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Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter A5

A MODULAR FINITE-ELEMENT MODEL (MODFE) FOR AREAL AND AXISYMMETRIC GROUND-WATER-FLOW PROBLEMS, PART 3: DESIGN PHILOSOPHY AND PROGRAMMING DETAILS

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Book 6
MODELING TECHNIQUES

Linear Versions

Subroutine DATIN

Variable	Definition
ALPH(J)	α term for head-dependent (Cauchy-type) boundary [length/time].
HB	Head on specified-head boundary [length].
IPBC	Indicator variable to suppress printout of initial Cauchy-type boundary data.
IPH	Indicator variable to suppress printout of initial aquifer heads.
IPHB	Indicator variable to suppress printout of initial specified-head boundaries.
IPHR	Indicator variable to suppress printout of initial source-bed heads.
IPND	Indicator variable to suppress printout of node numbers for each element.
IPQW	Indicator variable to suppress printout of initial point sources and sinks.
IPXY	Indicator variable to suppress printout of x-y coordinates.
NDC	Index for vector containing node numbers.
NLHS	Number of specified-head nodes that are located at the end of the head vector.
QBND(J)	q_B term for specified-flux boundary [length^2/time].
QWEL	Strength of point source or sink [length^3/time].
WF	Weighting factor for specified-head-boundary nodes, equals 2/3 for transient simulations and 1 for steady state.

Subroutines DATOUT and EXTRAP

Variables that are contained in these subroutines have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines.

Subroutine FMCO

Variable	Definition
ALF	α term for head-dependent (Cauchy-type) boundary [length/time].
ANG	Rotation angle θ of equation (20) in Cooley (1992), to transform global Cartesian coordinates to local coordinates.
AREA	Twice the area of element e, $2\Delta^e$,[length^2].
BJ,BK,BL	Differences in nodal-coordinates used for coordinate functions N_i^e, y direction.
CA	Scaling factor for coefficients (= .5).
CB	Scaling factor for coefficients (= SCALE × SCALE/ 6).
CJ,CK,C1	Differences in nodal coordinate used for coordinate functions N_i^e , x direction.
CS	Cosine of θ.
DIST	Length of element side on head-dependent (Cauchy-type) or specified-flux boundary.
ICA,ICB,ICC	Index to the storage location in A of capacitance term for nodes of NA, NB, and NC, respectively.
IEL	Element number.
IW	Length of storage in A allocated to each node.
IZ	Zone counter.
IZN	Vector containing zone numbers for each element.
KNT	Index for vector IZN, counter for elements.

Subroutine FMCO (continued)

Variable	Definition
KZ	Zone number.
M	Index to the storage location in $\underline{A}$ of capacitance term for node NA.
MI	Index for JPT.
MBM1	Number of storage locations in JPT that is allocated for each node.
NA,NB,NC	Node numbers identifying an element.
NE	Index to node numbers for combined-element input.
NDC	Index for node numbers.
NDID(I)	Node numbers for each element, I=1,4.
ND	Number of elements in zone KZ.
NT	Index for locating nodes in an element.
NTE	Element index.
QB	q_B term or specified-flux boundary [length^2/time].
QD	Unit rate of areally distributed flow [length/time].
RJ,RK,RL	Factors used in formulating coefficients for Cartesian or radial coordinate.
R(1), R(2), R(3)	Factors used to convert from Cartesian to radial coordinate system.
SN	Sine of θ.
STR	Storage coefficient [dimensionless], specific yield [dimensionless], or specific storage [length $^{-1}$].

Subroutine FMCO (continued)

Variable	Definition
TESJ,TESK,TESL	Nodal coefficient $(1/3)S^e\Delta^e$ for aquifer storage.
TEQ	Nodal coefficient $(1/3)W^{e\Delta e}$ for areally distributed flow.
TFL(1),TFL(2),TFL(3)	$(T_{\bar{x}\bar{x}}/4\Delta^e)\ \bar{b}_i^e\bar{b}_j^e + (T_{\bar{y}\bar{y}}/4\Delta e)\ \bar{c}_i^e\bar{c}_j^e$ for transmissivity "link" between nodes i and j, $i \neq j = j, k, l$.
TMPA	Difference in x coordinates for nodes on head-dependent (Cauchy-type) or specified-flux boundary, the length $L_{kl}/2$ for node K on boundary, unrotated xcoordinate, and cetroidal radius $\bar{r}$.
TMPB	Difference in y coordinates for nodes on head-dependent (Cauchy-type) or specified-flux boundary, the length $L_{kl}/2$ for node L on boundary, unrotated y coordinate.
VLC	Hydraulic conductance, R, for steady vertical leakage [length $^{-1}$].
XL	Local $\bar{x}$ coordinate [length].
XNA,XNB,XNC	Local $\bar{x}$ coordinates for nodes NA, NB, NC, respectively [length].
XTR	Transmissivity in the local $\bar{x}$ direction [length^2/time].
YL	Local $\bar{y}$ coordinate [length].
YNA,YNB,YNC	Local $\bar{y}$ coordinates for NA, NB, NC, respectively [length].
YTR	Transmissivity in the local $\bar{y}$ direction [length^2/time].

Subroutine FMEQ

B	Right side of finite-element matrix equations.

Subroutine FMEQ (continued)

Variable	Definition
DT	Time-step size [time].
IW	Length of storage in A allocated to each node.
MBM1	Index to pointer vector JPT; defines maximum amount of storage that is allocated to JPT for each node.
NC	Index to the storage location in A where the capacitance term is located for each node.
ND	Index to the storage location in A for the transmissivity terms of each node.
NME	Index to the location of the main diagonal of the upper-triangular matrix A stored in condensed-matrix form, for each node.
NP	Index to the pointer vector JPT.
NVL	Index to storage location in program vector A for steady-vertical-leakage term for each node.
TMPA,TMPB	Steady-vertical-leakage terms and coefficients for head-dependent (Cauchy-type) and specified-flux boundaries.

Subroutine HCALC

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines.

Subroutine MASBAL

DTM	The factor $1/(2/3)\Delta t$ for computing average volumetric rates from aquifer storage.
IW	Length of storage in A allocated to each node.

Subroutine MASBAL (continued)

Variable	Definition
MBM1	Maximum number of locations in JPT that is allocated for each node.
NC	Index to the storage location in A for capacitance (aquifer-storage) terms.
ND	Index to the storage location in A preceding the location where transmissivity terms are located, for each node.
NP	Index to the pointer vector JPT.
NVL	Index to storage location in A for the vertical-leakage coefficient.
TMPA	Temporary-storage variable that is used to compute nodal volumetric rates for aquifer storage, convective flow (involving transmissivity) and Cauchy-type boundaries.
TMPB	Temporary-storage variable that is used to compute nodal volumetic rates for steady vertical leakage and Cauchy-type boundaries.

Subroutine MASOUT

ISTP	Number of the current time step.

Subroutine PRTOA

L	Index for printing out values (VAL).
NO	The number of values that is printed out, such as NNDS.
NR	Number of rows of values.
VAL	The variable that is printed out in three columns, such as hydraulic head, H.

Subroutine PRTOB

Variable	Definition
L	Index for printing out values (VALA and VALB).
NO	The number of pairs of VALA and VALB that is printed out, such as NNDS.
NR	Number of rows of values.
VALA	The first of two values printed out by node in two columns per line, such as XG.
VALB	The second of two values printed out by node in two columns per line, such as YG.

Subroutine PRTCBV

INS	Number of sides on a boundary-condition zone (linear or nonlinear).
INZ	Zone number for bondary condition.
J	Index to nodal flow rates for element sides.
JB	Index for beginning number of boundary nodes and flow rates in zone.
NBZ	Total number of boundary-condition zones.
NVLA	Node K on head-dependent (Cauchy-type) boundary (linear or nonlinear).
NVLB	Node L on head-dependent (Cauchy-type) boundary (linear or nonlinear).
NZ	Index for zone loop.
QNET	Net volumetric flow rate, positive for inflow, from head-dependent (Cauchy-type) boundary (linear or nonlinear) [length^3/time].

Subroutine PRTCBV (continued)

Variable	Definition
SMQI	Sum of volumetric inflow rates from head-dependent (Cauchy-type) boundary (linear or nonlinear) [length^3/time].
SMQO	Sum of volumetric outflow rates from head-dependent (Cauchy-type) boundary (linear or nonlinear) [length^3/time].
SMVI	Sum of inflow volumes from head-dependent (Cauchy-type) boundary (linear or nonlinear) [length^3].
SMVO	Sum of outflow volumes from head-dependent (Cauchy-type) boundary (linear or nonlinear) [length^3].
VALA	Nodal volumetric flow rate from head-dependent (Cauchy-type) boundary at node NVLA [length^3/time].
VALB	Nodal volumetric flow rate from head-dependent (Cauchy-type) boundary at node NVLB [length^3/time].
VNET	Net volume of water, positive for accumulation, derived from head-dependent (Cauchy-type) boundaries [length^3].

Transient Leakage

Subroutine CBADEQ

L	Index to main diagonal and right side of matrix equation.
NME	Index to main diagonal of reduced matrix, A, stored in condensed-matrix form.

Subroutine CBADWT

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines.

Subroutine CBCHG

Variable	Definition
HRJ	Value of new source-layer head [length].
HR(J)	Average source-layer head [length].
J	Node number where source-layer head is changed.
WF	Galerkin-weighting factor (=2/3) used to compute average source-layer head.

Subroutine CBFMCO

L	Zone number where transient leakage is simulated.
NA,NB,NC	Node numbers in an element.
NBE	Beginning (lowest) element number in zone L.
NDC	Index to ND for locating nodes in element.
NE	Counter used in computing transient leakage coefficients from combined-element input.
NEND	Ending (highest) element number in zone L.
NO	Number of elements contained in zone L.
NTE	Index to AR for element area.
NVL	Index to storage location in program vector A for hydraulic conductance term, C_{Ri} of equation (205) in Cooley (l992).
SPST	Specific storage [length $^{-1}$] of confining bed in zone L.
TESA	Effective specific storage $S_s^{'e}\Delta^e$ for element e.
TEVC	Effective vertical hydraulic conductivity $(1/3)K_{zz}^{'e}\Delta^e$ for element e.
VCON	Vertical hydraulic conductivity [length/time] of confining bed in zone L.

Subroutine CBFMEQ

Variable	Definition
DTD	Dimensionless time step $\Delta t_{n+1} \gamma_i$.
L	Index for storing main-diagonal and right-side coefficients for transient leakage, by node.
NQ	Index to transient-leakage, five terms per node.
NT	Counter for number of terms used to approximate either M_1 (NT = 3) or M_2 (NT = 2).
QOM1	The transient-leakage flow from the previous time step, given by $P_{hi,n}$ of equation (199) in Cooley (1992).
QOM2	The transient-lekage flow from the previous time step, given by $P_{Hi,n}$ in equation (200) in Cooley (1992).
SM1	$M_1(\Delta t_D)$, given by equation (188) in Cooley (1992).
TMPA	(1) Exponent $-\alpha_m \Delta t_D$ used to compute M_1.
	(2) Exponent $-\beta_m \Delta t_D$ used to compute M_2.
XP	(1) The term exp $(-\alpha_m \Delta t_D)$ used for approximating M_1.
	(2) The term exp $(-\beta_m \Delta t_D)$ used for approximating M_2.

Subroutine CBHRXT

DHR	Change in source-layer head, $H_{i,n+1} - H_{i,n}$ [length], for next time step.
HR	Source-layer head, $H_{i,n+1}$ [length], at end of time step.
TMPA	Factor (= 1/3) for computing value of source-layer head at end of time step.

Subroutine CBINIT

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines.

Subroutine CBTQC

Variable	Definition
DTM	1/(2/3) Δt_{n+1} used for coefficient formulation.
NQ	Index to transient-leakage terms CBTQ, five terms per node.
DTD	Dimensionless time step, Δt_D.
XP	The term exp $(-\alpha_m \Delta t_D)$.
TMPA	(1) The exponent $-\alpha_m \Delta t_D$. (2) $(\hat{h}_{i,n+1} - \hat{h}_{i,n})/\Delta t_D$, multiplies M_1 for computing transient-leakage term $I_{mi,\, n+1}$.
CBTQ	Part of transient-leakage flux from head changes during current time step [length/time].
TMPA	(1) Volumetric rate of accumulation of water in aquifer storage [length^3/time]. (2) Volumetric flow rate along a transmissivity "link" between nodes i and j on an element side [length^3/time] $i \neq j = k,l,m$.
TMPB	Volumetric flow rate from steady and transient leakage from a confining bed [length^3/time].
VLQI	Total volumetric rate of recharge from confining bed to aquifer caused by steady and transient leakage [length^3/time].
VLQO	Total volumetric rate of discharge from confining bed to aquifer caused by steady and transient leakage [length^3/time].

Subroutine MBWTCB

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines (the "WT" and "CB" subroutines and in subroutines MBALCB and MBALWT).

Table 19.—Variable names by subroutine for transient leakage

Main program variable	Subroutine									
	CBADEQ	CBADWT	CBCHG	CBFMCO	CBFMEQ	CBHRXT	CBINIT	CBTQC	MBALCB	MBWTCB
DT					DT			DT	DT	DT
G							G			
G(IAA)	A	A		A	A				A	A
G(IACA)				AC	AC					
G(IALFA)				ALF	ALF			ALF		
G(IARA)				AR					DTK	DTK
G(IBA)	B	B						B	B	
G(IBCA)				BC	BC					
G(IBTA)				BTA	BTA					
G(ICHA)	CH	CH			CH				CH	CH
G(ICKA)									CFDK	CFDK
G(ICLA)									CFDL	CFDL
G(ICTQA)					CBTQ			CBTQ		
G(ICQA)	CBQ	CBQ			CBQ				CBQ	CBQ
G(IDHA)		DH								DH
G(IDHRA)			DHR		DHR	DHR				
G(IGMA)	GMA	GMA		GMA	GMA			GMA	GMA	GMA
G(IHA)									H	H
G(IHBA)								DHB	DHB	DHB
G(IHKA)									HK	HK
G(IHLA)									HL	HL
G(IHRA)			HR			HR			HR	HR
G(IJPA)									JPT	JPT
G(IKA)									KQB	KQB
G(ILA)									LQB	LQB
G(INA)	IN	IN			IN			IN	IN	IN
G(INDA)				ND						
G(IQA)									Q	Q
G(ISYA)										ASY
G(ITKA)										THK
G(ITPA)										TOP
G(IYGA)				WVCN					R	R
IACA							IACA			
IALFA							IALFA			
IBCA							IBCA			
IBTA							IBTA			
ICHA							ICHA			
ICQA							ICQA			
ICTQA							ICTQA			
IDHRA							IDHRA			
IGMA							IGMA			
ISTP			ISTP							
NCBZ				NCBZ			NCBZ			
TIME			TIME							

Changing Time-Step Size, Stresses, and Boundary Conditions

Subroutine COCHG

Variable	Definition
AREA	One-third the element area, $(1/3)\Delta^e$ [length^2].
DQ	Difference in volumetric flow rate [length^3/time] between old and new areally distributed flows.
HB	New value for specified head.
L	Zone number where changes to areally distributed flows are made.
M1	Length of storage needed for element areas in AR.
M2	Length of storage needed for node numbers in ND.
N	The number of stresses or controlling heads for boundary conditions that are changed; represents either nodes, element sides, or zones.
QNEW	(1) New value of point source or sink [length^3/time] at boundary J. (2) New value of unit areally distributed flow rate [length^3/time].
QOLD	(1) Old value of point source or sink at node J [length^3/time]. (2) Old value of unit areally distributed flow rate [length/time]. (3) Old value of specified-flux part of Cauchy-type boundary, q_B [length^2/time] or q_B/α [length] if $\alpha \neq 0$.

Subroutine COCHG (continued)

TMPA	Total change to areally distributed inflows [length^3/time].
TMPB	Total change to areally distributed outflows [length^3/time].
WF	Weighting factor used to compute average head change at specified-head boundaries.

Subroutine NXTPD

Variable	Definition
NSTEPS	Counter equal to the number of time steps in the new stress period if either time-step sizes or the number of time steps change from the previous stress period.
NTMP	Time-step indicator; the number of time steps in the initial stress period and, either the number of time steps in the new stress period, or zero, if previous values are used.

Table 20.—Variable names by subroutine for changing time-step size, stresses, and boundary conditions

Main program variable	Subroutine COCHG	Subroutine NXTPD
G(IALA)	ALFH	
G(IARA)	AR	
G(ICKA)	CFDK	
G(ICLA)	CFDL	
G(IDTA)		DELT
G(IHA)	H	
G(IHBA)	DHB	
G(IHKA)	HK	
G(IHLA)	HL	
G(IHRA)	HR	
G(IKA)	KQB	
G(ILA)	LQB	
G(INA)	IN	
G(INDA)	ND	
G(IQA)	Q	
G(IQBA)	QBND	
ISTP	ISTP	
JPER		JPER
TIME	TIME	

Nonlinear Versions

Water-table (unconfined) conditions

Subroutine FMECWT

Variable	Definition
C1,C2,C3	Galerkin weighting factors.
DHP	Predicted value of the total head change over the time step.
HO	Aquifer head at the beginning of the time step.
HP	Predicted aquifer head at the end of the time step.
THKI	Temporary-storage term for aquifer thickness at node I.
THKL	Temporary storage term for aquifer thickness at node L.
THKP	Negative aquifer thickness predicted to occur at a dry node.
TMPA	(1) Temporary-storage term for capcitance coefficient $(1/(2/3)\Delta t_{n+1})\ \underline{\underline{C}}$ of matrix equation (4). (2) Transmissivity term in $\tilde{G}_{ij}^{*}$ of matrix equation (4).
TMPB	Transmissivity terms in $(\underline{\underline{\tilde{G}}}^{*} - \underline{\underline{\bar{G}}}^{*})\ \underline{\bar{\delta}}^{*} - \underline{\underline{\bar{G}}}^{*}\ \underline{\bar{h}}^{*}$ for the right side of matrix equation (4).

Subroutine FMEPWP

THKI	Aquifer thickness for node I.
THKL	Aquifer thickness for node L.
TMPA	Transmissivity term given by equation (77) in Cooley (1992).
TMPB	Transmissivity term, predictor equation (3) right side.

Subroutine HCALWT

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines.

Subroutine MBALWT

Variable	Definition
A(NC)	Effective storage coefficient resulting from integrations of equations (93) and (94) in Cooley (1992) for conversion between confined and unconfined conditions.
C	Galerkin-weighting factor for transmissivity formulation, equal to 1/16.
DHC	Total head change over the time step [length].
HO	Aquifer head, $\hat{h}_{i,n}$ [length], at beginning of time step.
HC	Aquifer head, $\hat{h}_{i,n+1}$ [length], at end of time step.
THET	Estimate of conversion point, θ_i, of equation (96) in Cooley (l992).
TMPA	(1) Volumetric rate of accumulation of water from aquifer storage [length^3/time].
	(2) Transmissivity terms $\bar{\bar{G}}\,\bar{h} + (\tilde{G} - \bar{\bar{G}})\,\bar{\delta}$ [length^3/time] equation (83) in Cooley (1992).
	(3) Volumetric-flow rates from Cauchy-type boundaries; first represents $(1/2)(\alpha L)_{kl}(h_{Bk}-\bar{h}_k)$, then $(1/2)(\bar{q}_B L)ij + (1/2)(\alpha L)_{kl}(h_{Bk}-\bar{h}_k)$,

Subroutine MBALWT (continued)

Variable	Definition
	for $\alpha \neq 0$ or, $(1/2)(\bar{q}_B L)ij$ for $\alpha = 0$ and $q_B \neq 0$, of equation (64) in Cooley (l992) [length^3/time].
TMPB	(1) Volumetric flow rate for confining-bed leakage $(1/3)R^e\Delta^e(H_i - \hat{h}_i)$.
TMPB	(2) Volumetric-flow rates from Cauchy-type boundaries; first represents $(1/2)(\underline{\alpha} L)_{kl}(h_{Bl}-\bar{h}_l)$, then $(1/2)(\bar{q}_B L)ij + \underline{(1/2)}(\alpha L)_{kl}(h_{Bl}-\bar{h}_l)$, for $\alpha \neq 0$; or, $(1/2)(q_B L)ij$ for $\alpha = 0$ and $q_B \neq 0$, of equation (64) in Cooley (l992).

Subroutine WTCCHK

ISC	Indicator for unpredicted conversion or nonconversion of aquifer storage.

Subroutine WTFMCO

SY	Specific yield for aquifer-property zone [dimensionless].
TESY	Capacitance coefficient c^e_{kk} of equation (36) in Cooley (1992).

Subroutine WTINIT

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in other subroutines.

Table 21.—Variable names by subroutine for water-table (unconfined) conditions

Main program variable	Subroutine									
	FMECWT	FMEPWT	HCALWT	MBALWT	WTCCHK	WTFMCO	WTINIT	CBTQC	MBALCB	MBWTCB
DT	DT	DT		DT						
G							G			
G(IAA)	A	A		A						
G(IARA)	AD	AD		DTK		AR				
G(IBA)	B	B	B		B					
G(ICKA)	CFDK	CFDK		CFDK						
G(ICLA)	CFDL	CFDL		CFDL						
G(IDHA)	DH		DH	DH	DH					
G(IHA)	H	H	H	H	H					
G(IHBA)		DHB		DHB						
G(IHKA)	HK	HK		HK						
G(IHLA)	HL	HL		HL						
G(IHRA)	HR	HR		HR						
G(IJPA)	JPT	JPT							JPT	JPT
G(IKA)	KQB	KQB		KQB						
G(ILA)	LQB	LQB		LQB						
G(INA)	IN	IN	IN	IN	IN					
G(INDA)						ND				
G(IQA)	Q	Q		Q					Q	Q
G(IQBA)				QBND						
G(ISYA)	ASY	ASY		ASY		ASY				ASY
G(ITKA)	THK	THK		THK		THK				THK
G(ITPA)	TOP	TOP			TOP	TOP				TOP
G(IYGA)	DTK			R						
IDHA							IDHA			
ISC					ISC					
ISYA							ISYA			
ITKA							ITKA			
ITPA							ITPA			

Head-dependent (Cauchy-type) flux and point sinks

Subroutine GNBAL

Variable	Definition
CA,CB	Galerkin-weighting factors, equal to 1/3 and 2/3, respectively.
DHC	Total head change for time step; $\hat{h}_{i,n+1} - \hat{h}_{i,n}$ [length].
DHZ	Altitude difference, $\hat{h}_{i,n} - z_{ri}$, for nonlinear Cauchy-type boundaries; $z_{pi} - \hat{h}_{i,n}$ for nonlinear point sinks [length].
DRZ	Altitude difference, $\hat{h}_{ri} - z_{ri}$ [length].
HC	Hydraulic head, $\hat{h}_{i,n+1}$ [length], at end of time step.
HO	Hydraulic head, $\hat{h}_{i,n}$ [length], at beginning of time step.
HR	Controlling heads, HRK and HRL [length].
IP	Index to GC for nonlinear-point sinks.
NL	Boundary nodes, KR and LR.
PHC	Term $(1 - \phi_i)$ used for leakage expression in case 3.
TMPA	Head or altitude difference that multiplies coefficient C_{ri} for head-dependent (Cauchy-type) boundaries and C_{pi} for point sinks [length].
TMPB	Volumetric flow rate for head-dependent (Cauchy-type point sinks [length^3/time].
ZPI	Controlling altitude, ZP [length], for point sinks
ZR	Controlling altitude, ZR [length], for head-dependent (Cauchy-type) boundaries.

Subroutine GNBLSS

Variable	Definition
HL	Aquifer head on final iteration, $\hat{h}_i^{\ell+1}$ [length].
HR	Controlling head, h_{ri} [length].
QR	Nodal volumetric flow rate [length^3/time].
TMPA	Head or altitude difference that multiplies coefficient C_{ri} for head-dependent (Cauchy-type) boundaries and C_{pi} for point sink [length].
TMPB	Volumetric flow rate from head-dependent (Cauchy-type) boundaries and point sinks [length^3/time].

Subroutine GNCHG

Variables that are contained in this subroutine have been defined in previous sections that give definitions of program variables in the general-storage vector G, in Fortran COMMON statements, and in subroutines GNBAL and GNBLSS.

Subroutine GNCORR

DHP	Predicted-aquifer head, $\hat{h}_{i,n+1}$ [length].
N	Index to A for the main diagonal of nodes k and l on the nonlinear boundary.
TMPA	Head or altitude difference that multiplies C_{ri} for head-dependent (Cauchy-type) boundaries and C_{pi} for point sinks [length].

Subroutine GNFMCO

CA	Factor for scaling lengths of boundary sides.
DIST	Length of boundary side.
GC	α term for nonlinear head-dependent (Cauchy-type boundary [length^2/time].

Subroutine GNFMCO (continued)

Variable	Definition
GCP	α term for nonlinear point sinks [length^2/time].
IPNC	Indicator variable to suppress printout of input for nonlinear head-dependent (Cauchy-type) boundaries.
IPNP	Indicator variable to suppress printout of input for nonlinear point sinks.
TMPA	Difference in x coordinates between nodes on boundary side.
TMPB	Difference in y coordinates between nodes on boundary side.

Subroutine GNINIT

NBNC	Number of nonlinear, head-dependent (Cauchy-type) boundaries.
NLCZ	Number of zones for nonlinear head-dependent (Cauchy-type) boundaries.
NPNB	Number of nonlinear, head-dependent point sinks.

Subroutine GNINIT

Variables that are used in this subroutine have been defined previously as variables in the main program and in storage vector G.

Subroutine GNPRED

IP	Index for α term for nonlinear point sinks.
N	Index to main-diagonal location of reduced matrix stored in condensed-matrix form.
TMPA	Head or altitude difference that multiplies coefficient C_{ri} for head-dependent (Cauchy-type) boundaries and C_{pi} for point sinks [length].

Table 22.—Variable names by subroutine for nonlinear head-dependent (Cauchy-type) boundaries

Main program variable	Subroutine						
	GNBAL	GNBLSS	GNCHG	GNCORR	GNFMCO	GNINIT	GNPRED
DT	DT	DT					
G						G	
G(IAA)				A			A
G(IARA)	VQK	VQK					
G(IBA)				B			B
G(IDHA)	DH			DH			
G(IGCA)	GC	GC		GC	GC		GC
G(IHA)	H	H		H			H
G(IHBA)	DHB						
G(IHRK)	HRK	HRK	HRK	HRK	HRK		HRK
G(IHRL)	HRL	HRL	HRL	HRL	HRL		HRL
G(IKPA)	KP	KP		KP	KP		KP
G(IKRA)	KR	KR	KR	KR	KR		KR
G(ILRA)	LR	LR	LR	LR	LR		LR
G(INA)	IN	IN		IN			IN
G(INSA)					INLS		
G(INZA)					INLZ		
G(IXGA)	VQL	VQL			XG		
G(IYGA)	R	R			YG		
G(IZPA)	ZP	ZP		ZP	ZP		ZP
G(IZRK)	ZRK	ZRK		ZRK	ZRK		ZRK
G(IZRL)	ZRL	ZRL		ZRL	ZRL		ZRL
IGCA						IGCA	
IHRK						IHRK	
IHRL						IHRL	
IKPA						IKPA	
IKRA						IKRA	
ILRA						ILRA	
INSA						INSA	
INZA						INZA	
ISTP			ISTP				
IZPA						IZPA	
IZRK						IZRK	
IZRL						IZRL	
NBNC	NBNC	NBNC		NBNC	NBNC	NBNC	NBNC
NLCZ						NLCZ	
NPNB	NPNB	NPNB		NPNB	NPNB	NPNB	NPNB
TIME			TIME				