 360 I=1,LENGTH
360   WS(I)=1-XY**((I-1.)/(LENGTH-1))
      WRITE(6,5056)
      WRITE(6,1003) L9,ITMAX,LENGTH,HMAX,XYFC,ERR,WMAX,XX10
      WRITE(6,5006)
      WRITE(6,3555) (WS(I),I=1,LENGTH)
      GO TO 390
370   IF(ISOR.NE.1) GO TO 380
      WRITE(6,5057)
      WRITE(6,1003) NSKP1,NSKP2,ITMAX,RELX1,RELX2,COEF,ERR,XX10
      GO TO 390
380   WRITE(6,5058) NUM4
      WRITE(6,4501) ITMAX,ERR,XX10
390   CONTINUE
      DO 640 IPINT=1,NPINT
      WRITE(6,8003) IPINT
      READ(5,2000) NINT,DTO,TFAC,TOT
      IF(TOT.NE.0.0) DTO=TOT*(TFAC-1)/(TFAC**NINT-1)
C  READ IN AND PRINT YQ FOR THIS PUMPING INTERVAL
      WRITE(6,5053)
      NK1115=NK11
      IT15=1
      ICRO=0
      CALL RDWRT
      SUMYQ=SUMQ2
      DO 391 IDBZ=1,3
      DO 391 N=1,250
391   SYQ(IDBZ,N)=SQ2(IDBZ,N)
      DO 400  K=2,NK11
      DO 400  J=2,NJ11
      DO 400  I=2,NI11
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      YQIJ=NT(IJ)
      YQ(IJ)=YQIJ+YQ1(IJ)
      SYQ(1,I)=SYQ(1,I)+YQIJ
      SYQ(2,J)=SYQ(2,J)+YQIJ
      SYQ(3,K)=SYQ(3,K)+YQIJ
      SUMYQ=SUMYQ+YQIJ
400   CONTINUE
      X=SUMYQ-SUMQ2
      WRITE(6,9011) X,SUMQ2,SUMYQ
C  ADD YQ1 TO YQ, PUT INTO YQ.
      TOTIME=0
      DO 600 INT=1,NINT
      DELT=DTO*(TFAC**(INT-1))
      TOTIME=DELT+TOTIME
      WRITE(6,7000) INT,DELT,TOTIME
      IO1=1
      IF((IPRNT.EQ.0).AND.(INT.LT.NINT)) IO1=0
      IWR1=IWRT*IO1
      LFLO1=LFLOW*IO1
      IF(IWR1.NE.1) GO TO 420
      WRITE(6,5007)
      WRITE(6,5072) NU1(1),NU2(1),NU3(1)
      WRITE(6,5073) NU1(2),NU2(2),NU3(2)
      WRITE(6,5074) NU1(3),NU2(3),NU3(3)
```

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420   CONTINUE                                                          MAN04880
C  BEGIN SIP,SOR,OR PCG ITERATIONS.                                     MAN04890
      IF(ISOR.EQ.0) CALL SIP                                            MAN04900
      IF(ISOR.EQ.1) CALL SOR                                            MAN04910
      IF(ISOR.GE.2) CALL PCG                                            MAN04920
      WRITE(6,5075) ICNT,ER5,SRZ,SUMRZ                                  MAN04930
C  SAVE XX, FOR USE DURING THE NEXT TIME STEP, IN XXS                   MAN04940
      DO 430 IJ=2,N320                                                  MAN04950
430   XXS(IJ)=XX(IJ)                                                    MAN04960
      IF(LFLO1.EQ.0) GO TO 560                                          MAN04970
C  DETERMINE  WATER FLOW RATES                                          MAN04980
      DO 440 IJ=1,NNN                                                   MAN04990
440   G2(IJ)=0                                                          MAN05000
      DO 510 IDBZ=1,3                                                   MAN05010
      DO 450 N=1,250                                                    MAN05020
      SUNF(IDBZ,N)=0                                                    MAN05030
450   SUMF(IDBZ,N)=0                                                    MAN05040
      IRITE=0                                                           MAN05050
      L1=LFLO(1)                                                        MAN05060
      IF((L1.EQ.IDBZ).OR.(L1.EQ.4)) IRITE=1                             MAN05070
      IF(IRITE.NE.1) GO TO 460                                          MAN05080
      IF(IDBZ.EQ.1) WRITE(6,5101)                                       MAN05090
      IF(IDBZ.EQ.2) WRITE(6,5102)                                       MAN05100
      IF(IDBZ.EQ.3) WRITE(6,5103)                                       MAN05110
      WRITE(6,6000)                                                     MAN05120
460   CONTINUE                                                          MAN05130
      KOUT=0                                                            MAN05140
      DO 510 K=2,NK11                                                   MAN05150
      KOUT=KOUT+MAG1(K)                                                 MAN05160
      KLB=NK11+KOUT                                                     MAN05170
      IF((IRITE.EQ.1).AND.(IPH(K).EQ.1)) WRITE(6,4002) K                MAN05180
      DO 510 J=2,NJ11                                                   MAN05190
      IJMI=NI10*(J-2)+NIJ10*(K-2)                                       MAN05200
      IJLBMI=NI10*(J-2)+NIJ10*(KLB-2)                                   MAN05210
      DO 500 I=2,NI11                                                   MAN05220
      IJ=IJMI+I                                                         MAN05230
      IJLB=IJLBMI+I                                                     MAN05240
      XXO=XX(IJ)                                                        MAN05250
      BTO=LRO(IJ)*1.0D-5                                                MAN05260
      LZO=LZ2(IJ)                                                       MAN05270
      IF(IDBZ.NE.1) GO TO 470                                           MAN05280
      DBZ=DD(IJ)                                                        MAN05290
      IF(I.EQ.2) GO TO 490                                              MAN05300
      IM1JK=IJ-1                                                        MAN05310
      XXI=XX(IM1JK)                                                     MAN05320
      BTDD=LRO(IM1JK)*1.0D-5                                            MAN05330
      DXII=DXI(I)                                                       MAN05340
      DXIM1=DXI(I-1)                                                    MAN05350
      BTOX=BTO*DXII                                                     MAN05360
      FLOW=((BTDD*DXIM1+BTOX)/(DXIM1+DXII))*(LZ2(IM1JK)-LZO)*.1D0       MAN05370
      GO TO 490                                                         MAN05380
470   IF(IDBZ.NE.2) GO TO 480                                           MAN05390
      DBZ=BB(IJ)                                                        MAN05400
      IF(J.EQ.2) GO TO 490                                              MAN05410
      IJM1K=IJ-NI10                                                     MAN05420
      XXI=XX(IJM1K)                                                     MAN05430
      BTBB=LRO(IJM1K)*1.0D-5                                            MAN05440
      DYJJ=DYJ(J)                                                       MAN05450
      DYJM1=DYJ(J-1)                                                    MAN05460
      BTOY=BTO*DYJJ                                                     MAN05470
      FLOW=((BTBB*DYJM1+BTOY)/(DYJM1+DYJJ))*(LZ2(IJM1K)-LZO)*.1D0       MAN05480
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```
      GO TO 490
480   DBZ=ZZ(IJ)
      IF(K.EQ.2) GO TO 490
      IJKM1=IJ-NIJ10
      XXI=XX(IJKM1)
      BO=LB(IJ)
      B4=LB(IJKM1)
      BT4=LRO(IJKM1)*1.OD-5
      FLOW=-(.5DO*(BTO*BO+BT4*B4)+MAQ1(K)*(LRO(IJLB)*1.OD-5)*LB(IJLB))
490   X=DBZ*(XXI-XXO+FLOW)
      DT(I)=X
      IJK=I
      IF(IDBZ.EQ.2) IJK=J
      IF(IDBZ.EQ.3) IJK=K
      IF(X.GT.O) SUMF(IDBZ,IJK)=SUMF(IDBZ,IJK)+X
      IF(X.LT.O) SUNF(IDBZ,IJK)=SUNF(IDBZ,IJK)-X
      G2(IJ)=G2(IJ)+X
      IM=1
      IF(IDBZ.EQ.2) IM=NI10
      IF(IDBZ.EQ.3) IM=NIJ10
      IJM=IJ-IM
      IF(IJM.LT.1) IJM=1
      G2(IJM)=G2(IJM)-X
500   CONTINUE
510   IF((IRITE.EQ.1).AND.(IPH(K).EQ.1)) WRITE(6,4500) J,(DT(I),I=2
     1,NI11)
      IF(LFLO(2).EQ.1) WRITE(6,8010)
      I5=0
      SUMG2=0
      DO 549 IDBZ=1,3
      DO 549 N=1,250
549   SG2(IDBZ,N)=0
      DO 550 K=2,NK11
      DO 550 J=2,NJ11
      DO 550 I=2,NI11
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      IF(MHD(IJ).NE.1) GO TO 540
      G2IJ=G2(IJ)
      I5=I5+1
      DT(I5)=G2IJ
      I7(I5)=I
      J7(I5)=J
      K7(I5)=K
      SG2(1,I)=SG2(1,I)+G2IJ
      SG2(2,J)=SG2(2,J)+G2IJ
      SG2(3,K)=SG2(3,K)+G2IJ
      SUMG2=SUMG2+G2IJ
540   IF(I5.NE.5) GO TO 550
      I5=0
      IF(LFLO(2).EQ.1) WRITE(6,3560) (I7(L),J7(L),K7(L),DT(L),L=1,5)
550   CONTINUE
      IF((LFLO(2).EQ.1).AND.(I5.GE.1))
     1WRITE(6,3560) (I7(L),J7(L),K7(L),DT(L),L=1,I5)
      IF(LFLO(3).EQ.1) WRITE(6,9010)
      I5=0
      SUMVV=0
      DO 649 IDBZ=1,3
      DO 649 N=1,250
649   SVV(IDBZ,N)=0
      DO 650 K=2,NK11
      DO 650 J=2,NJ11
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      DO 650 I=2,NI11
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      X=XX(IJ)-XXE(IJ)
      VVIJ=X*ALN(IJ)
      IF(.NOT.((IEVP.EQ.1).AND.(VVIJ.GT.0))) GO TO 641
      I5=I5+1
      DT(I5)=VVIJ
      I7(I5)=I
      J7(I5)=J
      K7(I5)=K
      SVV(1,I)=SVV(1,I)+VVIJ
      SVV(2,J)=SVV(2,J)+VVIJ
      SVV(3,K)=SVV(3,K)+VVIJ
      SUMVV=SUMVV+VVIJ
641   IF(I5.NE.5) GO TO 650
      I5=0
      IF(LFLO(3).EQ.1) WRITE(6,3560) (I7(L),J7(L),K7(L),DT(L),L=1,5)
650   CONTINUE
      IF((LFLO(3).EQ.1).AND.(I5.GE.1))
     1WRITE(6,3560) (I7(L),J7(L),K7(L),DT(L),L=1,I5)
      WRITE(6,8011) SUMYQ,SUMG2,SUMVV
      IF(LFLO(4).EQ.0) GO TO 530
      WRITE(6,7001)
      IDBZ1=LFLO(4)
      IDBZ3=IDBZ1
      IF(IDBZ1.GE.4) IDBZ1=1
      IF(IDBZ3.GE.4) IDBZ3=3
      DO 520 IDBZ=IDBZ1,IDBZ3
      N20=NI11
      IF(IDBZ.EQ.2) N20=NJ11
      IF(IDBZ.EQ.3) N20=NK11
      DO 519 N=2,N20
      NP1=N+1
519   WRITE(6,8012) IDBZ,N,SYQ(IDBZ,N),SQ2(IDBZ,N),SVV(IDBZ,N)
     1,SUNF(IDBZ,N),SUMF(IDBZ,NP1),SUMF(IDBZ,N),SUNF(IDBZ,NP1)
520   CONTINUE
530   CONTINUE
560   IF(I01.EQ.0) GO TO 590
      WRITE(6,5008)
      WRITE(6,6000)
C  DETERMINE HYDRAULIC HEAD FROM XX = H PRIME = (PRESSURE HEAD H) + Z
      DO 580 K=2,NK11
      IF(IPH(K).NE.1) GO TO 580
      WRITE(6,4002) K
      DO 580 J=2,NJ11
      IJMI=NI10*(J-2)+NIJ10*(K-2)
      DO 570 I=2,NI11
      IJ=IJMI+I
      XZ210=LZ2(IJ)*.1D0
      DTI=(1/(LRO(IJ)*1.0D-5+1))*(XX(IJ)-XZ210)+XZ210
      IF(MHD(IJ).EQ.2) DTI=0
570   DT(I)=DTI
      IF(IWRTXX.LE.1) WRITE(6,1001) J,(DT(I),I=2,NI11)
      IF(IWRTXX.GE.1) WRITE(6,1001) J,(XX(IJMI+I),I=2,NI11)
580   CONTINUE
590   CONTINUE
600   CONTINUE
C  IF IPDD=1, DETERMINE DRAWDOWNS FOR THIS PUMPING INTERVAL
      IF(IPDD.NE.1) GO TO 630
      WRITE(6,8004)
      WRITE(6,6000)
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      DO 620 K=2,NK11                                                   MAN06710
      IF(IPH(K).NE.1) GO TO 620                                         MAN06720
      WRITE(6,4002) K                                                   MAN06730
      DO 620 J=2,NJ11                                                   MAN06740
      IJMI=NI10*(J-2)+NIJ10*(K-2)                                       MAN06750
      DO 610 I=2,NI11                                                   MAN06760
      IJ=IJMI+I                                                         MAN06770
      DT(I)=(XXSTR(IJ)-XX(IJ))/(LRO(IJ)*1.D-5+1)                        MAN06780
610   XXSTR(IJ)=XX(IJ)                                                  MAN06790
      WRITE(6,1001) J,(DT(I),I=2,NI11)                                  MAN06800
620   CONTINUE                                                          MAN06810
630   CONTINUE                                                          MAN06820
640   CONTINUE                                                          MAN06830
1001  FORMAT(I12,15F8 1/(12X,15F8.1))                                   MAN06840
1003  FORMAT(3I10,6D18.4)                                               MAN06850
1004  FORMAT(12X,15F8.1)                                                MAN06860
2000  FORMAT(8G10.0)                                                    MAN06870
2003  FORMAT(20I4)                                                      MAN06880
2007  FORMAT(4(3I3,D11.3))                                              MAN06890
2020  FORMAT(8I10)                                                      MAN06900
3004  FORMAT(I12,20I6/(12X,20I6))                                       MAN06910
3007  FORMAT(4(I12,2I4,D11.3))                                          MAN06920
3010  FORMAT(' ',12F10.1)                                               MAN06930
3555  FORMAT(8D15.7)                                                    MAN06940
3560  FORMAT(' ',5(3I4,D12.3))                                          MAN06950
4002  FORMAT(I6,I12)                                                    MAN06960
4500  FORMAT(I12,10D12.3/(12X,10D12.3))                                 MAN06970
4501  FORMAT(I12,9D12.3)                                                MAN06980
4997  FORMAT('1',44X,'LENGTH IN FEET OF WATER COLUMN IN WELL BORE')     MAN06990
4998  FORMAT('1',64X,'MOLALITY')                                        MAN07000
4999  FORMAT('1',53X,'TEMPERATURE DEGREES CENTIGRADE')                  MAN07010
5000  FORMAT('1',52X,'FIXED HYDRAULIC HEAD ')                           MAN07020
5001  FORMAT('1',49X,'X AND Y DIMENSIONS OF GRID ELEMENTS')             MAN07030
5002  FORMAT('1',41X,'(DENSITY OF WATER RHO, IN GRAMS PER CUBIC CENTIMETMAN07040
     1ER)-1.0 ')                                                        MAN07050
5003  FORMAT('1',59X,'BASE ELEVATION')                                  MAN07060
5004  FORMAT('1',52X,'Z DIMENSION OF GRID ELEMENTS')                    MAN07070
5005  FORMAT('1',54X,'HYDRAULIC CONDUCTIVITY')                          MAN07080
5052  FORMAT('1',56X,'INITIAL HYDRAULIC HEAD')                          MAN07090
5053  FORMAT('0',53X,'RECHARGE RATE YQ  (L*L*L/T)')                     MAN07100
5054  FORMAT('1',57X,'SPECIFIC STORAGE')                                MAN07110
5055  FORMAT('1',53X,'RECHARGE RATES Q2    (L*L*L/T)')                  MAN07120
5056  FORMAT('1',51X,'SIP CONVERGENCE PARAMETERS CHOSEN'//              MAN07130
     18X,'L9',5X,'ITMAX',4X,'LENGTH',14X,'HMAX',14X,'XYFC',             MAN07140
     215X,'ERR',14X,'WMAX',14X,'XX10')                                  MAN07150
5057  FORMAT('1',51X,'SOR CONVERGENCE PARAMETERS CHOSEN'//              MAN07160
     15X,'NSKP1',5X,'NSKP2',5X,'ITMAX',13X,'RELX1',13X,'RELX2',         MAN07170
     214X,'COEF',15X,'ERR',14X,'XX10')                                  MAN07180
5058  FORMAT('1',51X,'PCG(',I1,') CONVERGENCE PARAMETERS CHOSEN'//      MAN07190
     17X,'ITMAX',9X,'ERR',8X,'XX10')                                    MAN07200
5060  FORMAT('1',50X,'Z COMPONENT OF HYDRAULIC CONDUCTIVITY')           MAN07210
5006  FORMAT('0',58X,'SIP COEFFICIENTS')                                MAN07220
5007  FORMAT('0',56X,'WATCHING CONVERGENCE'//25X,'I,J,K, IS THE LOCATIONMAN07230
     1 AT WHICH THE MAXIMUM CHANGE IN XX OCCURED.'/25X,'MAXIMUM RESIDUALMAN07240
     2 ERROR  = THE MAXIMUM OVER ALL THE GRID ELEMENTS OF THE'/25X,'DIFFMAN07250
     3ERENCE BETWEEN THE WATER FLOW RATE INTO AND OUT OF EACH GRID ELEMEMAN07260
     4NT.')                                                             MAN07270
5074  FORMAT(7X,' I     J     K',9X,'XX(I,J,K)',9X,'XX(I,J,K)',13X,'ERROR'MAN07280
     1,3(12X,'K=',I4))                                                  MAN07290
5072  FORMAT('0',72X,3(6X,'XX AT I=',I4))                               MAN07300
5073  FORMAT(46X,'CHANGE IN',6X,'MAX RESIDUAL',3(12X,'J=',I4))          MAN07310
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5075  FORMAT('0','ITERATIONS USED =',I3,                                    MAN07320
     1'     MAXIMUM CHANGE IN XX BETWEEN LAST 2 ITERATIONS =',D11.3/         MAN07330
     2' MAXIMUM RESIDUAL ERROR FOR GRID ELEMENTS NOT HAVING FIXED HYDRAUMAN07340
     3LIC HEAD =',D11.3,'      TOTAL =',D11.3)                               MAN07350
5008  FORMAT('1',59X,'HYDRAULIC HEAD')                                       MAN07360
5010  FORMAT('1',37X,                                                        MAN07370
     1'LAYERS UNDERLAIN BY A CONFINING BED HAVE 1, OTHER LAYERS 0')          MAN07380
5101  FORMAT('1',46X,'WATER FLOW RATE IN NEGATIVE I DIRECTION')              MAN07390
5102  FORMAT('1',46X,'WATER FLOW RATE IN NEGATIVE J DIRECTION')              MAN07400
5103  FORMAT('1',46X,'WATER FLOW RATE OUT GRID ELEMENT BOTTOM')              MAN07410
6000  FORMAT('0','LAYER   ROW')                                              MAN07420
7000  FORMAT('1','TIME INTERVAL NUMBER',I3,'     DURATION =',D11.4,'         MAN07430
     1    TOTAL ELAPSED TIME =',D11.4)                                       MAN07440
7001  FORMAT('0',31X,'FLOW FROM',1X,'HEAD DEPENDANT',8X,'FLOW IN'            MAN07450
     1,8X,'FLOW IN',7X,'FLOW OUT',7X,'FLOW OUT'                              MAN07460
     2/18X,'RECHARGE',4X,'FIXED HEADS',6X,'DISCHARGE',9X,'BOTTOM'            MAN07470
     3,12X,'TOP',9X,'BOTTOM',12X,'TOP'//)                                    MAN07480
8000  FORMAT('1',25X,'THE ELEVATION OF THE HYDRAULIC HEAD (MEASURED RELAMAN07490
     1TIVE TO THE CENTER OF'/26X,'THE GRID ELEMENT) AT WHICH HEAD DEPENDMAN07500
     2ANT DISCHARGE BEGINS')                                                 MAN07510
8001  FORMAT('1',20X,'(RATE OF LOSS (L/T))/(((HYDRAULIC HEAD)-(ELEVATIONMAN07520
     1 AT WHICH DISCHARGE BEGINS)) (L))')                                    MAN07530
8002  FORMAT ('1',36X,'THE ELEVATION OF THE TOP OF THE UPPERMOST GRID ELMAN07540
     1EMENT LAYER')                                                          MAN07550
8003  FORMAT('1','PUMPING INTERVAL=',I5)                                     MAN07560
8004  FORMAT('1',45X,'DRAWDOWN DURING THIS PUMPING INTERVAL')                MAN07570
8010  FORMAT('1',30X,'WATER FLOW RATES OUT OF FIXED HEAD GRID ELEMENTS')MAN07580
8011  FORMAT('1',50X,'FLOW RATE BUDGETS'//5X                                 MAN07590
     1,'TOTAL RECHARGE TO MODELED REGION=',D13.4/5X                          MAN07600
     2,'TOTAL FLOW FROM FIXED HEAD GRID ELEMENTS INTO MODELED REGION='       MAN07610
     3,D13.4/5X,'TOTAL HEAD DEPENDANT DISCHARGE FROM MODELED REGION'         MAN07620
     4,D13.4)                                                                MAN07630
8012  FORMAT(' ',2I5,7D15.3)                                                 MAN07640
9010  FORMAT('1',50X,'HEAD DEPENDANT DISCHARGE RATES')                       MAN07650
9011  FORMAT('0',4X,'TOTAL YQ RECHARGE RATE TO MODELED REGION=',D13.4/       MAN07660
     15X,'TOTAL Q2 RECHARGE RATE TO MODELED REGION=',D13.4/                  MAN07670
     25X,'TOTAL RECHARGE RATE TO MODELED REGION=',D13.4)                     MAN07680
      STOP                                                                   MAN07690
      END                                                                    MAN07700
      SUBROUTINE RDWRT                                                       RDW00010
      IMPLICIT REAL*8 (A-H,O-Z)                                              RDW00020
      COMMON WS,HMAX,RELX1,RELX2,COEF,ERR,XX10,DELT,ER5,SRZ,SUMRZ            RDW00030
     1,XX,DT,VV,E2,F2,G2,YQ,NIJ10,NI11,NJ11,NK11,NNN,NSKP1                   RDW00040
     2,NSKP2,ITMAX,ICNT,IEVP,IWR1,NW1,NW2,NW3,N320,NUM4                      RDW00050
     3,L9,LENGTH,NK1115,IT01,IT15,ICRO,DDK,BBK                               RDW00060
     4,NT,DD,BB,ZZ,XXE,XXS,ALN,SV                                            RDW00070
     5,NI10,NJ10,NK10,NI12,NJ12,NK12,LB,MHD                                  RDW00080
      REAL*4 DD(377),BB(377),ZZ(377),XXE(377),XXS(377),ALN(377),             RDW00090
     1SV(377),YQ(377),DDK(50),BBK(50),NT(502)                                RDW00100
      DIMENSION XX(377),DT(377),VV(377),E2(377),F2(377)                      RDW00110
     1,WS(10),MHD(377),G2(377),LB(502)                                       RDW00120
     2,IF1(10),IF2(10),NNT(250)                                              RDW00130
      READ(5,1000) II,(IF1(I1),I1=1,9),(IF2(I2),I2=1,10)                     RDW00140
      WRITE(6,6000)                                                          RDW00150
      DO 161 K=2,NK1115                                                      RDW00160
      READ(5,2000) FCNTK,IVAR,IPRN,DDK(K),BBK(K)                             RDW00170
      IF(IPRN.EQ.1) GO TO 158                                                RDW00180
      IF(IT15.EQ.1) WRITE(6,1002) K,FCNTK                                    RDW00190
      IF(IT15.EQ.2) WRITE(6,1002) K,FCNTK,DDK(K),BBK(K)                      RDW00200
158   DO 161 J=2,NJ11                                                        RDW00210
      IJMI=NI10*(J-2)+NIJ10*(K-2)                                            RDW00220
```

```
      IF(IVAR.EQ.1) READ(5,IF1) (NT(IJMI+I),I=2,NI11)
      DO 159 I=2,NI11
      IJ=IJMI+I
      X=1
      IF(IVAR.EQ.1) X=NT(IJ)
159   NT(IJ)=X
      IF(ICRO.EQ.0) GO TO 1605
      DO 13 I=2,NI11
      IJ=IJMI+I
      LBIJ=LB(IJ)
      IF(LBIJ.NE.-30000) NT(IJ)=LBIJ*1.D-5/FCNTK
13    CONTINUE
1605  IF(.NOT.((IPRN.EQ.0).AND.(IVAR.EQ.1))) GO TO 41
      DO 40 I=2,NI11
40    NNT(I)=NT(IJMI+I)
      IF(II.EQ.0) WRITE(6,IF2) J,(NNT(I),I=2,NI11)
      IF(II.EQ.1) WRITE(6,IF2) J,(NT(IJMI+I),I=2,NI11)
41    CONTINUE
      DO 42 I=2,NI11
      IJ=IJMI+I
42    NT(IJ)=NT(IJ)*FCNTK
161   CONTINUE
1000  FORMAT(I4,19A4)
1002  FORMAT(I6,6D18.4)
2000  FORMAT(8G10.0)
4000  FORMAT(I6,I10)
6000  FORMAT('0','LAYER   ROW')
      RETURN
      END
      SUBROUTINE SOR
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON WS,HMAX,RELX1,RELX2,COEF,ERR,XX10,DELT,ER5,SRZ,SUMRZ
     1,XX,DT,VV,E2,F2,G2,YQ,NIJ10,NI11,NJ11,NK11,NNN,NSKP1
     2,NSKP2,ITMAX,ICNT,IEVP,IWR1,NW1,NW2,NW3,N320,NUM4
     3,L9,LENGTH,NK1115,IT01,IT15,ICRO,DDK,BBK
     4,NT,DD,BB,ZZ,XXE,XXS,ALN,SV
     5,NI10,NJ10,NK10,NI12,NJ12,NK12,LB,MHD
      REAL*4 DD(377),BB(377),ZZ(377),XXE(377),XXS(377),ALN(377),
     1SV(377),YQ(377),DDK(50),BBK(50),NT(502)
      DIMENSION XX(377),DT(377),VV(377),E2(377),F2(377)
     1,WS(10),MHD(377),G2(377),LB(502)
      ICNT=0
      ER5S=100
      DO 200 ITER=1,100
      ICNT=ICNT+1
      IF(ICNT.EQ.ITMAX) GO TO 202
      RELX3=1
      IF(ICNT.GE.6) RELX3=RELX2
      IF(ICNT.GE.21) RELX3=RELX2*(1-(ICNT-20)*COEF)
      IF(RELX3.LT..2) RELX3=.2
      DO 101 I3=1,3
      IF((I3.EQ.NSKP1).OR.(I3.EQ.NSKP2)) GO TO 101
      GO TO (1,2,3),I3
1     MI11=NI11
      MJ11=NJ11
      MK11=NK11
      GO TO 4
2     MI11=NJ11
      MJ11=NK11
      MK11=NI11
      GO TO 4
```

```
3      MI11=NK11
       MJ11=NI11
       MK11=NJ11
4      CONTINUE
       SUMRZ=0
       SRZ=0
       DO 100 K1=2,MK11
       DO 100 J1=2,MJ11
       GO TO (8,9,10),I3
8      J=J1
       K=K1
       GO TO 11
9      K=J1
       I=K1
       GO TO 11
10     I=J1
       J=K1
11     CONTINUE
       MI12=MI11+1
       DO 12 IJ=1,MI12
       DT(IJ)=0
12     VV(IJ)=0
       DO 90 I1=2,MI11
       IF(I3.EQ.1) I=I1
       IF(I3.EQ.2) J=I1
       IF(I3.EQ.3) K=I1
       IJ=I+NI10*(J-2)+NIJ10*(K-2)
       IF(MHD(IJ).GE.1) GO TO 90
       IJM1K=IJ-NI10
       IJP1K=IJ+NI10
       IJKM1=IJ-NIJ10
       IJKP1=IJ+NIJ10
       IF(IJM1K.LT.1) IJM1K=1
       IF(IJP1K.GT.NNN) IJP1K=NNN
       IF(IJKM1.LT.1) IJKM1=1
       IF(IJKP1.GT.NNN) IJKP1=NNN
       XXIJ=XX(IJ)
       D=DD(IJ)
       B=BB(IJ)
       Z=ZZ(IJ)
       F=DD(IJ+1)
       H=BB(IJP1K)
       S=ZZ(IJKP1)
       SVDT=SV(IJ)/DELT
       E=-(D+F+B+H+Z+S)+SVDT
       LEV=0
       IF((IEVP.EQ.1).AND.(XXIJ.GT.XXE(IJ))) LEV=1
       IF(LEV.NE.1) GO TO 44
       ALNI=ALN(IJ)
       E=E+ALNI
44     CONTINUE
       DF=D*XX(IJ-1)+F*XX(IJ+1)
       BH=B*XX(IJM1K)+H*XX(IJP1K)
       ZS=Z*XX(IJKM1)+S*XX(IJKP1)
       AFLW=DF+BH+ZS
       GO TO (18,19,20),I3
18     DI=D
       FI=F
       QP=BH+ZS
       GO TO 21
19     DI=B
```

```
      FI=H
      QP=DF+ZS
      GO TO 21
20    DI=Z
      FI=S
      QP=DF+BH
21    CONTINUE
      AI=DI
      BI=E-AI*DT(I1-1)
      DT(I1)=FI/BI
      YQIJ=YQ(IJ)+SVDT*XXS(IJ)
      IF(LEV.EQ.1) YQIJ=YQIJ+ALNI*XXE(IJ)
      VV(I1)=(YQIJ-QP-AI*VV(I1-1))/BI
      RZ=YQIJ-AFLW-XXIJ*E
      SUMRZ=SUMRZ+RZ
      DSR=DABS(RZ)
      IF(DSR.GT.SRZ) SRZ=DSR
90    CONTINUE
      DO 95 I1R=2,MI11
      I1=MI11+2-I1R
      IF(I3.EQ.1) I=I1
      IF(I3.EQ.2) J=I1
      IF(I3.EQ.3) K=I1
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      IF(MHD(IJ).GE.1) GO TO 95
      F2(IJ)=XX(IJ)
      IP=IJ+1
      IF(I3.EQ.2) IP=IJ+NI10
      IF(I3.EQ.3) IP=IJ+NIJ10
      IF(IP.GT.NNN) IP=NNN
      X=VV(I1)-DT(I1)*XX(IP)
      XX(IJ)=X
95    CONTINUE
      DO 96 I1=2,MI11
      IF(I3.EQ.1) I=I1
      IF(I3.EQ.2) J=I1
      IF(I3.EQ.3) K=I1
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      IF(MHD(IJ).GE.1) GO TO 96
      XX(IJ)=RELX1*XX(IJ)+(1-RELX1)*F2(IJ)
96    CONTINUE
100   CONTINUE
101   CONTINUE
      ER5=0
      DO 150 K=2,NK11
      DO 150 J=2,NJ11
      DO 150 I=2,NI11
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      E2IJ=E2(IJ)
      X=RELX3*XX(IJ)+(1-RELX3)*E2IJ
      CHG=DABS(X-E2IJ)
      IF(CHG.LT.ER5) GO TO 111
      IMX=I
      JMX=J
      KMX=K
      XXPMX=X
      ER5=CHG
111   CONTINUE
      XX(IJ)=X
150   E2(IJ)=X
      IF(IWR1.EQ.1) WRITE(6,1000) ICNT,IMX,JMX,KMX,XXPMX,ER5,SRZ,
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     1XX(NW1),XX(NW2),XX(NW3)                                           SOR01550
      IF((ER5+ER5S).LT.ERR) GO TO 202                                   SOR01560
      IF(SRZ.LT.XX10) GO TO 202                                         SOR01570
      ER5S=ER5                                                          SOR01580
200   CONTINUE                                                          SOR01590
202   CONTINUE                                                          SOR01600
1000  FORMAT(' ',I3,3I5,6D18.7)                                         SOR01610
      RETURN                                                            SOR01620
      END                                                               SOR01630
      SUBROUTINE PCG                                                    PCG00010
      IMPLICIT REAL*8 (A-H,O-Z)                                         PCG00020
      COMMON WS,HMAX,RELX1,RELX2,COEF,ERR,XX10,DELT,ER5,SRZ,SUMRZ       PCG00030
     1,XX,DT,VV,E2,F2,G2,YQ,NIJ10,NI11,NJ11,NK11,NNN,NSKP1              PCG00040
     2,NSKP2,ITMAX,ICNT,IEVP,IWR1,NW1,NW2,NW3,N320,NUM4                 PCG00050
     3,L9,LENGTH,NK1115,IT01,IT15,ICRO,DDK,BBK                          PCG00060
     4,NT,DD,BB,ZZ,XXE,XXS,ALN,SV                                       PCG00070
     5,NI10,NJ10,NK10,NI12,NJ12,NK12,LB,MHD                             PCG00080
      REAL*4 DD(377),BB(377),ZZ(377),XXE(377),XXS(377),ALN(377),        PCG00090
     1SV(377),YQ(377),DDK(50),BBK(50),NT(502)                           PCG00100
     2,D2S(377),E22(377)                                                PCG00110
      DIMENSION XX(377),DT(377),VV(377),E2(377),F2(377)                 PCG00120
     1,WS(10),MHD(377),G2(377),LB(502)                                  PCG00130
C  IF YOU WANT TO SAVE STORAGE, REMOVE D2S AND E22 FROM THE DIMENSION   PCG00140
C  STATEMENT AND CARDS "76 CONTINUE" THROUGH "56 CONTINUE", AND "86     PCG00150
C  CONTINUE" THROUGH "662 CONTINUE". THIS REMOVES PCG METHODS SIPCG     PCG00160
C  AND SFPCG.                                                           PCG00170
      IG31=0                                                            PCG00180
      IF(NUM4.EQ.3) IG31=1                                              PCG00190
      DO 1 IJ=1,NNN                                                     PCG00200
      D2S(IJ)=0                                                         PCG00210
      E22(IJ)=0                                                         PCG00220
      DT(IJ)=0                                                          PCG00230
      E2(IJ)=0                                                          PCG00240
      F2(IJ)=0                                                          PCG00250
      G2(IJ)=0                                                          PCG00260
1     VV(IJ)=0                                                          PCG00270
      DO 16 IJ=2,N320                                                   PCG00280
      E2(IJ)=XX(IJ)                                                     PCG00290
      IF(MHD(IJ).GE.1) GO TO 16                                         PCG00300
      DELY=(SV(IJ)/DELT)*XXS(IJ)                                        PCG00310
      IF((IEVP.EQ.1).AND.(XX(IJ).GT.XXE(IJ))) DELY=DELY+ALN(IJ)*XXE(IJ) PCG00320
      VV(IJ)=YQ(IJ)+DELY                                                PCG00330
16    CONTINUE                                                          PCG00340
      DO 2 IJ=2,N320                                                    PCG00350
      DELE=0                                                            PCG00360
      IF(MHD(IJ).GE.1) GO TO 19                                         PCG00370
      DELE=SV(IJ)/DELT                                                  PCG00380
      IF((IEVP.EQ.1).AND.(XX(IJ).GT.XXE(IJ))) DELE=DELE+ALN(IJ)         PCG00390
19    XXS(IJ)=DELE                                                      PCG00400
2     CONTINUE                                                          PCG00410
      GO TO (71,71,71,80,74,74,76,76),NUM4                              PCG00420
71    CONTINUE                                                          PCG00430
      DO 51 IJ=2,N320                                                   PCG00440
      IF(.NOT.(MHD(IJ).GE.1)) GO TO 777                                 PCG00450
      Y1=0                                                              PCG00460
      Z1=0                                                              PCG00470
      GO TO 51                                                          PCG00480
777   CONTINUE                                                          PCG00490
      IJP1K=IJ+NI10                                                     PCG00500
      IJM1K=IJ-NI10                                                     PCG00510
      IJKP1=IJ+NIJ10                                                    PCG00520
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```
      IJKM1=IJ-NIJ10
      IF(IJP1K GT NNN) IJP1K=NNN
      IF(IJKP1.GT.NNN) IJKP1=NNN
      IF(IJM1K.LT 1) IJM1K=1
      IF(IJKM1.LT 1) IJKM1=1
      X=DD(IJ)
      Y=BB(IJ)
      Z=ZZ(IJ)
      Y1Z1=0
      XP=X
      F2X=F2(IJ-1)
      F2Y=F2(IJM1K)
      F2Z=F2(IJKM1)
      IF(NUM4.EQ.1) GO TO 20
      JP1=IJM1K+1
      KP1=IJKM1+1
      IJMMN=IJ-(NIJ10-NI10)
      IF(IJMMN.LT.1) IJMMN=1
      WY1=0
      WZ1=0
      IF(F2Y.NE.0.0) WY1=Y/F2Y
      IF(F2Z.NE.0.0) WZ1=Z/F2Z
      XP=X-(WY1*Y1+WZ1*Z1)
      G2(IJ)=XP
      Y1=-WY1*G2(JP1)
      Z1=-WZ1*G2(KP1)
      ZB=-WZ1*BB(IJMMN)*IG31
      F21=F2(JP1)
      F22=F2(KP1)
      F23=F2(IJMMN)
      P1=0
      P2=0
      P3=0
      IF(F21.NE.0.0) P1=Y1*Y1/F21
      IF(F22.NE.0.0) P2=Z1*Z1/F22
      IF(F23.NE.0.0) P3=ZB*ZB/F23
      Y1Z1=P1+P2+P3
20    CONTINUE
      EEIJ=-(X+Y+Z+DD(IJ+1)+BB(IJP1K)+ZZ(IJKP1))+XXS(IJ)
      XF=0
      YF=0
      ZF=0
      IF(F2X.NE.0.0) XF=XP*XP/F2X
      IF(F2Y.NE.0.0) YF=Y*Y/F2Y
      IF(F2Z.NE.0.0) ZF=Z*Z/F2Z
      F2(IJ)=EEIJ-(XF+YF+ZF+Y1Z1)
51    CONTINUE
      GO TO 80
74    CONTINUE
      DO 54 IJ=2,N320
      IF(MHD(IJ).GE.1) GO TO 54
      IJP1K=IJ+NI10
      IJKP1=IJ+NIJ10
      IF(IJP1K.GT.NNN) IJP1K=NNN
      IF(IJKP1.GT.NNN) IJKP1=NNN
      EEIJ= (-(DD(IJ)+BB(IJ)+ZZ(IJ)+DD(IJ+1)
     1+BB(IJP1K)+ZZ(IJKP1))+XXS(IJ))
      IF(NUM4.EQ.5) GO TO 539
      X=DD(IJ)
      F2X=F2(IJ-1)
      XF=0
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      IF(F2X.NE.0.0) XF=X*X/F2X
      F2(IJ)=EEIJ-XF
      GO TO 54
539   F2(IJ)=EEIJ
54    CONTINUE
      GO TO 80
76    CONTINUE
      W=.95-(NUM4-7)*.55
      DO 56 IJ=2,N320
      IF(MHD(IJ).GE.1) GO TO 56
      IP1JK=IJ+1
      IJP1K=IJ+NI10
      IJKP1=IJ+NIJ10
      IM1JK=IJ-1
      IJM1K=IJ-NI10
      IJKM1=IJ-NIJ10
      IF(IJP1K.GT.NNN) IJP1K=NNN
      IF(IJKP1.GT.NNN) IJKP1=NNN
      IF(IJM1K.LT.1) IJM1K=1
      IF(IJKM1.LT.1) IJKM1=1
      Z=ZZ(IJ)
      B=BB(IJ)
      D=DD(IJ)
      F=DD(IP1JK)
      H=BB(IJP1K)
      S=ZZ(IJKP1)
      E=-(Z+B+D+F+H+S)+XXS(IJ)
      E2I=E22(IM1JK)
      E2J=E22(IJM1K)
      E2K=E22(IJKM1)
      F2I=F2(IM1JK)
      F2J=F2(IJM1K)
      F2K=F2(IJKM1)
      G2I=G2(IM1JK)
      G2J=G2(IJM1K)
      G2K=G2(IJKM1)
      IF(NUM4.EQ.8) GO TO 761
      A2=Z/(1+W*(E2K+F2K))
      B2=B/(1+W*(G2J+E2J))
      C2=D/(1+W*(G2I+F2I))
      GO TO 762
761   A2=G2K*D2S(IJKM1)
      B2=F2J*D2S(IJM1K)
      C2=E2I*D2S(IM1JK)
762   CONTINUE
      AC=W*(A2*E2K+B2*E2J)
      TG=W*(A2*F2K+C2*F2I)
      WU=W*(C2*G2I+B2*G2J)
      D2=E+(AC+TG+WU)-C2*E2I-B2*F2J-A2*G2K
      D2S(IJ)=D2
      D2=1/D2
      E22(IJ)=D2*(F-AC)
      F2(IJ)=D2*(H-TG)
      G2(IJ)=D2*(S-WU)
56    CONTINUE
80    CONTINUE
      SPR=1.D-50
      ICNT=0
      ER5S=100
      L78=2.5*ER5S
      DO 100 ITER=1,L78
```

```
      ICNT=ICNT+1
      IF(ICNT.EQ.ITMAX) GO TO 202
      SPP=0
      DO 3 IJ=2,N320
      IF(MHD(IJ).GE.1) GO TO 3
      IP1JK=IJ+1
      IJP1K=IJ+NI10
      IJM1K=IJ-NI10
      IJKP1=IJ+NIJ10
      IJKM1=IJ-NIJ10
      IF(IJP1K.GT.NNN) IJP1K=NNN
      IF(IJKP1.GT.NNN) IJKP1=NNN
      IF(IJM1K.LT.1) IJM1K=1
      IF(IJKM1.LT.1) IJKM1=1
      DDIJ=DD(IJ)
      DDIP1=DD(IP1JK)
      BBIJ=BB(IJ)
      BBIJP=BB(IJP1K)
      ZZIJ=ZZ(IJ)
      ZZIJK=ZZ(IJKP1)
      E2IJ=E2(IJ)
      DTIJ=(-(DDIJ+DDIP1+BBIJ+BBIJP+ZZIJ+ZZIJK)+XXS(IJ))*E2IJ
     1+DDIJ*E2( IJ-1)+DDIP1*E2(IP1JK)
     2+BBIJ*E2(IJM1K)+BBIJP*E2(IJP1K)
     3+ZZIJ*E2(IJKM1)+ZZIJK*E2(IJKP1)
      DT(IJ)=DTIJ
      SPP=SPP+E2IJ*DTIJ
3     CONTINUE
      A1=SPR/(SPP+1.D-70)
      A2=A1
      IF(ITER.GT.1) GO TO 35
      A1=0
      A2=1.
35    SRZ=0
      SUMRZ=0
      ER5=0
      DO 4 K=2,NK11
      DO 4 J=2,NJ11
      DO 4 I=2,NI11
      IJ=I+NI10*(J-2)+NIJ10*(K-2)
      IF(MHD(IJ).GE.1) GO TO 4
      DX=A1*E2(IJ)
      X=XX(IJ)+DX
      XX(IJ)=X
      ADX=DABS(DX)
      IF(ADX.LT.ER5) GO TO 111
      IMX=I
      JMX=J
      KMX=K
      XXPMX=X
      ER5=ADX
111   CONTINUE
      X=VV(IJ)-A2*DT(IJ)
      SUMRZ=SUMRZ+X
      DSR=DABS(X)
      IF(DSR.GT.SRZ) SRZ=DSR
      VV(IJ)=X
4     CONTINUE
      IF(IWR1.EQ.1) WRITE(6,1000) ICNT,IMX,JMX,KMX,XXPMX,ER5,SRZ,
     1XX(NW1),XX(NW2),XX(NW3)
      IF((ER5+ER5S).LT.ERR) GO TO 202
```

```
      IF(SRZ.LT.XX10) GO TO 202                                         PCG02360
      ER5S=ER5                                                          PCG02370
      SPRS=SPR                                                          PCG02380
      SPR=0                                                             PCG02390
      GO TO (81,81,81,83,83,85,86,86),NUM4                              PCG02400
81    CONTINUE                                                          PCG02410
      DO 10 IJ=2,N320                                                   PCG02420
      IF(MHD(IJ).GE.1) GO TO 10                                         PCG02430
      IJM1K=IJ-NI10                                                     PCG02440
      IJKM1=IJ-NIJ10                                                    PCG02450
      IF(IJM1K.LT.1) IJM1K=1                                            PCG02460
      IF(IJKM1.LT.1) IJKM1=1                                            PCG02470
      B6=0                                                              PCG02480
      Z6=0                                                              PCG02490
      DDIJ=DD(IJ)                                                       PCG02500
      IF(NUM4.EQ.1) GO TO 21                                            PCG02510
      DDIJ=G2(IJ)                                                       PCG02520
      JP1=IJM1K+1                                                       PCG02530
      KP1=IJKM1+1                                                       PCG02540
      IJMMN=IJ-(NIJ10-NI10)                                             PCG02550
      IF(IJMMN.LT.1) IJMMN=1                                            PCG02560
      B6=DT(JP1)*G2(JP1)/(F2(IJM1K)+1.D-40)                             PCG02570
      Z6=(DT(KP1)*G2(KP1)+DT(IJMMN)*BB(IJMMN)*IG31)/(F2(IJKM1)+1.D-40)  PCG02580
21    CONTINUE                                                          PCG02590
      DT(IJ)=(VV(IJ)-DDIJ*DT(IJ-1)-BB(IJ)*(DT(IJM1K)-B6)                PCG02600
     1-ZZ(IJ)*(DT(IJKM1)-Z6))/F2(IJ)                                    PCG02610
10    CONTINUE                                                          PCG02620
      DO 11 IJB=2,N320                                                  PCG02630
      IJ=N320+2-IJB                                                     PCG02640
      IF(MHD(IJ).GE.1) GO TO 11                                         PCG02650
      IP1JK=IJ+1                                                        PCG02660
      IJP1K=IJ+NI10                                                     PCG02670
      IJKP1=IJ+NIJ10                                                    PCG02680
      JM1=IJP1K-1                                                       PCG02690
      KM1=IJKP1-1                                                       PCG02700
      IF(IJP1K.GT.NNN) IJP1K=NNN                                        PCG02710
      IF(IJKP1.GT.NNN) IJKP1=NNN                                        PCG02720
      XAD=0                                                             PCG02730
      DDD=DD(IP1JK)                                                     PCG02740
      IF(NUM4.EQ.1) GO TO 22                                            PCG02750
      IF(JM1.GT.NNN) JM1=NNN                                            PCG02760
      IF(KM1.GT.NNN) KM1=NNN                                            PCG02770
      IJM1K=IJ-NI10                                                     PCG02780
      IJPMN=IJ+(NIJ10-NI10)                                             PCG02790
      IF(IJM1K.LT.1) IJM1K=1                                            PCG02800
      IF(IJPMN.GT.NNN) IJPMN=NNN                                        PCG02810
      DDD=G2(IP1JK)                                                     PCG02820
      X=G2(IJ)/(F2(IJ-1)+1.D-40)                                        PCG02830
      XAD=-(BB(JM1)*DT(JM1)+ZZ(KM1)*DT(KM1))*X                          PCG02840
     1-ZZ(IJPMN)*BB(IJ)*DT(IJPMN)*IG31/(F2(IJM1K)+1.D-40)               PCG02850
22    CONTINUE                                                          PCG02860
      DTIJ=DT(IJ)-(DDD*DT(IP1JK)+BB(IJP1K)*DT(IJP1K)+ZZ(IJKP1)          PCG02870
     1*DT(IJKP1)+XAD)/F2(IJ)                                            PCG02880
      DT(IJ)=DTIJ                                                       PCG02890
      SPR=SPR+DTIJ*VV(IJ)                                               PCG02900
11    CONTINUE                                                          PCG02910
      GO TO 90                                                          PCG02920
83    CONTINUE                                                          PCG02930
      DO 63 IJ=2,N320                                                   PCG02940
      IF(MHD(IJ).GE.1) GO TO 63                                         PCG02950
      F2IJ=1                                                            PCG02960
```

```
      IF(NUM4.EQ.5) F2IJ=F2(IJ)
      VVIJ=VV(IJ)
      DTIJ=VVIJ/F2IJ
      DT(IJ)=DTIJ
      SPR=SPR+DTIJ*VVIJ
63    CONTINUE
      GO TO 90
85    CONTINUE
      DO 651 IJ=2,N320
      IF(MHD(IJ).GE.1) GO TO 651
      DT(IJ)=(VV(IJ)-DD(IJ)*DT(IJ-1))/F2(IJ)
651   CONTINUE
      DO 652 IJB=2,N320
      IJ=N320+2-IJB
      IF(MHD(IJ).GE.1) GO TO 652
      IP1JK=IJ+1
      DTIJ=DT(IJ)-DD(IP1JK)*DT(IP1JK)/F2(IJ)
      DT(IJ)=DTIJ
      SPR=SPR+DTIJ*VV(IJ)
652   CONTINUE
      GO TO 90
86    CONTINUE
      DO 661 IJ=2,N320
      IF(MHD(IJ).GE.1) GO TO 661
      IM1JK=IJ-1
      IJM1K=IJ-NI10
      IJKM1=IJ-NIJ10
      IF(IJM1K.LT.1) IJM1K=1
      IF(IJKM1.LT.1) IJKM1=1
      C2S=D2S(IM1JK)*E22(IM1JK)
      B2S=D2S(IJM1K)*F2(IJM1K)
      A2S=D2S(IJKM1)*G2(IJKM1)
      DT(IJ)=(VV(IJ)-C2S*DT(IJ-1)-B2S*DT(IJM1K)
     1-A2S*DT(IJKM1))/D2S(IJ)
661   CONTINUE
      DO 662 IJB=2,N320
      IJ=N320+2-IJB
      IF(MHD(IJ).GE.1) GO TO 662
      IP1JK=IJ+1
      IJP1K=IJ+NI10
      IJKP1=IJ+NIJ10
      IF(IJP1K.GT.NNN) IJP1K=NNN
      IF(IJKP1.GT.NNN) IJKP1=NNN
      DTIJ=DT(IJ)-(E22(IJ)*DT(IP1JK)+F2(IJ)*DT(IJP1K)
     1+G2(IJ)*DT(IJKP1))
      DT(IJ)=DTIJ
      SPR=SPR+DTIJ*VV(IJ)
662   CONTINUE
90    CONTINUE
      B6=SPR/SPRS
      IF(ITER.EQ.1) B6=0
      DO 5 IJ=2,N320
      E2IJ=DT(IJ)+B6*E2(IJ)
      IF(MHD(IJ).GE.1) E2IJ=0
      E2(IJ)=E2IJ
5     CONTINUE
100   CONTINUE
202   CONTINUE
1000  FORMAT(' ',I3,3I5,6D18.7)
      RETURN
      END
```

```
      SUBROUTINE SIP
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON WS,HMAX,RELX1,RELX2,COEF,ERR,XX10,DELT,ER5,SRZ,SUMRZ
     1,XX,DT,VV,E2,F2,G2,YQ,NIJ10,NI11,NJ11,NK11,NNN,NSKP1
     2,NSKP2,ITMAX,ICNT,IEVP,IWR1,NW1,NW2,NW3,N320,NUM4
     3,L9,LENGTH,NK1115,IT01,IT15,ICRO,DDK,BBK
     4,NT,DD,BB,ZZ,XXE,XXS,ALN,SV
     5,NI10,NJ10,NK10,NI12,NJ12,NK12,LB,MHD
      REAL*4 DD(377),BB(377),ZZ(377),XXE(377),XXS(377),ALN(377),
     1SV(377),YQ(377),DDK(50),BBK(50),NT(502)
      DIMENSION XX(377),DT(377),VV(377),E2(377),F2(377)
     1,WS(10),MHD(377),G2(377),LB(502)
      DO 889 IJ=1,NNN
      E2(IJ)=0
      DO 889 IJ=1,NNN
      E2(IJ)=0
      F2(IJ)=0
      G2(IJ)=0
      VV(IJ)=0
889   DT(IJ)=0
      ICNT=0
      ICT=0
      ER5S=100
      DO 501 ITERO=1,60
      DO 499 I33=1,2
      I3=I33
      I4=1
      IF(L9.EQ.2) I4=I3
      IF(L9.LT.3) GO TO 195
      I3=1
      I4=I33
195   CONTINUE
      ICT=ICT+1
      IF(ICT.EQ.(LENGTH+1)) ICT=1
      ICNT=ICNT+1
      IF(ICNT.EQ.ITMAX) GO TO 202
      W=WS(ICT)
      JJM1=2*I3-3
      JJP1=-JJM1
      KKM1=2*I4-3
      KKP1=-KKM1
C  ACCOMPLISH EQUATIONS (10) AND (14) BY WEINSTEIN [1969]
      SRZ=0
      SUMRZ=0
      DO 100 KB=2,NK11
      ISF1=0
      IF((KB.GE.3).AND.(KB.LE.NK10)) ISF1=1
      DO 100 JB=2,NJ11
      ISF2=0
      IF((JB.GE.3).AND.(JB.LE.NJ10)) ISF2=1
      J=JB
      K=KB
      IF(I3.EQ.2) J=NJ12+1-JB
      IF(I4.EQ.2) K=NK12+1-KB
      DO 50 I=2,NI11
      IJF=I+NI10*(J-2)
      IJ=IJF+NIJ10*(K-2)
      IF(MHD(IJ).GE.1) GO TO 50
      IM1JK=IJ-1
      IP1JK=IJ+1
      IJM1K=IJ+JJM1*NI10
```

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      IJP1K=IJ+JJP1*NI10                                                SIP00620
      IJP2K=IJ+NI10                                                     SIP00630
      IJKM1=IJ+KKM1*NIJ10                                               SIP00640
      IJKP1=IJ+KKP1*NIJ10                                               SIP00650
      IJKP2=IJ+NIJ10                                                    SIP00660
      IF(ISF1.EQ.1) GO TO 91                                            SIP00670
      IF(IJKM1.LT.1) IJKM1=1                                            SIP00680
      IF(IJKM1.GT.NNN) IJKM1=NNN                                        SIP00690
      IF(IJKP1.LT.1) IJKP1=1                                            SIP00700
      IF(IJKP1.GT.NNN) IJKP1=NNN                                        SIP00710
      IF(IJKP2.GT.NNN) IJKP2=NNN                                        SIP00720
      IF(ISF2.EQ.1) GO TO 91                                            SIP00730
      IF(IJM1K.LT.1) IJM1K=1                                            SIP00740
      IF(IJM1K.GT.NNN) IJM1K=NNN                                        SIP00750
      IF(IJP1K.LT.1) IJP1K=1                                            SIP00760
      IF(IJP1K.GT.NNN) IJP1K=NNN                                        SIP00770
      IF(IJP2K.GT.NNN) IJP2K=NNN                                        SIP00780
91    CONTINUE                                                          SIP00790
      XXIJ=XX(IJ)                                                       SIP00800
      Z=ZZ(IJ)                                                          SIP00810
      B=BB(IJ)                                                          SIP00820
      D=DD(IJ)                                                          SIP00830
      F=DD(IP1JK)                                                       SIP00840
      H=BB(IJP2K)                                                       SIP00850
      S=ZZ(IJKP2)                                                       SIP00860
      IF(I3.EQ.1) GO TO 42                                              SIP00870
      BS=B                                                              SIP00880
      B=H                                                               SIP00890
      H=BS                                                              SIP00900
42    CONTINUE                                                          SIP00910
      IF(I4.EQ.1) GO TO 43                                              SIP00920
      ZS=Z                                                              SIP00930
      Z=S                                                               SIP00940
      S=ZS                                                              SIP00950
43    CONTINUE                                                          SIP00960
      SVDT=SV(IJ)/DELT                                                  SIP00970
      E=-(Z+B+D+F+H+S)+SVDT                                             SIP00980
      LEV=0                                                             SIP00990
      IF((IEVP.EQ.1).AND.(XXIJ.GT.XXE(IJ))) LEV=1                       SIP01000
      IF(LEV.NE.1) GO TO 44                                             SIP01010
      ALNI=ALN(IJ)                                                      SIP01020
      E=E+ALNI                                                          SIP01030
44    CONTINUE                                                          SIP01040
      E2I=E2(IM1JK)                                                     SIP01050
      E2J=E2(IJM1K)                                                     SIP01060
      E2K=E2(IJKM1)                                                     SIP01070
      F2I=F2(IM1JK)                                                     SIP01080
      F2J=F2(IJM1K)                                                     SIP01090
      F2K=F2(IJKM1)                                                     SIP01100
      G2I=G2(IM1JK)                                                     SIP01110
      G2J=G2(IJM1K)                                                     SIP01120
      G2K=G2(IJKM1)                                                     SIP01130
      A2=Z/(1+W*(E2K+F2K))                                              SIP01140
      B2=B/(1+W*(G2J+E2J))                                              SIP01150
      C2=D/(1+W*(G2I+F2I))                                              SIP01160
      AC=W*(A2*E2K+B2*E2J)                                              SIP01170
      TG=W*(A2*F2K+C2*F2I)                                              SIP01180
      WU=W*(C2*G2I+B2*G2J)                                              SIP01190
      D2=E+(AC+TG+WU)-C2*E2I-B2*F2J-A2*G2K                              SIP01200
      D2=1/D2                                                           SIP01210
      E2(IJ)=D2*(F-AC)                                                  SIP01220
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      F2(IJ)=D2*(H-TG)                                                  SIP01230
      G2(IJ)=D2*(S-WU)                                                  SIP01240
      RZ=YG(IJ)-(XX(IM1JK)*D+XX(IP1JK)*F+XX(IJM1K)*B+XX(IJP1K)*H        SIP01250
     1+XX(IJKM1)*Z+XX(IJKP1)*S+XXIJ*E)+SVDT*XXS(IJ)                     SIP01260
      IF(LEV.EQ.1) RZ=RZ+ALNI*XXE(IJ)                                   SIP01270
      SUMRZ=SUMRZ+RZ                                                    SIP01280
      DSR=DABS(RZ)                                                      SIP01290
      IF(DSR.GT.SRZ) SRZ=DSR                                            SIP01300
      VV(IJ)=D2*(RZ-A2*VV(IJKM1)-B2*VV(IJM1K)-C2*VV(IM1JK))             SIP01310
50    CONTINUE                                                          SIP01320
100   CONTINUE                                                          SIP01330
C  EQUATIONS (10) AND (14) ARE NOW ACCOMPLISHED                         SIP01340
C  ACCOMPLISH EQUATION (15) BY WEINSTEIN [1969]                         SIP01350
      ER5=0                                                             SIP01360
      DO 102 KB=2,NK11                                                  SIP01370
      ISF1=0                                                            SIP01380
      IF((KB.GE.3).AND.(KB.LE.NK10)) ISF1=1                             SIP01390
      DO 102 JB=2,NJ11                                                  SIP01400
      ISF2=0                                                            SIP01410
      IF((JB.GE.3).AND.(JB.LE.NJ10)) ISF2=1                             SIP01420
      J=NJ12+1-JB                                                       SIP01430
      K=NK12+1-KB                                                       SIP01440
      IF(I3.EQ.2) J=JB                                                  SIP01450
      IF(I4.EQ.2) K=KB                                                  SIP01460
      DO 62 IB=2,NI11                                                   SIP01470
      I=NI12+1-IB                                                       SIP01480
      IJ=I+NI10*(J-2)+NIJ10*(K-2)                                       SIP01490
      IF(MHD(IJ).GE.1) GO TO 62                                         SIP01500
      IP1JK=IJ+1                                                        SIP01510
      IJP1K=IJ+JJP1*NI10                                                SIP01520
      IJKP1=IJ+KKP1*NIJ10                                               SIP01530
      IF(ISF1.EQ.1) GO TO 92                                            SIP01540
      IF(IJKP1.LT.1) IJKP1=1                                            SIP01550
      IF(IJKP1.GT.NNN) IJKP1=NNN                                        SIP01560
      IF(ISF2.EQ.1) GO TO 92                                            SIP01570
      IF(IJP1K.LT.1) IJP1K=1                                            SIP01580
      IF(IJP1K.GT.NNN) IJP1K=NNN                                        SIP01590
92    CONTINUE                                                          SIP01600
      X=VV(IJ)-E2(IJ)*DT(IP1JK)-F2(IJ)*DT(IJP1K)-G2(IJ)*DT(IJKP1)       SIP01610
      DT(IJ)=X                                                          SIP01620
      X=X*HMAX                                                          SIP01630
      XXP=XX(IJ)+X                                                      SIP01640
      XX(IJ)=XXP                                                        SIP01650
      X=DABS(X)                                                         SIP01660
      IF(X.LE.ER5) GO TO 111                                            SIP01670
      IMX=I                                                             SIP01680
      JMX=J                                                             SIP01690
      KMX=K                                                             SIP01700
      XXPMX=XXP                                                         SIP01710
      ER5=X                                                             SIP01720
111   CONTINUE                                                          SIP01730
62    CONTINUE                                                          SIP01740
102   CONTINUE                                                          SIP01750
C  EQUATION (15) IS NOW ACCOMPLISHED                                    SIP01760
      IF(IWR1.EQ.1) WRITE(6,1000)                                       SIP01770
     1 ICNT,IMX,JMX,KMX,XXPMX,ER5,SRZ,XX(NW1),XX(NW2),XX(NW3)           SIP01780
      IF((ER5+ER5S).LT.ERR) GO TO 202                                   SIP01790
      IF(SRZ.LT.XX10) GO TO 202                                         SIP01800
      ER5S=ER5                                                          SIP01810
499   CONTINUE                                                          SIP01820
501   CONTINUE                                                          SIP01830
```

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202   CONTINUE
1000  FORMAT(' ',I3,3I5,6D18.7)
      RETURN
      END
```