PROJECTED EFFECTS OF GROUND-WATER WITHDRAWALS IN THE ARKANSAS RIVER VALLEY, 1980-99, HAMILTON AND KEARNY COUNTIES, SOUTHWESTERN KANSAS

By L. E. Dunlap, R. J. Lindgren, and J. E. Carr

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CONVERSION TABLE

Inch-pound units of measurement in this report may be converted to International System (SI) of Units using the following conversion factors:

To convert from inch-pound units	To SI unit	Multiply by
inch	millimeter	25.4
foot	meter	0.3048
mile	kilometer	1.609
acre	square meter	4,047
square mile	square kilometer	2.590
acre-foot	cubic meter	1,233
cubic foot per second (ft^3/s)	cubic meter per second	0.02832
foot per day (ft/d)	meter per day	0.3048
acre-foot per year (acre-ft/yr)	cubic meter per year	1,233
inch per year	millimeter per year	25.4

DEFINITION OF TERMS

Aquifer - A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells or springs.

Consumptive use - Volume of water that is used by vegetative growth in transpiration and building of plant tissue and that is evaporated from adjacent soil or intercepted precipitation on plant foliage.

Deep percolation - Volume of water from precipitation and irrigation that infiltrates the soil and moves by the force of gravity to the water table.

Evapotranspiration - Volume of water that is lost to the atmosphere by transpiration from vegetative growth and by evaporation from the soil or from the aquifer in shallow water-table areas.

Head, static - The height above a standard datum of the surface of a column of water than can be supported by the static pressure at a given point.

Hydraulic conductivity - Volume of water at the existing kinematic viscosity that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydraulic gradient - The change in static head per unit of distance in a given direction.

Moisture-holding capacity - Amount of moisture that the soil can hold in a form available to plants. It is the amount of moisture held between field capacity and the permanent wilting point.

Specific yield - Ratio of the volume of water that the saturated material will yield by gravity drainage to the volume of the material.

Steady state - Equilibrium conditions when water levels and the volume of water in storage do not change with time.

Storage coefficient - Volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Streambed leakance - Ratio of the vertical hydraulic conductivity of the streambed to the thickness of the streambed material.

Transmissivity - Rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

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ABSTRACT

A study was made, in cooperation with the Division of Water Resources, Kansas State Board of Agriculture, to determine the effects that additional ground-water development would have on streamflow and water levels in an area along the Arkansas River in Hamilton and Kearny Counties, southwestern Kansas. A computer model was used to simulate the changes in streamflow and water levels from 1980 through 1999. Six pumpage options were tested using variations in pumpage rate and number of wells pumping in the model area.

The projected effects of ground-water withdrawals from 1980-99 indicate that net annual streamflow losses would be reduced only 1 percent if annual withdrawals were reduced by 24 percent from the continued 1979 pumpage rate of wells with water rights, as computed using energy-consumption techniques, to the amount appropriated by water rights for these wells. The higher the pumpage rate results in very little change in stored ground water and net streamflow losses because, after satisfying initial soil-moisture requirements, a greater percentage of the additional applied water percolates back to the aquifer.

If pumpage were increased along with an increase in the number of irrigated acres over the 1979 rate, additional water would be removed from storage, and net annual streamflow losses would increase. A 19-percent increase in pumpage over the 1979 rate, with the additional acres irrigated, would cause the net annual streamflow loss to increase 5 to 9 percent.

INTRODUCTION

In January 1977, the Chief Engineer of the Division of Water Resources, Kansas State Board of Agriculture, declared a moritorium on the approval of applications for permits to appropriate water from an area of 500 square miles along the Arkansas River in Hamilton and Kearny Counties, southwestern Kansas (fig. 1). The moratorium was prompted by a growing concern over decreasing streamflow and declining water levels and by the need for a better understanding of ground- and surface-water interaction in the area.

When the moratorium was declared, hydrologic information was insufficient to allow adequate scientific evaluation of the interaction of ground and surface water and the extent to which diversion from either source might impair water use under existing water rights in the area. The effect of year-to-year decreases in streamflow at the State line during

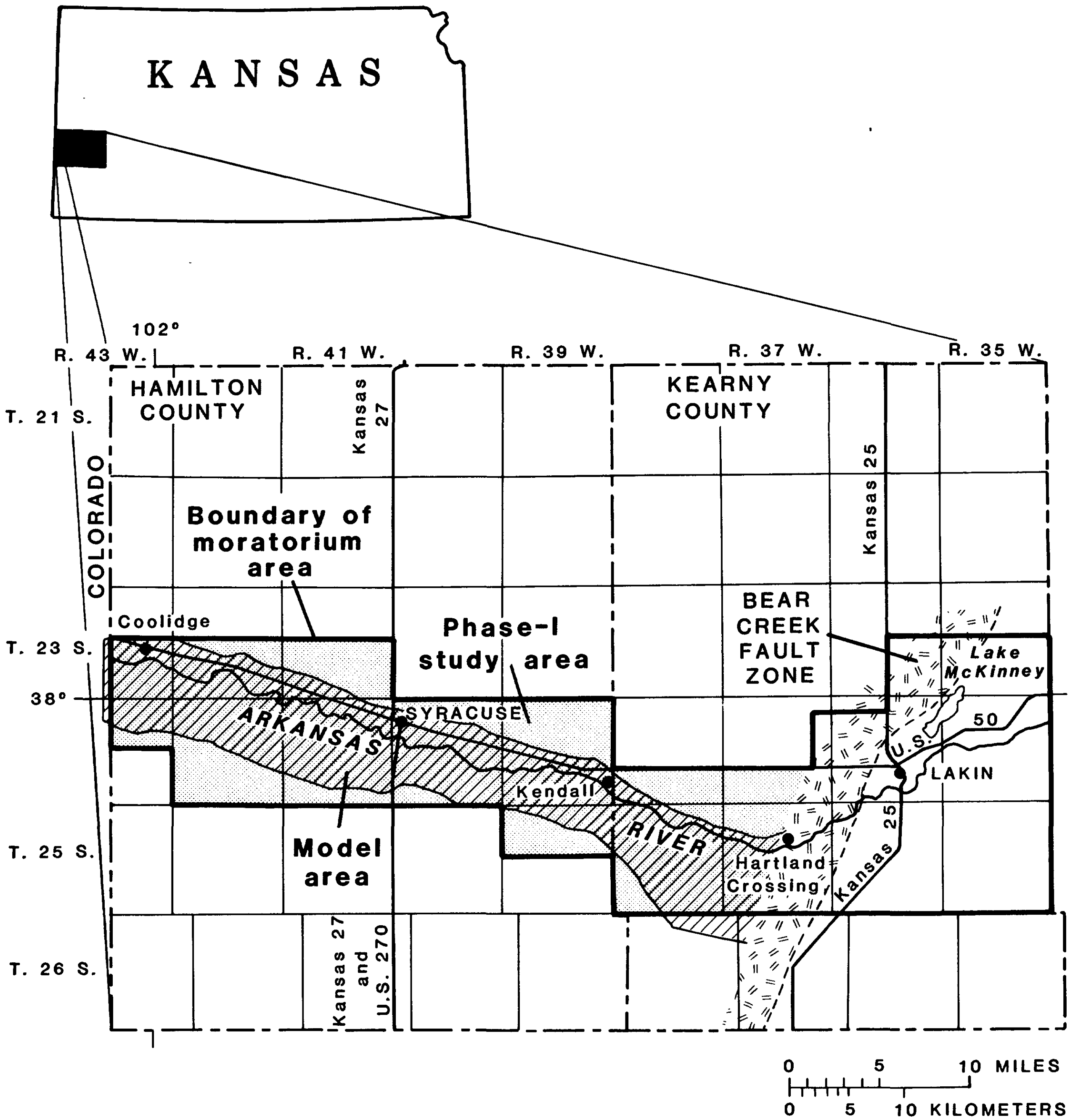

Figure 1.--Location of moratorium, study, and model areas.

the 1970's also needed evaluation. The Division of Water Resources entered into a 5-year cooperative investigation of the moratorium area with the U.S. Geological Survey in October 1977 to provide better hydrologic information for use in managing the water resources of the area.

The study of the moratorium area was divided into two parts in order to separate the geological differences due to the Bear Creek Fault zone--phase I (1977-81) and phase II (1979-82). In 1981, the primary investigation of the stream-aquifer hydrology along the Arkansas River valley west of the Bear Creek Fault zone (phase I) was completed (Barker and others, 1983). As part of the phase-I study, long-term model projections were used to assess the effects that additional pumpage might have on future streamflow and water levels (fig. 2).

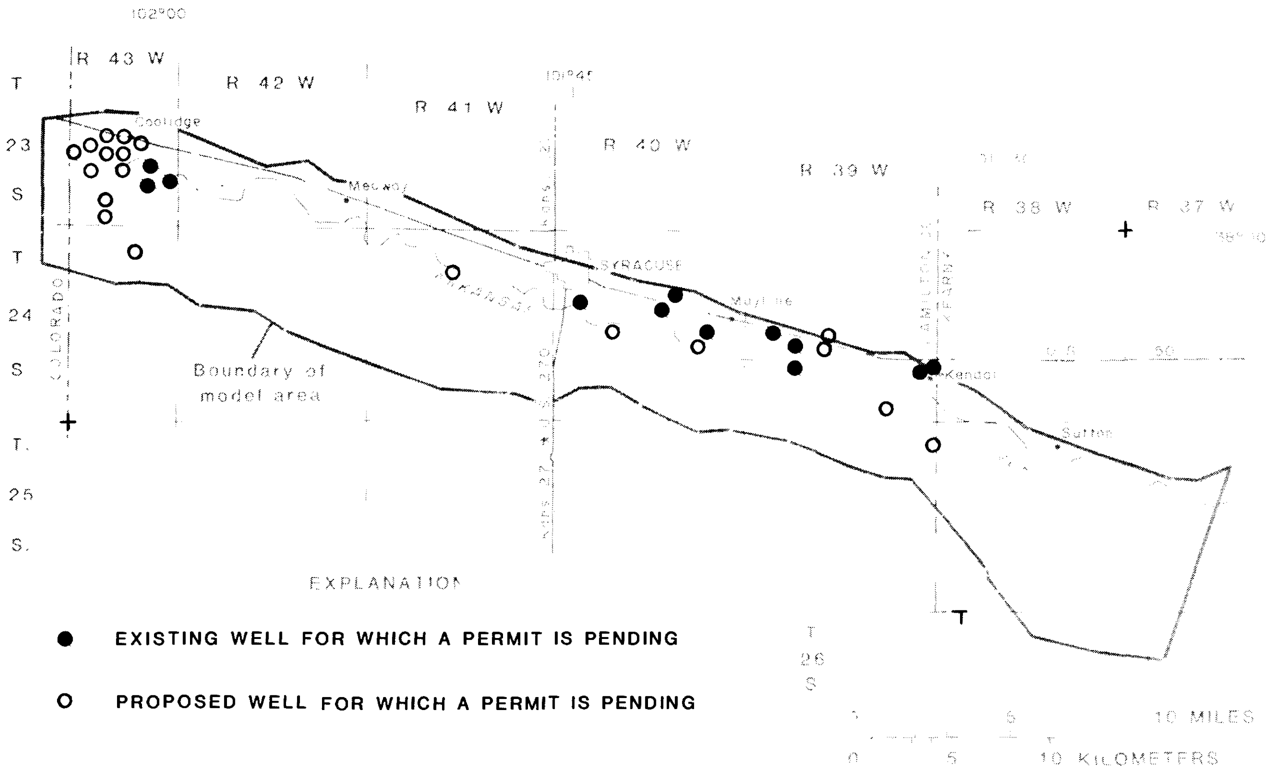

Figure 2.--Location of additional pumpage sites used in model projections.

Purpose and Scope

The purpose of this report is to evaluate the effects that additional ground-water development might have on streamflow loss in the Arkansas River and on water-level changes in the aquifer from 1980 through 1999. Sixteen long-term projections of possible future hydrologic conditions were made using a calibrated finite-element model. The report will describe briefly: the hydrologic properties used as input to the model, the 16 projection options used, and the results of those projections. For complete information on the environmental setting of the area and the background, input, and calibration of the computer-model analysis, the reader is referred to a previous report of the study area (Barker and others, 1983). Documentation for the Tracy finite-element model used to make the long-term projections is presented at the end of this report.

Method of Investigation

Digital-Computer Model

The digital model of the Arkansas River valley stream-aquifer system uses a computer program written by J. V. Tracy (U.S. Geological Survey, written commun., 1980). The Tracy finite-element model is based on the Galerkin finite-element method (Desai and Abel, 1972). Additional reference to this method can be found in Pinder and Gray (1977). A "direct" solution method is used to solve the nonlinear, partial-differential equation that describes nonsteady, two-dimensional ground-water flow.

The simulation of future conditions requires that time be broken into a series of finite intervals called time steps. Because the solution changes with time, the size of the time steps affects the computational-work effort needed to approximate aquifer performance during a selected period and the accuracy of the approximation. A progression of 5-day time steps was used for all model analyses.

Development of the digital-computer model as a predictive tool is based on the premise that, if historic hydrologic phenomena can be satisfactorily approximated by the model, then so can future conditions. The historic cause-and-effect relationship between stresses in the real flow system and the system's response to those stresses were simulated with acceptable accuracy in the previous study by Barker and others (1983). The investigation reported here assumed that the cause-and-effect relationship did not change significantly in the real system during the simulation period, 1980 to 1999.

However, the hydrologic system in the study area is very dynamic. Large changes in streamflow at the Colorado-Kansas State line and in ground-water pumpage during the 1970's greatly influenced streamflow and water levels in the study area (Barker and others, 1983). Although it may be possible to estimate future pumpage based on management control, it is highly speculative to forecast changes in the streamflow at the State line for the 1980's and 1990's. The method of investigation chosen was to input various streamflow and pumpage patterns, allowing interested authorities to make management decisions based upon the different results.

Acknowledgments

The staff of the Division of Water Resources, Kansas State Board of Agriculture, especially David Pope, Chief Engineer, and Howard Corrigan, Water Commissioner, are thanked for the information they provided on water rights, surface-water diversion, well discharge, and water levels for the study.

SIMULATED HYDROLOGIC PROPERTIES

Boundary conditions on the east and west sides of the model area, precipitation, streamflow conditions, and pumpage conditions were the only simulated hydrologic properties whose values for the 1980-99 projections varied from the values used in the previous study by Barker and others (1983).

Boundary Conditions

Boundary conditions were specified in order to terminate lateral ground-water flow at the northern and southern boundaries of the modeled system and to maintain the December 31, 1979, water level at the western and eastern boundaries. The boundaries on the north and south depicted the effects of the thinning of the alluvial aquifer system to termination against the relatively impervious bedrock. The boundaries on the east and west maintained constant water levels at nodes representing lateral inflow across the Colorado-Kansas State line and lateral outflow near Hartland Crossing. Specified water levels at these locations were maintained at the December 31, 1979, altitude throughout the 1980-99 projections because of the unpredictability of water-level trends in the distant future. In the previous study by Barker and others (1983), specified hydraulic-head nodes, which were updated at the beginning of each time step, were used on the east and west boundaries of the modeled area. The simulated water-level surface on December 31, 1979, was used as the starting water-level surface for the 1980-99 projections.

Streamflow Conditions

The model used 87 riverbed nodes to control the simulation of stream-aquifer interaction and to orient the routing of river discharge from the Colorado-Kansas State line to the downstream limits of the modeled area. Streambed altitude, lengths, and widths were specified for each riverbed node as part of the model input. The model simulated rates of streamflow for all riverbed nodes in an iterative, upstream-to-downstream fashion. Starting with input streamflow at the uppermost stream node and working downstream, the flow was calculated for each reach on the basis of incoming flow and the gain from, or loss to, the aquifer throughout the length of the reach.

Variations in 1971-80 streamflow at the Colorado-Kansas State line were used in running the 1980-99 future projections. Monthly discharge of the Arkansas River at the Colorado-Kansas State line for a U.S. Geological Survey streamflow-gaging station (near Coolidge) during 1970-80 is shown in figure 3. The average annual discharge during 1951-69 is also shown. Streamflow during the early 1970's was much higher than during the late 1970's. The streamflow during 1980 was exceptionally high.

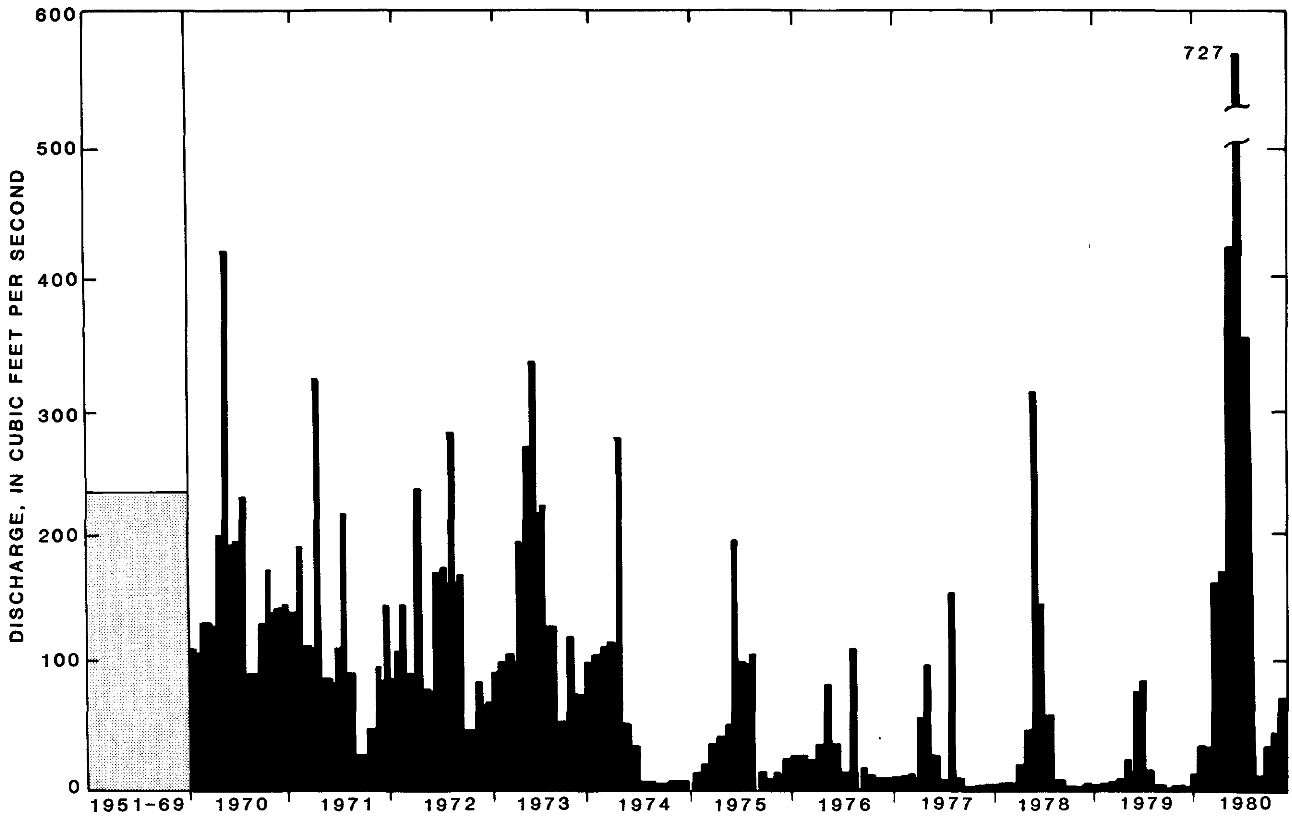

Figure 3.--Discharge of Arkansas River near Coolidge, 1951-69 (average) and 1970-80 (monthly).

Four variations in streamflow conditions were simulated:

OPTION A - Cycle the 1971-80 gaged daily flow of the Arkansas River near Coolidge for the consecutive time periods 1980 through 1989 and 1990 through 1999. In other words, the gaged daily flow near Coolidge on January 1, 1971, was used for the streamflow on January 1, 1980, and January 1, 1990. The dates correspond until gaged daily flow on December 31, 1980, was used for the streamflow on December 31, 1989, and December 31, 1999.

OPTION B - Cycle the 1971-80 average monthly flow of the Arkansas River near Coolidge for the time period 1980-99. In other words, averages of the individual months during the 1971-80 time period were used as daily flow from 1980 through 1999.

OPTION C - Cycle the 1976-80 gaged daily flow of the Arkansas River near Coolidge for the consecutive time periods 1980-84, 1985-89, 1990-94, and 1995-1999. This is similar to option A, except that the gaged daily flow near Coolidge on January 1, 1976, was used for the streamflow on January 1, 1980, January 1, 1985, January 1, 1990, and January 1, 1995.

OPTION D - Cycle the 1979 gaged daily flow of the Arkansas River near Coolidge throughout the 1980-99 projection.

Aquifer Parameters

Values for hydraulic conductivity, a measure of the aquifer's ability to transmit water, and saturated thickness, which is dependent on water levels, were used by the model to compute the required transmissivity distribution during the simulation. An area-constant hydraulic conductivity of 800 ft/d was used in the calibrated model for the Arkansas River alluvium. This was the same value used in the investigation by Barker and others (1983, p. 25).

The magnitude of water-level change that occurs in a water-table aquifer in response to recharge or discharge of ground water depends on the specific yield. The Arkansas River model used a simple distribution of specific yield that ranged in value from 0.14 to 0.20. This was the same distribution used by Barker and others (1983, p. 26).

Discharge

Pumpage and Pumpage Options 1-6

The largest vertical discharge from the aquifer was pumpage. The pumpage history of the modeled area was estimated by making an inventory of public-supply and irrigation wells in the area and by computing monthly pumpage rates for those wells from energy-consumption and, in a few instances, water-right and billing records. Area-wide averages were determined from monthly pumpage rates, where available, and applied to annual totals for other wells to provide the monthly patterns of pumpage throughout the area (Barker and others, 1983). Variations in these pumpage estimates and the appropriated amount on the landowner's water right were used in the 1980-99 projections.

Six hypothetical pumpage conditions were used in the 1980-99 projections. They were:

OPTION 1 - Includes pumpage from all wells in the study area (147 wells as of 1981) that had water rights from the Division of Water Resources. Pumpage rates were determined from 1979 energy-consumption, water-right, or billing records. The 1979 calculated ground-water withdrawals are greater than the appropriated rights when this technique is used to determine pumpage.

OPTION 2 - Includes pumpage from all wells in the study area that had water rights as of 1981. Pumpage rates were determined from the amount of water appropriated on the water rights. This option includes 152 wells. Five additional wells were added, in addition to those in option 1, that did not pump during 1978 or 1979.

OPTION 3 - Includes pumpage from all wells that had water rights, plus pumpage from 12 existing wells for which permits were pending (159 wells as of 1981). Pumpage rates for all these wells were determined from 1979 energy-consumption, water-right, or billing records.

OPTION 4 - Includes pumpage from all wells that had water rights, pumpage from existing wells for which permits were pending, plus pumpage from an additional 19 proposed wells for which permits were pending (178 wells as of 1981). Pumpage rates for wells with water rights and existing wells for which permits were pending were determined from 1979 energy-consumption, water-right, or billing records. Pumpage rates for proposed wells for which permits were pending were based on the amounts of water requested by well applications.

OPTION 5 - Includes the same wells as in OPTION 4 but use pumpage rates determined from the amount of water appropriated on the water right or requested by well application. This option includes 183 wells. Five additional wells were added, in comparison to to option 4, that did not pump during 1978 or 1979.

OPTION 6 - Includes the same wells as in OPTION 3 but increase the 1979 pumpage rate of each well by 50 percent (159 wells).

Monthly patterns of the six hypothetical annual pumpage conditions were cycled 20 times over the 20-year projection period.

Stream-Aquifer Leakage

The exchange of water between the Arkansas River and the alluvium occurs through the streambed. Stream-aquifer leakage can be either a source of recharge or discharge to the aquifer. A streambed-leakance value of 1.34 d^{-1} was used for all riverbed nodes in the model (Barker and others 1983, p. 30).

Ground-Water Evapotranspiration

Significant discharge can occur from the Arkansas River alluvial aquifer as ground-water evapotranspiration when the water table is above the root zone or within reach of roots through capillary attraction. Ground-water evapotranspiration can completely satisfy the consumptive-use demand by plants if the water table is at or above land surface. That part of the deficit that can be met when the water table is below land surface declines by about 8 percent per each additional foot below land surface, reaching zero at depths of 12 feet and greater. Ground-water evapotranspiration was calculated by the model in the same manner as in the previous investigation (Barker and others, 1983, p. 34).

Recharge

Deep Percolation

Recharge to the ground-water system occurs as water infiltrates from the land surface through the soil zone to the aquifer. The sources of water that may infiltrate from the land surface are precipitation and irrigation water (including both well pumpage and surface-water diversion). The amount of deep percolation depends on the amount of precipitation and irrigation water applied to the land surface, the rate of consumptive-use demand by plants, and the moisture-holding capacity of the soil zone. The model used a composite area-weighted average of crop and land-use categories to determine the consumptive-use demands (Barker and others, 1983).

Precipitation

When precipitation exceeds storage capacity of the soil, it recharges the aquifer as part of deep percolation. Precipitation in the moratorium area ranges from about 14.5 in/yr near the Colorado-Kansas State line to about 17.5 in/yr at Lakin. The 30-year (1941-70) normal precipitation at Syracuse, near the center of the modeled area, is 16.86 in/yr. The monthly normal precipitation at Syracuse was used in the model for the 1980-99 projections.

SIMULATED WATER-LEVEL CHANGES

Sixteen model simulations were made projecting streamflow at the Colorado-Kansas State line and pumpage from January 1980 through December 1999. For discussion herein, these projections are numbered 1 through 16. Water-level changes simulated by the model from January 1, 1980, to December 31, 1999, were used to illustrate the aquifer response.

Use of cyclic patterns of streamflow at the Colorado-Kansas State line and pumpage caused the alluvial aquifer to reach steady-state conditions after a period of time ranging from 3 to 5 years. Steady state is described as a state of dynamic equilibrium in which recharge virtually balances discharge. There is no long-term water-level change nor change of water in storage. In the strictest sense a constant, or single, steady-state condition will never exist in a large-scale stream-aquifer system due to year-to-year changes in recharge and discharge (for example: pumpage, streamflow, precipitation, etc.). However, if the hydrologic system undergoes changes of a uniform and cyclic nature, such as the cyclic patterns of streamflow and pumpage used in the model projections, then the system may reach a dynamic steady-state condition where changes in storage are consistent within each cycle.

After steady-state conditions are reached, the water level in the aquifer will change in response to a change in streamflow to maintain equilibrium. The streamflow at the Colorado-Kansas State line was cycled every 1 year for option B and every 5 years for option C. Therefore, after steady state is reached, the water-level altitude in the aquifer will be similar whenever the streamflow at the State line is repeated (every 1 and 5 years). Because streamflow option A is a 10-year repeating cycle, the water-level altitude on December 31, 1999, will be similar to the altitude on December 31, 1990. Therefore, a water-level-change map from January 1980 to December 1999 is also representative of the change from January 1980 to December 1989 in each of the options.

The model boundaries on the east and west maintained the water level at the December 31, 1979, altitude throughout the 1980-99 projections. Therefore, the water-level change at these boundaries was artificially held at zero, and the nearby changes should be viewed with caution. A 1980-99 projection, using a constant rate of water-level decline equal to 0.4 ft/yr (as used in the previous study by Barker and others, 1983) and based on the observed decline of water levels between 1970-79 in wells near the east and west boundaries of the model area, was made to determine the effect of the imposed constant heads at the east and west boundaries. Pumpage option 1 and streamflow option A were used for the projection. Water levels ranged from 8 feet lower at the boundaries to less than 0.2 foot lower near the center of the model area using a constant rate of decline as compared to using constant heads. Boundary inflow was 55 percent lower, and boundary outflow was 5 percent higher using a constant rate of decline, resulting in the greater simulated water-level declines. The projection indicated that the effect of the imposition of constant heads for the east and west boundaries does not significantly affect water levels except for areas near the boundaries. The net annual river loss was 5 percent (1,228 acre-ft/yr) greater for the projection using a constant rate of decline as compared to using constant heads, partially compensating for the decreased net boundary flow available to the system experienced using a constant rate of decline. A uniform rate of water-level decline was not used for the 16 projections because of the unpredictability of water-level trends in the distant future.

In the following sections the projections using pumpage options 1 through 5 are compared for streamflow options A, B, and C. Pumpage option 6 and streamflow option D are discussed separately. Pumpage options 1, 3, and 4 are variations in the number of wells in the study area, using the continued 1979 conditions of pumpage. Pumpage options 2 and 5 are variations in the number of wells in the study area, with each well pumping the appropriated amount of water on the water right or well application. Pumpage option 6 increased the 1979 pumpage rate for existing wells by 50 percent. The projection numbers of the combinations of streamflow and pumpage rates used are shown in table 1.

Table 1.--Relationship among streamflow options, pumpage options, and projection numbers

Pumpage option	Streamflow option A	B	C	D
	Projection number			
1	1	6	11	NC[1/]
2	2	7	12	NC
3	3	8	13	NC
4	4	9	14	NC
5	5	10	15	NC
6	NC	NC	NC	16

1 NC = not compared.

In this report, "continued 1979 pumpage rates" refers to pumpage option 1, which includes 147 wells and 60,540 acre-feet of pumpage. Although the terminology is similar to that used under "continued 1979 conditions" in the previous report by Barker and others (1983), it should be noted that none of the projections use exactly the same conditions. Pumpage option 3 in this report is similar in comparison to the number of wells and pumpage used by Barker and others (1983); however, the streamflow conditions that were used with option 3 are not similar to the conditions used by Barker and others (1983).

Streamflow Option A and Pumping Options 1-5

For streamflow option A, streamflow at the Colorado-Kansas State line was cycled on a 10-year basis using the 1971-80 gaged daily streamflow near Coolidge. This section describes the effects of pumpage options 1 through 5 and streamflow option A on the change in water levels in the aquifer and net annual river loss. Water-level-change maps for 1980-99 for each projection (figs. 4-19) were derived using 1980-99 simulated water-level changes at all nodes in the digital model grid (Barker and others, 1983).

Projection 1 combined streamflow option A and pumpage option 1. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 4). Most of the rise in water levels occurred near the northern boundary along the river. As shown in table 2, pumpage in projection 1 averaged 60,540 acre-ft/yr, deep percolation averaged 50,130 acre-ft/yr, and net river loss averaged 23,360 acre-ft/yr.

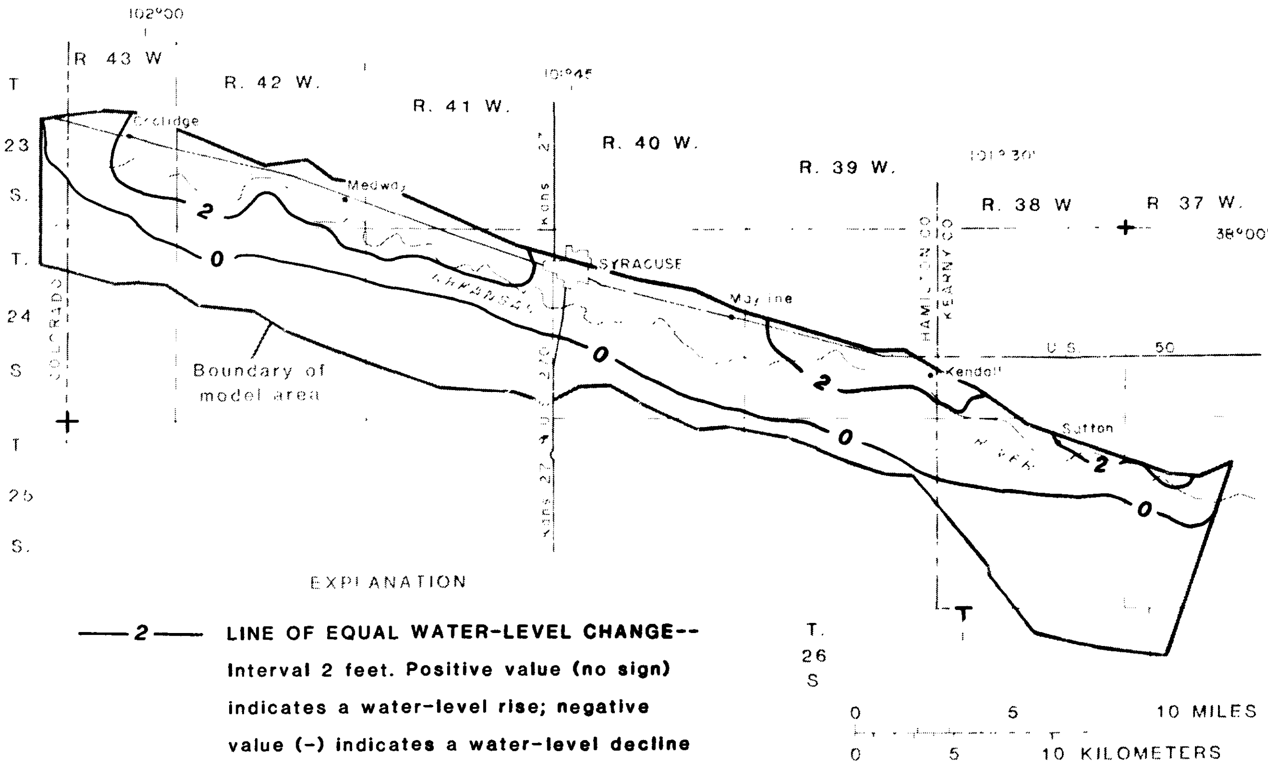

Figure 4.--Water-level change, 1980-99, using streamflow option A and pumpage option 1 (projection 1).

Table 2.--Pumpage, deep percolation, and net river loss for projections 1-16

Projection number	Pumpage option	Stream-flow option	Number of wells	Pumpage (acre-feet per year)	Deep percolation (acre-feet per year)	Net river loss (acre-feet per year)
1	1	A	147	60,540	50,130	23,360
2	2	A	[1]152	46,030	35,620	23,170
3	3	A	159	64,700	52,520	24,140
4	4	A	178	71,960	57,320	25,130
5	5	A	[1]183	57,840	43,240	24,930
6	1	B	147	60,540	50,130	26,380
7	2	B	152	46,030	35,620	26,310
8	3	B	159	64,700	52,250	27,340
9	4	B	178	71,960	57,320	28,740
10	5	B	183	57,840	43,240	28,660
11	1	C	147	60,540	48,500	21,450
12	2	C	152	46,030	33,940	21,150
13	3	C	159	64,700	50,900	22,050
14	4	C	178	71,960	55,610	22,610
15	5	C	183	57,840	41,500	22,280
16	6	[2]D	159	97,050	80,280	11,140

[1] Pumpage options 2 and 5 include five wells that did not pump during 1978 or 1979.

[2] Projection 16 uses continued 1979 streamflow.

Projection 2 combined streamflow option A and pumpage option 2. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 5). Most of the rise in water levels occurred near the northern boundary along the river. Pumpage in projection 2 averaged 46,030 acre-ft/yr, deep percolation averaged 35,620 acre-ft/yr, and net river loss averaged 23,170 acre-ft/yr.

Comparing projection 2 with projection 1 revealed that pumping a quantity of water equal to the amounts appropriated on water rights, instead of continuing 1979 pumpage rates, would decrease the annual pumpage by 24 percent. However, net annual river loss would decrease by only 1 percent. The water-level-change maps appear similar (figs. 4 and 5).

The ratio of deep percolation to pumpage was higher (83 percent) when wells pumped at the continued 1979 rate rather than pumping the appropriated amount (77 percent). In this case, increased pumpage from a given number of wells had the effect of recycling the additional water by recharge back to the aquifer, resulting in a negligible difference in the amount of ground water in storage.

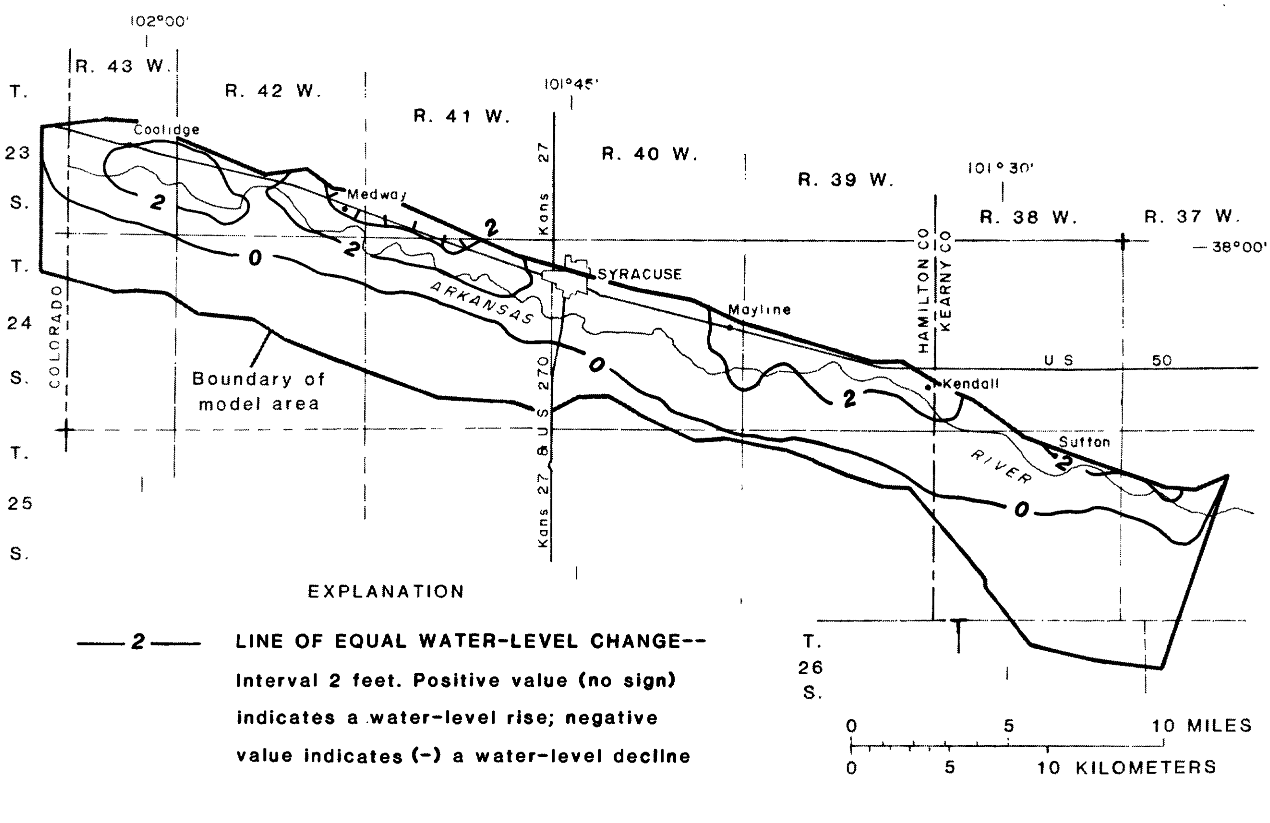

Figure 5.--Water-level change, 1980-99, using streamflow option A and pumpage option 2 (projection 2).

Projection 3 combined streamflow option A with pumpage option 3. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 6). Most of the rise in water levels occurred near the northern boundary along the river. Pumpage in projection 3 averaged 64,700 acre-ft/yr, deep percolation averaged 52,520 acre-ft/yr, and net river loss averaged 24,140 acre-ft/yr.

Comparing projection 3 with projection 1 revealed that including pumpage from existing wells for which permits were pending increased the annual pumpage by 7 percent and increased the net annual river loss by 3 percent. The water-level-change maps are very similar (figs. 4 and 6).

When pumpage was increased over the 1979 rates in the modeled area and distributed to new pumpage locations, additional ground water was removed from storage in the aquifer and net annual river loss increased. This is because the additional crops irrigated at the new sites increased the crop consumptive use. Therefore, more water was consumed by plants in the soil zone, and the ratio of deep percolation to pumpage decreased to 81 percent. The increased pumpage was not recycled completely back to the aquifer as it was in projection 1.

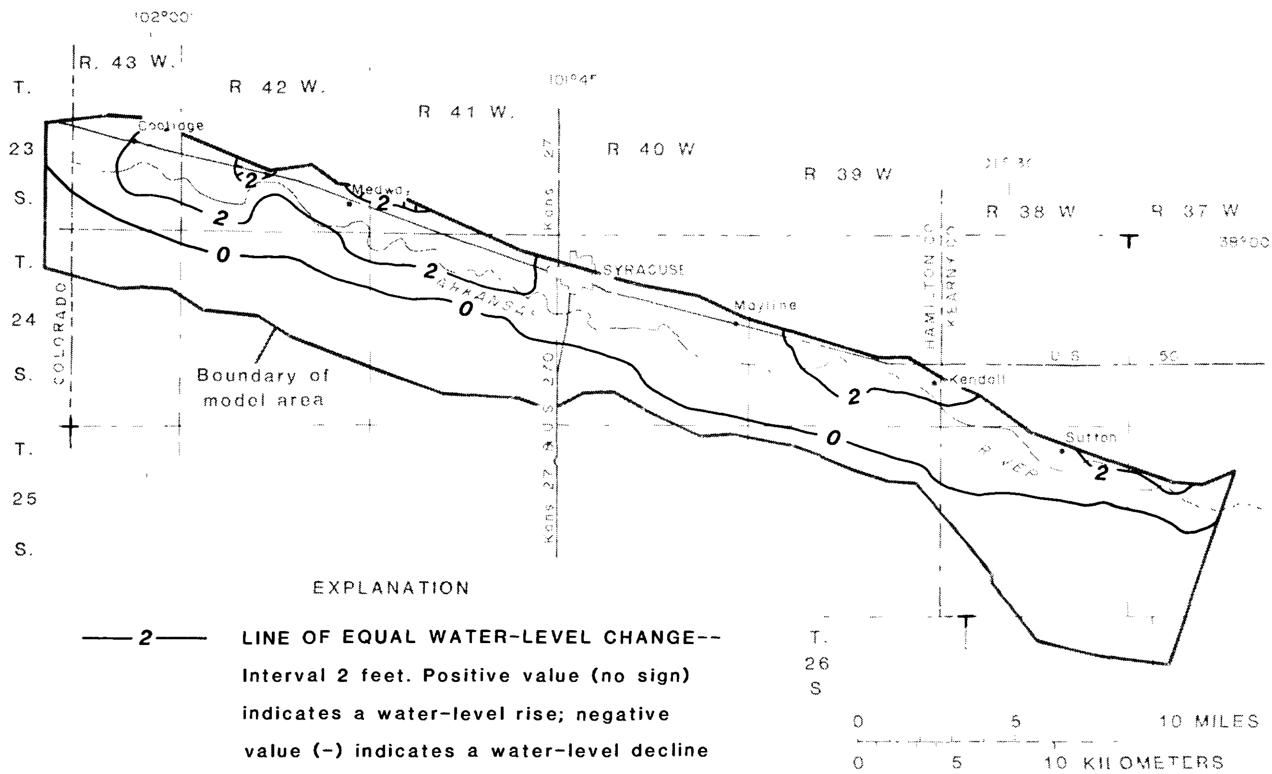

Figure 6.--Water-level change, 1980-99, using streamflow option A and pumpage option 3 (projection 3).

Projection 4 combined streamflow option A with pumpage option 4. The water-level change ranged from less than 4 feet of decline to less than 4 feet of rise (fig. 7). Most of the rise in water levels occurred near the northern boundary along the river. Pumpage in projection 4 averaged 71,960 acre-ft/yr, deep percolation averaged 57,320 acre-ft/yr, and net river loss averaged 25,130 acre-ft/yr.

Comparing projection 4 with projection 1 revealed that including both existing and proposed wells for which permits were pending increased the annual pumpage by 19 percent and increased the net annual river loss by 8 percent. A comparison of the water-level-change maps indicated that the rise in water levels would be slightly less in projection 4 than in projection 1 (figs. 4 and 7).

Projection 5 combined streamflow option A with pumpage option 5. The water-level change ranged from less than 4 feet of decline to less than 4 feet of rise (fig. 8). The largest area of decline occurred in the southwestern part of the model area. Pumpage in projection 5 averaged 57,840 acre-ft/yr, deep percolation averaged 43,240 acre-ft/yr, and net river loss averaged 24,930 acre-ft/yr.

Comparing projection 5 with projection 2 revealed that including both existing and proposed wells for which permits were pending increased the appropriated annual pumpage by 26 percent and increased the net annual river loss by 8 percent. A comparison of the water-level-change maps indicated that the rise in water levels would be noticeably less in projection 5 than in projection 2 (figs. 5 and 8), which explains the increase in the net annual river loss.

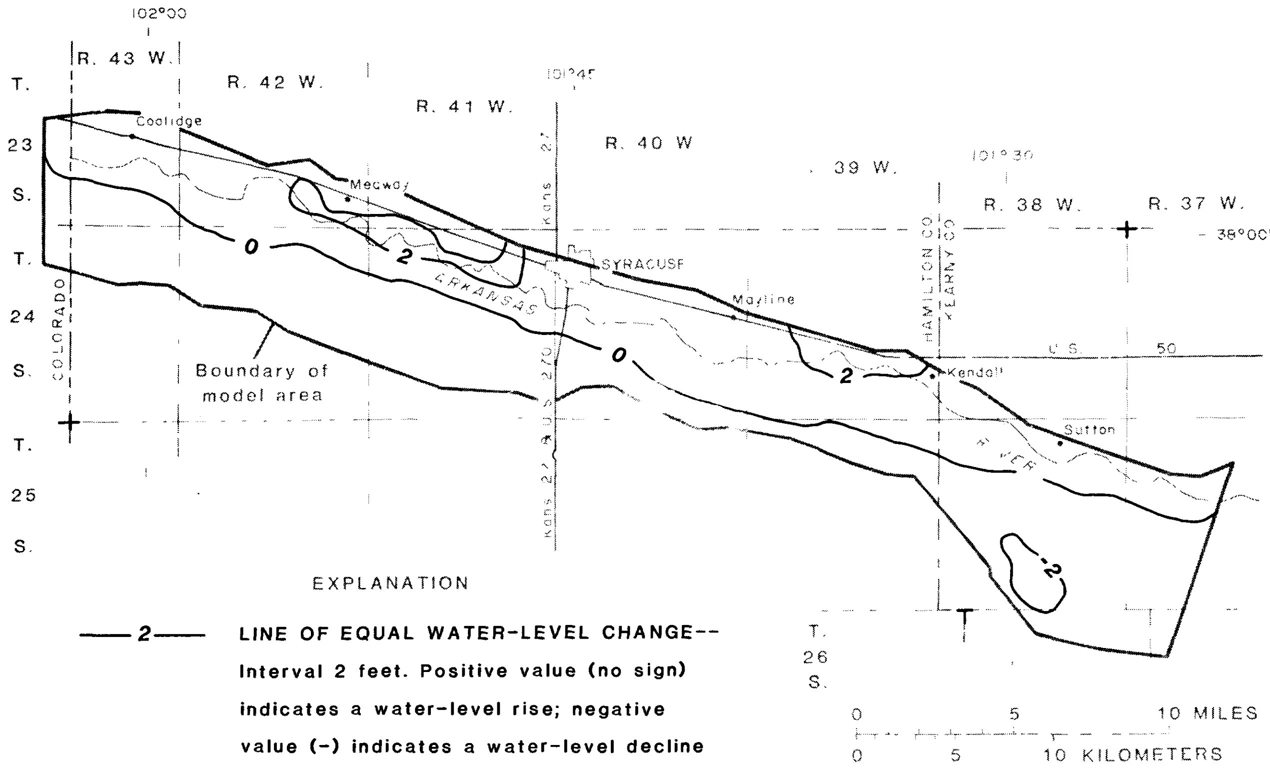

Figure 7.--Water-level change, 1980-99, using streamflow option A and pumpage option 4 (projection 4).

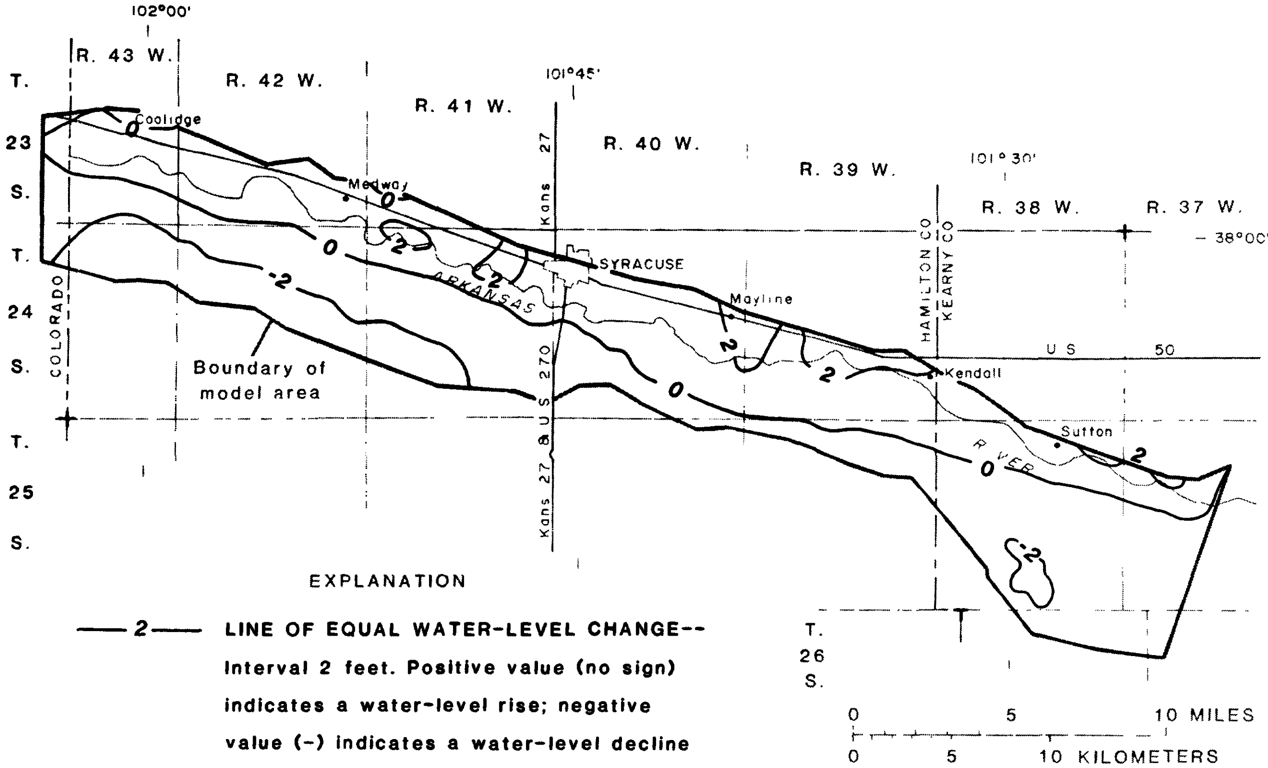

Figure 8.--Water-level change, 1980-99, using streamflow option A and pumpage option 5 (projection 5).

The results of a comparison between projection 5 and projection 4 are essentially the same as the comparison between projection 2 and projection 1. There is a greater difference in the water-level-change maps for projections 4 and 5 because there is a greater difference in ground-water storage than there is between projections 1 and 2. Much of the additional water from increased pumpage again was recycled back to the aquifer.

Streamflow Option B and Pumpage Options 1-5

For streamflow option B, the Colorado-Kansas State line streamflow of the Arkansas River was cycled on an annual basis using the gaged 1971-80 average monthly streamflow near Coolidge. This section describes the effects of pumpage options 1 through 5 and streamflow option B on the changes in water levels and net annual river loss.

Projection 6 combined streamflow option B and pumpage option 1. The water-level change ranged from less than 2 feet of decline to less than 6 feet of rise (fig. 9). Most of the rise occurred along the river in the western one-half of the study area. Pumpage in projection 6 averaged 60,540 acre-ft/yr, deep percolation averaged 50,130 acre-ft/yr, and net river loss averaged 26,380 acre-ft/yr.

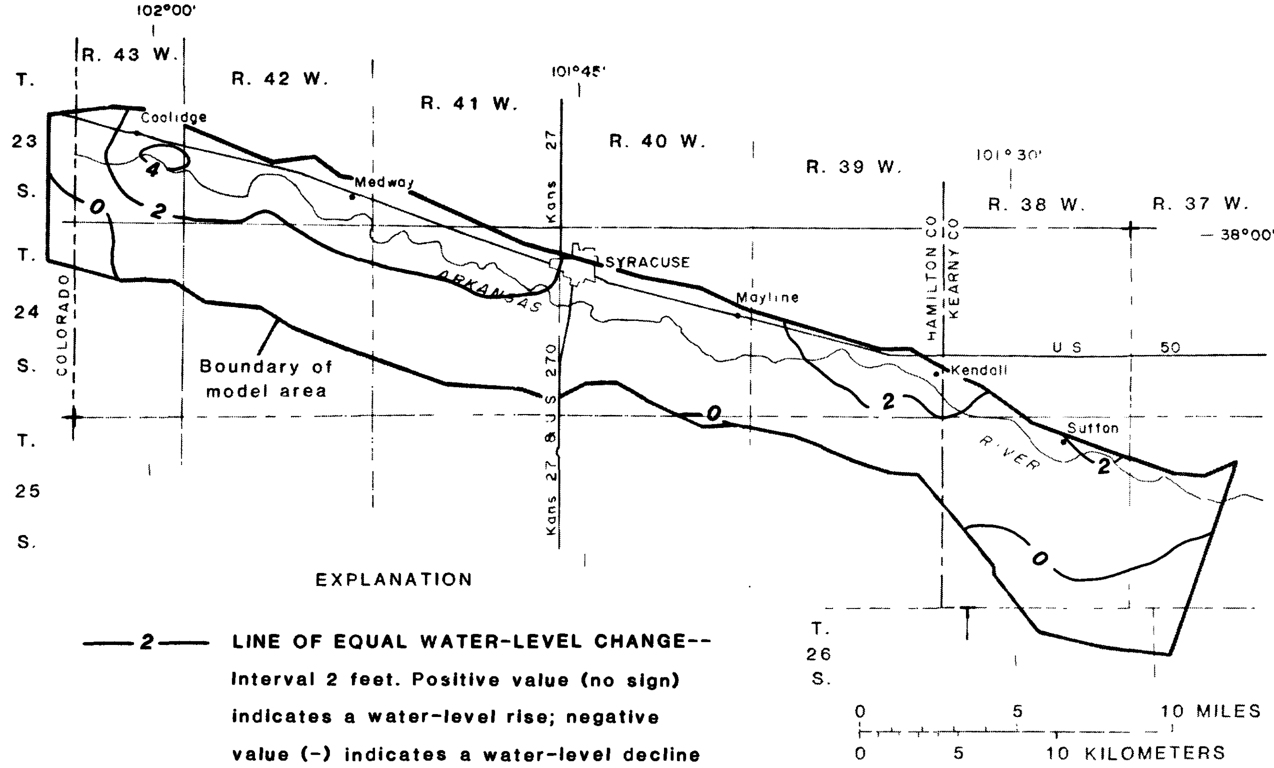

Figure 9.--Water-level change, 1980-99, using streamflow option B and pumpage option 1 (projection 6).

Projection 7 combined streamflow option B and pumpage option 2. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 10). Most of the rise occurred along the river in the western one-half of the modeled area. Pumpage in projection 7 averaged 46,030 acre-ft/yr, deep percolation averaged 35,620 acre-ft/yr, and net river loss averaged 26,310 acre-ft/yr.

Comparing projection 7 with projection 6 revealed that if the amount appropriated by water rights was pumped, then net annual river loss would decrease by less than 1 percent. The water-level-change maps appear similar (figs. 9 and 10). This is because a higher percentage of the pumped water in projection 6 (83 percent) returns to the aquifer via deep percolation than in projection 7 (77 percent). In this case, increased pumpage from a given number of wells had the effect of recycling the additional water back to the aquifer, resulting in a negligible difference in the ground water in storage and the net annual river loss.

Projection 8 combined streamflow option B with pumpage option 3. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 11). Most of the rise occurred along the river in the western one-half of the model area. Pumpage in projection 8 averaged 64,700 acre-ft/yr, deep percolation averaged 52,520 acre-ft/yr, and net river loss averaged 27,340 acre-ft/yr.

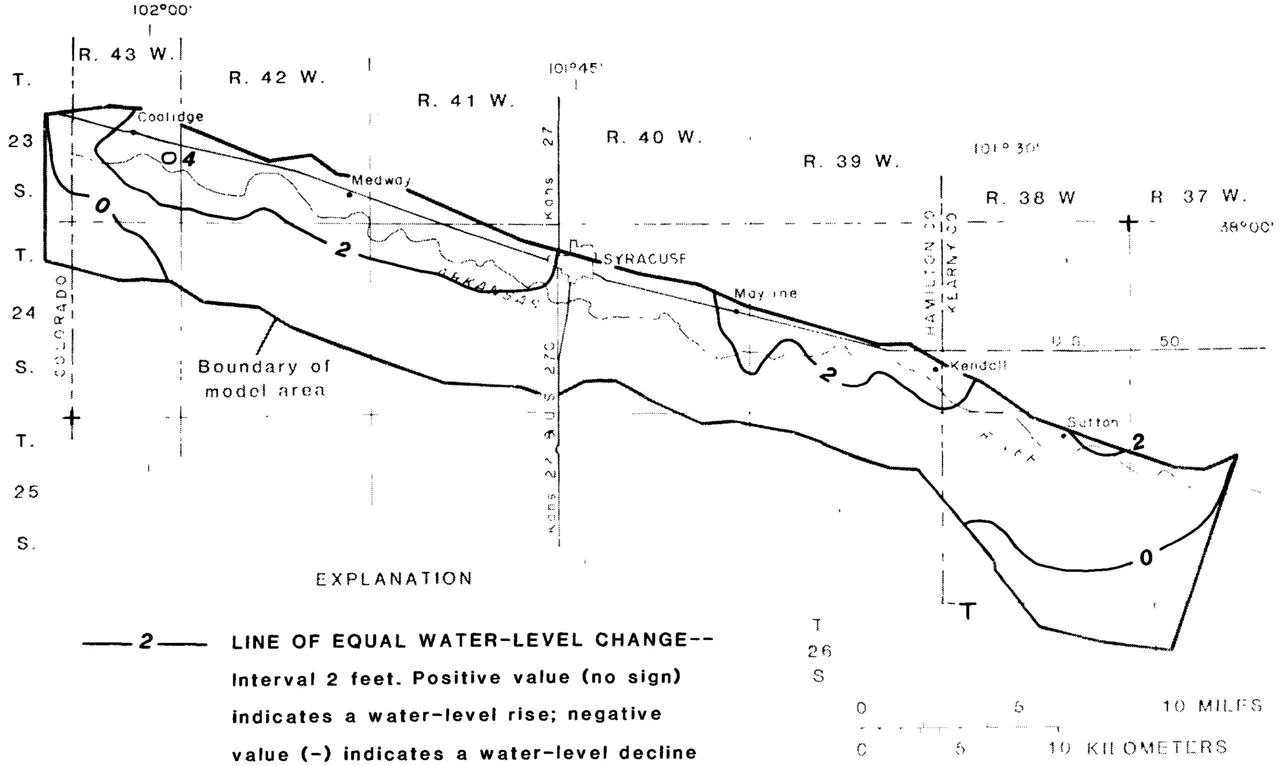

Figure 10.--Water-level change, 1980-99, using streamflow option B and pumpage option 2 (projection 7).

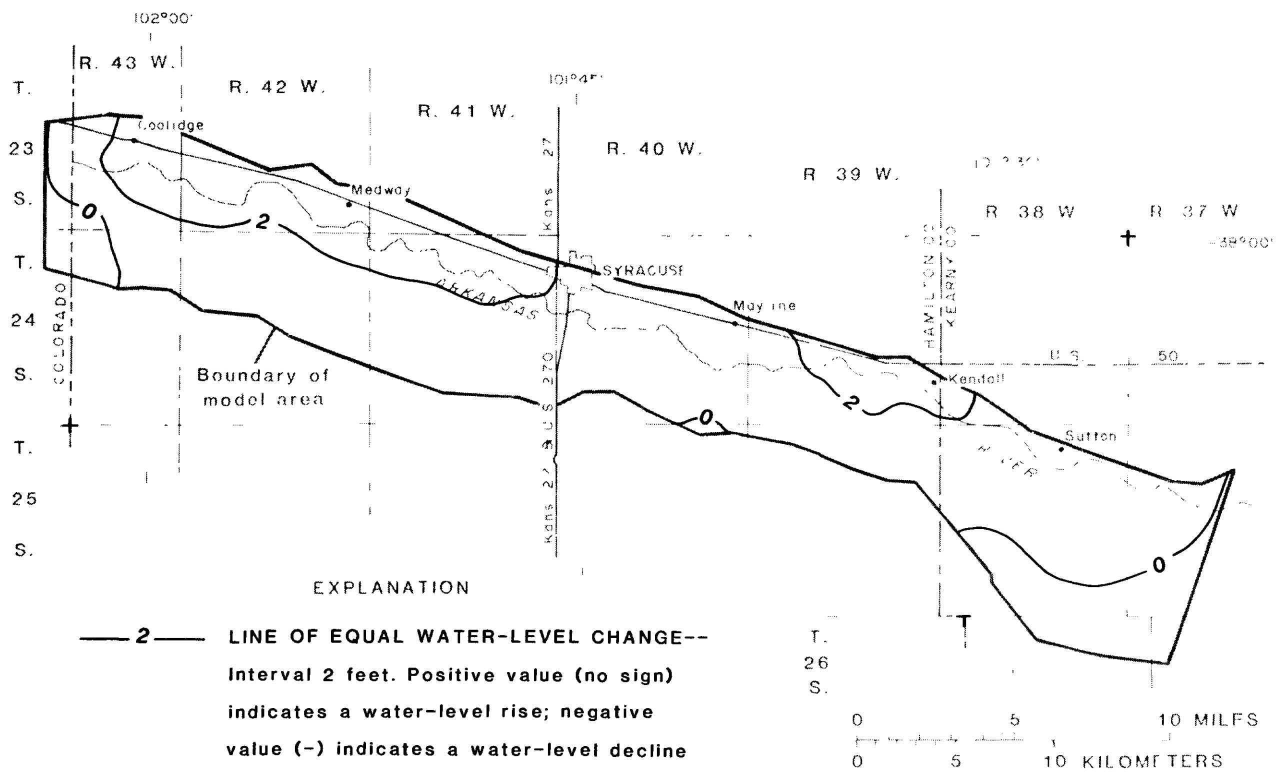

Figure 11.--Water-level change, 1980-99, using streamflow option B and pumpage option 3 (projection 8).

Comparing projection 8 with projection 6 revealed that including the existing wells for which permits were pending increased the net annual river loss by 4 percent. The water-level-change maps are similar (figs. 9 and 11). As in streamflow option A, when pumpage in the model area was increased in the form of new well sites, additional ground water was removed from storage in the aquifer and net annual river loss increased. This is because when additional well sites were included in the study area, crop consumptive use was increased with the additional crops, and the ratio of deep percolation to pumpage decreased. Therefore, the increased pumpage was not completely recycled back to the aquifer as it was in projection 6.

Projection 9 combined streamflow option B with pumpage option 4. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 12). Most of the rise was along the river in the western one-half of the study area. Pumpage in projection 9 averaged 71,960 acre-ft/yr, deep percolation averaged 57,320 acre-ft/yr, and net river loss averaged 28,740 acre-ft/yr.

Comparing projection 9 with projection 6 revealed that including both existing and proposed wells for which permits were pending increased the net annual river loss by 9 percent. A comparison of the water-level-change maps indicated that the rise in water levels would be slightly less in projection 9 than in projection 6 (figs. 9 and 12), which explains the increase in the net annual river loss.

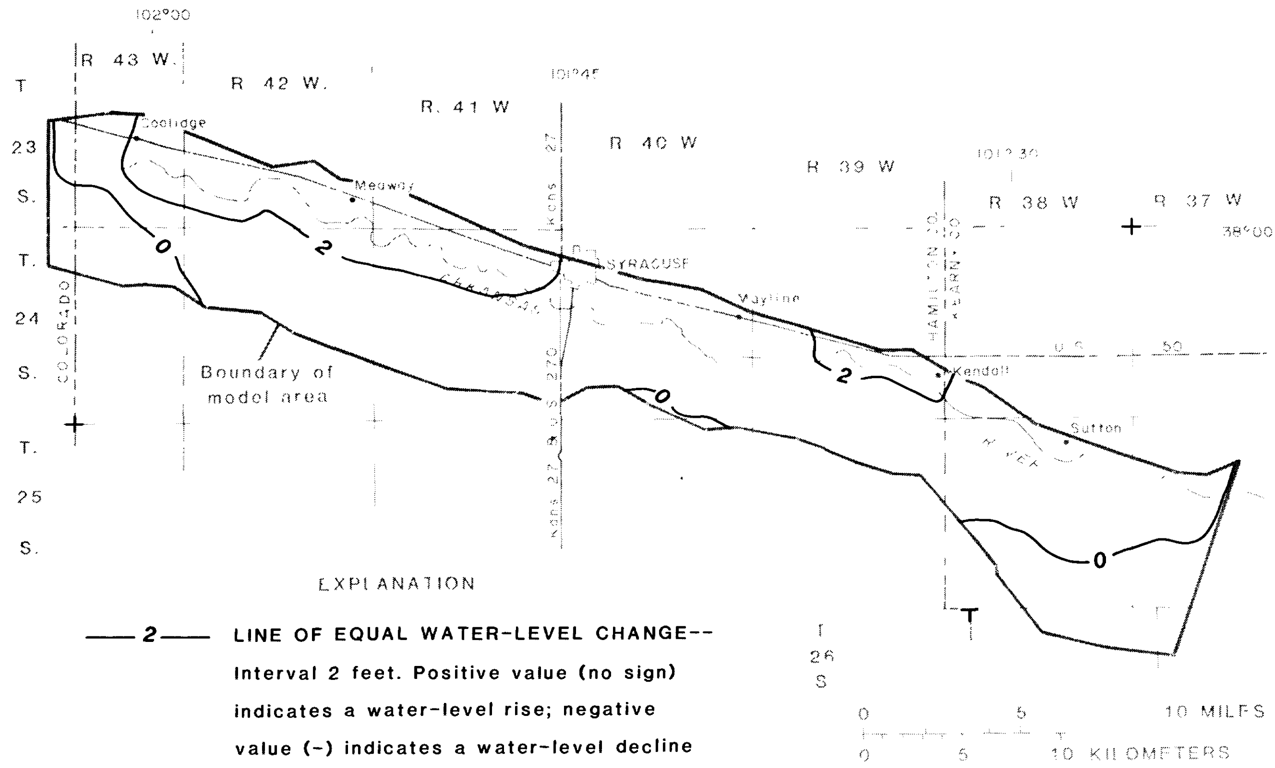

Figure 12.--Water-level change, 1980-99, using streamflow option B and pumpage option 4 (projection 9).

Projection 10 combined streamflow option B with pumpage option 5. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 13). The largest area of rise occurred along the river in the western one-half of the study area. Pumpage in projection 10 averaged 57,840 acre-ft/yr, deep percolation averaged 43,240 acre-ft/yr, and net river loss averaged 28,660 acre-ft/yr.

Comparing projection 10 with projection 7 revealed that including both existing and proposed wells for which permits were pending increased the net annual river loss by 9 percent. A comparison of the water-level-change maps indicated that the rise in water levels would be slightly less in projection 10 than in projection 7 (figs. 10 and 13), which explains the increase in the net annual river loss.

Streamflow Option C and Pumpage Options 1-5

For streamflow option C, the Colorado-Kansas State line streamflow of the Arkansas River was cycled on a 5-year basis using the 1976-80 gaged daily streamflow near Coolidge. This section describes the effects of pumpage options 1 through 5 and streamflow option C on the change in water levels and net annual river loss.

Projection 11 combined streamflow option C and pumpage option 1. The water-level change ranged from less than 2 feet of decline to less than 4 feet of rise (fig. 14). Most of the decline occurred along the southern boundary. Pumpage in projection 11 averaged 60,540 acre-ft/yr, deep percolation averaged 48,500 acre-ft/yr, and net river loss averaged 21,450 acre-ft/yr.

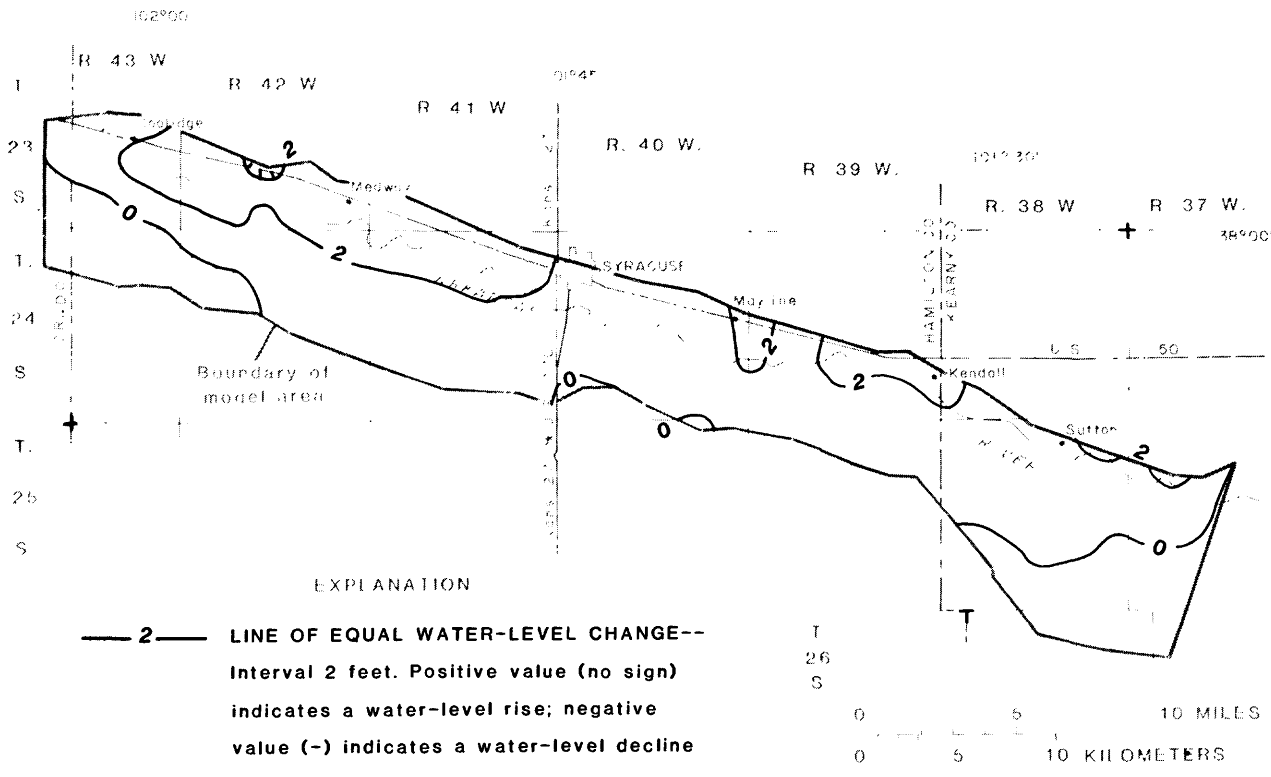

Figure 13.--Water-level change, 1980-99, using streamflow option B and pumpage option 5 (projection 10).

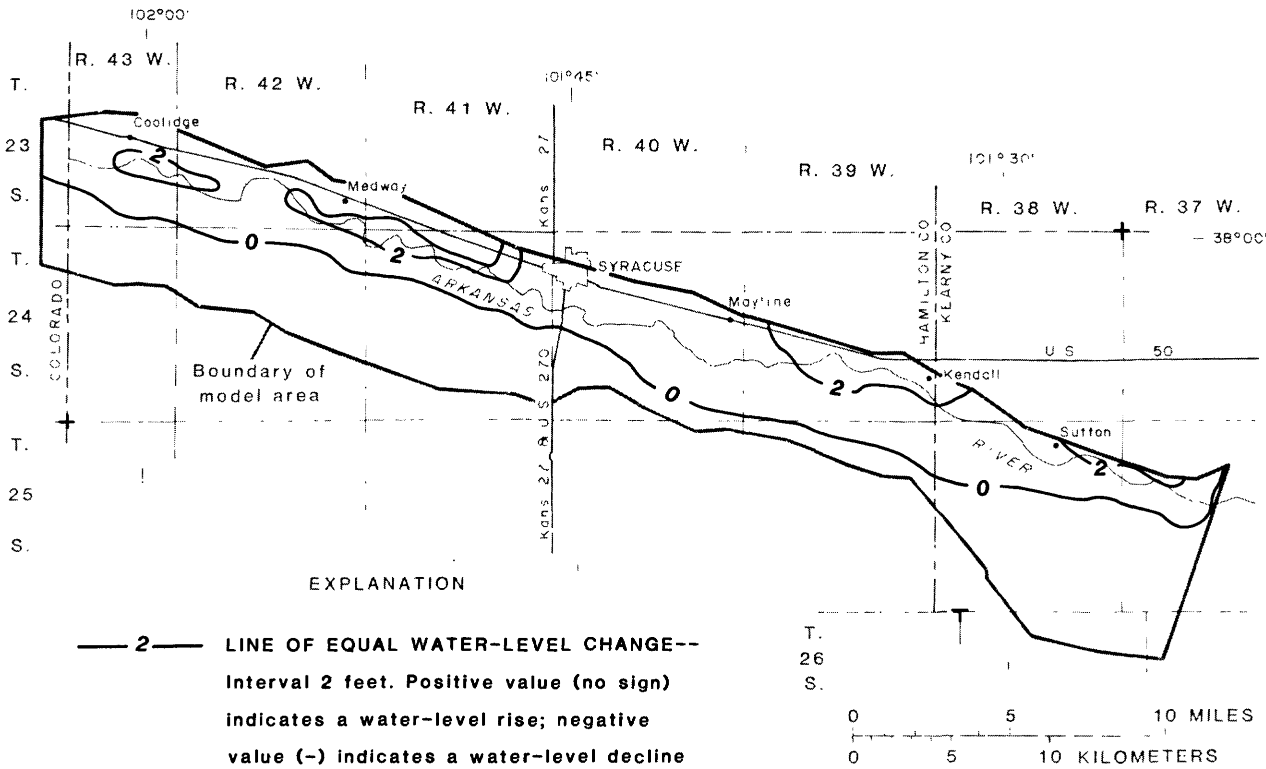

Figure 14.--Water-level change, 1980-99, using streamflow option C and pumpage option 1 (projection 11).

Projection 12 combined streamflow option C and pumpage option 2. The water-level change ranged from less than 4 feet of decline to less than 4 feet of rise (fig. 15). Most of the decline occurred along the southern boundary of the modeled area. Pumpage in projection 12 averaged 46,030 acre-ft/yr, deep percolation averaged 33,940 acre-ft/yr, and net river loss averaged 21,150 acre-ft/yr.

Comparing projection 12 with projection 11 revealed that if the amount appropriated by water rights was pumped, then the net annual river loss would decrease by 1 percent. The effect of increased pumpage in projection 11 was negated by increased deep percolation.

Projection 13 combined streamflow option C with pumpage option 3. The water-level change ranged from less than 4 feet of decline to less than 4 feet of rise (fig. 16). Most of the decline was in the southern one-half of the modeled area. Pumpage in projection 13 averaged 64,700 acre-ft/yr, deep percolation averaged 50,900 acre-ft/yr, and net river loss averaged 22,050 acre-ft/yr.

Comparing projection 13 with projection 11 revealed that adding the existing wells for which permits were pending increased the net annual river loss by 3 percent. A comparison of the water-level-change maps indicated that the rise in water levels would be slightly less in projection 13 than in projection 11 (figs. 14 and 16), which explains the increase in the net annual river loss.

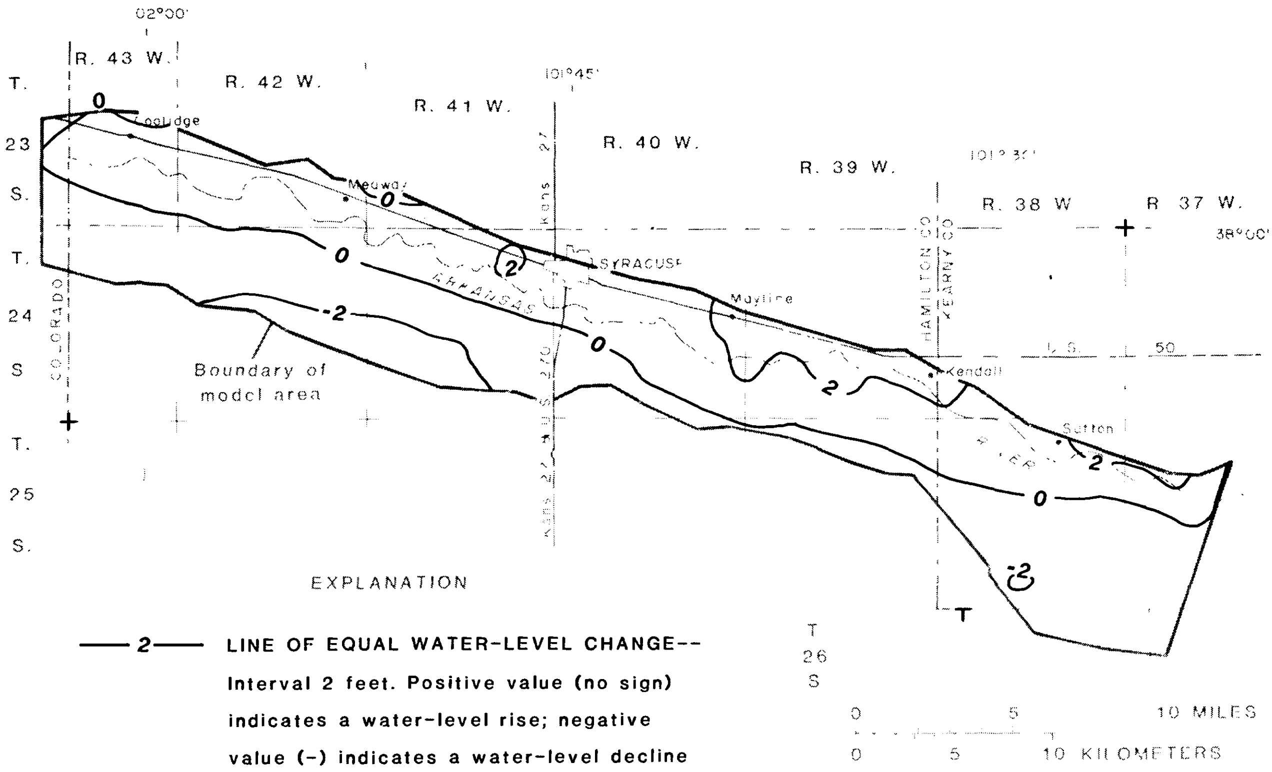

Figure 15.--Water-level change, 1980-99, using streamflow option C and pumpage option 2 (projection 12).

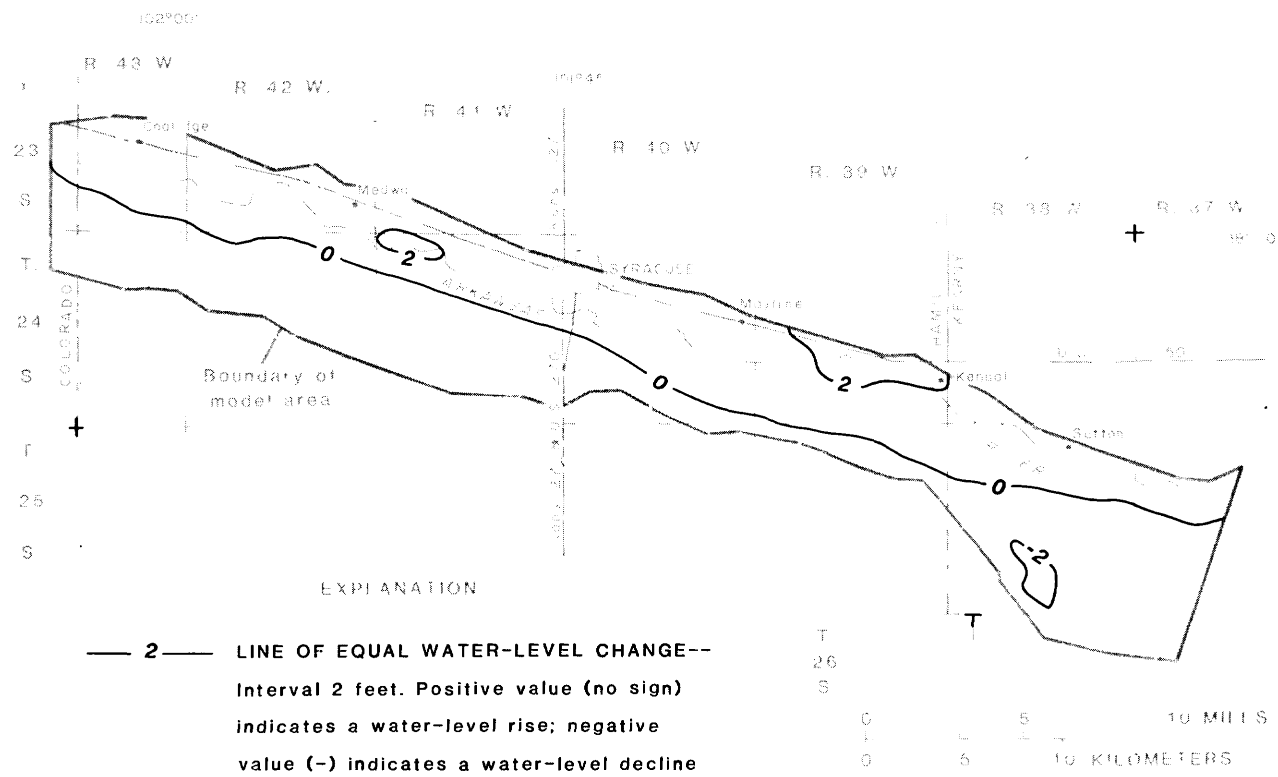

Figure 16.--Water-level change, 1980-99, using streamflow option C and pumpage option 3 (projection 13).

Projection 14 combined streamflow option C with pumpage option 4. The water-level change ranged from less than 4 feet of decline to less than 4 feet of rise (fig. 17). The largest area of decline was in the southwestern part of the model area. Pumpage in projection 14 averaged 71,960 acre-ft/yr, deep percolation averaged 55,610 acre-ft/yr, and net river loss averaged 22,610 acre-ft/yr.

Comparing projection 14 with projection 11 revealed that including both existing and proposed wells for which permits were pending increased the net annual river loss by 5 percent. A comparison of the water-level-change maps indicated that the rise in water levels would be noticeably less in projection 14 than in projection 11 (figs. 14 and 17), which explains the increased net annual river loss.

Projection 15 combined streamflow option C with pumpage option 5. The water-level change ranged from less than 4 feet of decline to less than 4 feet of rise (fig. 18). Most of the decline was in the southwestern part of the study area. Pumpage in projection 15 averaged 57,840 acre-ft/yr, deep percolation averaged 41,500 acre-ft/yr, and net annual river loss averaged 22,280 acre-ft/yr.

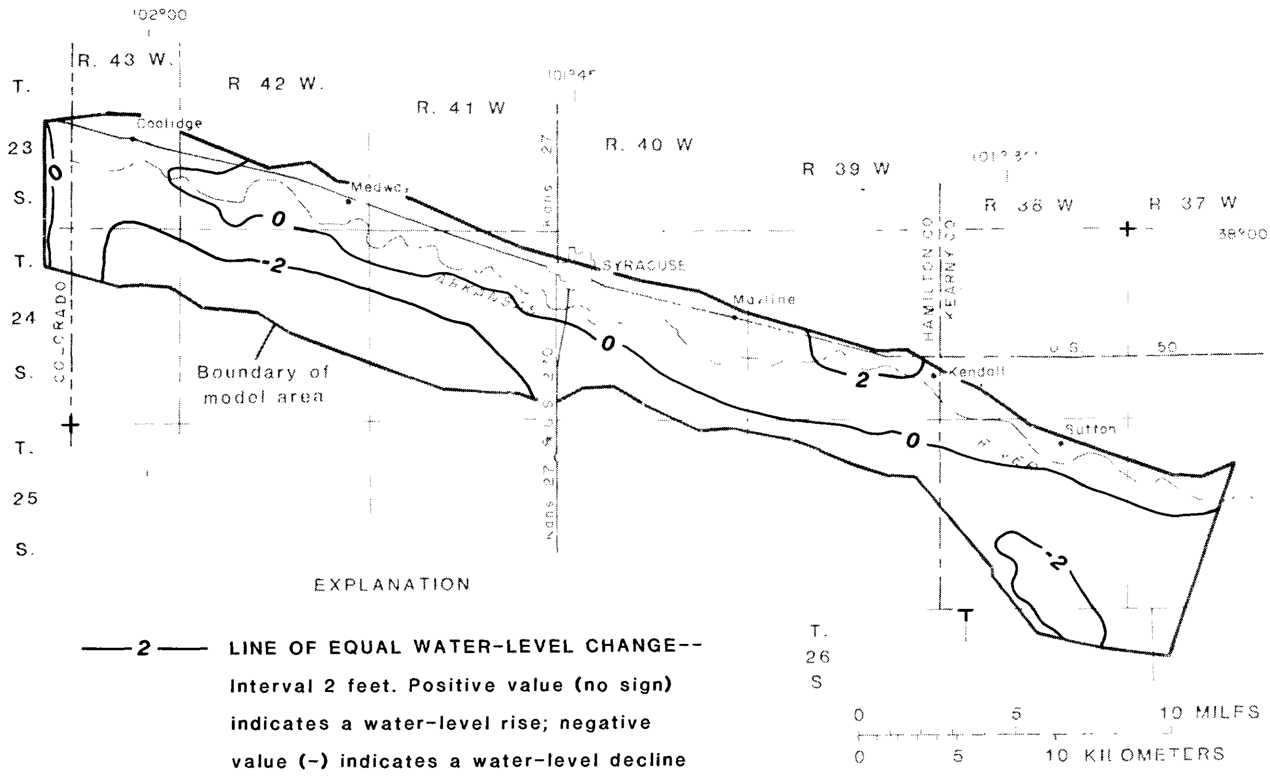

Figure 17.--Water-level change, 1980-99, using streamflow option C and pumpage option 4 (projection 14).

Comparing projection 15 with projection 12 revealed that including both existing and proposed wells for which permits were pending increased the net annual river loss by 5 percent. A comparison of the water-level-change maps indicated that the water-level declines were greater and the water-level rises were less in projection 15 than in projection 11 (figs. 15 and 18), which explains the increased net annual river loss.

Net annual river losses were smaller for streamflow option C than for options A and B because 1976-80 streamflow was generally less than 1971-75 streamflow. Deep percolation was less for streamflow option C than for options A and B because 1976-80 surface-water diversions were also less than those for 1971-75.

Streamflow Option D and Pumpage Option 6

An additional projection was made by cycling the 1979 gaged daily streamflow of the Arkansas River near Coolidge for 1980-99. The 1979 gaged flow was the lowest streamflow of the 1970's. The pumpage rate for wells that pumped during 1979 (pumpage option 3) was increased by 50 percent (pumpage option 6).

The water-level change for projection 16 ranged from 0 (resulting from the imposed constant heads at the east and west boundaries of the modeled area) to less than 8 feet of decline (fig. 19). Pumpage in projection 16 averaged 97,050 acre-ft/yr, deep percolation averaged 80,280 acre-ft/yr, and net river loss averaged 11,140 acre-ft/yr. This projection showed that water levels in the modeled area would have continued to decline in the next 20 years if the low streamflow that occurred during 1979 had continued and ground-water pumpage had increased. The net annual river loss was smaller because of the decreased streamflow in the river.

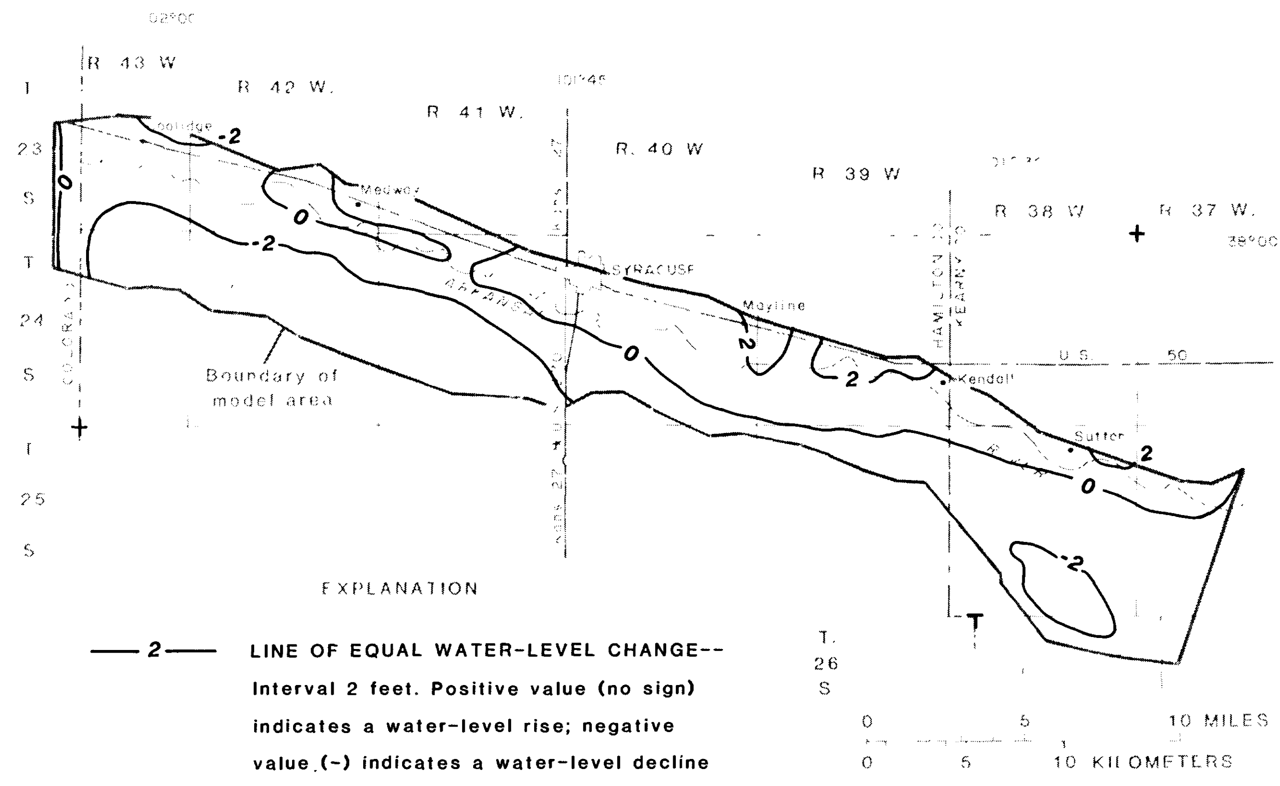

Figure 18.--Water-level change, 1980-99, using streamflow option C and pumpage option 5 (projection 15).

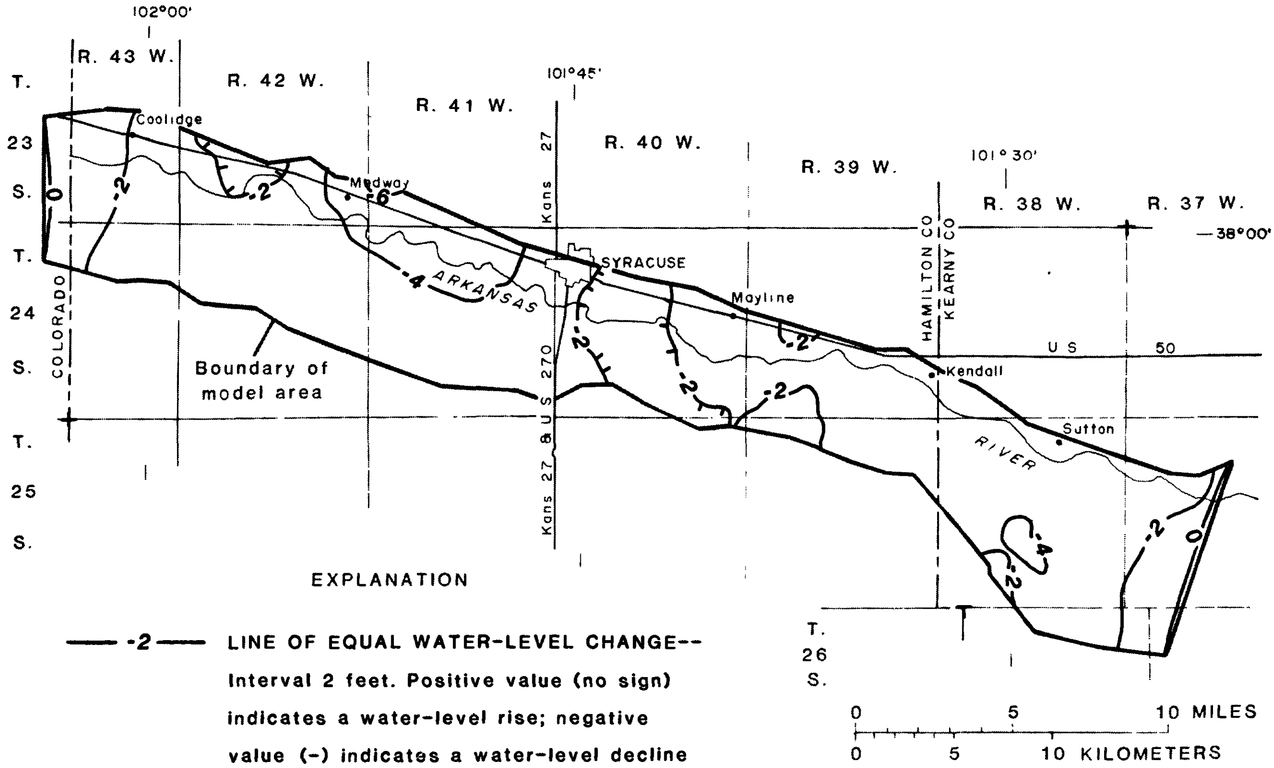

Figure 19.--Water-level change, 1980-99, using streamflow option D and pumpage option 6 (projection 16).

SUMMARY

Information was needed by the Kansas State Board of Agriculture, Division of Water Resources, on the effects that additional ground-water development would have on streamflow and water levels in an area along the Arkansas River in Hamilton and Kearny Counties, southwestern Kansas. A computer model, based on a finite-element numerical technique, was used to simulate the changes in streamflow and water levels from 1980 through 1999. Four hypothetical streamflow options and six hypothetical pumpage options were tested in the model. Pumpage options were variations in the number of wells using either the continued 1979 conditions of pumpage or the amount of water appropriated or requested by water-right applications. One pumpage option increased 1979 pumpage by 50 percent.

Results from 1980-99 simulations indicated that increased pumpage from a given number of wells, with no increase in irrigated acreage, has the effect of recycling the additional water back to the aquifer. If the amount appropriated by water rights was pumped rather than continued 1979 conditions of pumpage, annual pumpage in the modeled area would be reduced 24 percent. However, this reduction in pumpage would reduce the net annual river loss by only 1 percent. The ratio of deep percolation to pumpage was higher when wells continued to pump at 1979 rates rather than pumping the appropriated amounts, resulting in a negligible difference in the amount of ground water in storage and net annual river losses.

When pumpage in the modeled area was increased by adding new wells, additional ground water was removed from storage in the aquifer and net annual river loss increased. Additional crops irrigated by the new wells increase the crop consumptive use causing less water to percolate through the soil zone. Therefore, more water is consumed in the soil zone by plants, and the ratio of deep percolation to pumpage decreases. When pumpage from existing wells for which permits were pending was included with pumpage from wells with water rights, the pumpage at continued 1979 rates increased by 7 percent and the net annual river loss increased 3 to 4 percent.

When pumpage from both existing and proposed wells for which permits were pending was included with pumpage from wells with water rights, the pumpage at continued 1979 rates increased 19 percent and the net annual river loss increased 5 to 9 percent.

When both existing and proposed wells for which permits were pending and wells with water rights pumped the amounts appropriated on the water-right or well application, pumpage increased 26 percent over the pumpage from wells with water rights only. The net annual river loss increased by 5 to 9 percent.

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MODEL DOCUMENTATION

By Jerry E. Carr

The digital-computer model used to make the long-term projections for the Arkansas River valley in Hamilton and Kearny Counties was written by J. V. Tracy, U.S. Geological Survey. The Tracy finite-element model was selected because it offered a practical combination of features necessary to meet the project objectives. The model was desirable because it (1) added flexibility in grid design, (2) allowed simulation of the boundary conditions associated with the stream-aquifer interface and the bedrock-bounded limits of the relatively narrow alluvial aquifer, and (3) accounted for transient conditions of streamflow.

Included in this attachment are: a description of the model, sample problems, a description of program routines, flow charts, model-input setup, a description of program common blocks, variable definitions, and a program listing. The description of model-input setup, program routines, flow charts, and variable definitions were modified from those supplied by E. J. Wexler (U.S. Geological Survey, written commun., 1983).

Description of Model

The Tracy model is a two-dimensional, finite-element model based on the Galerkin finite-element method, described by Desai and Abel (1972). Additional descriptions of this method can be found in Pinder and Gray (1977). The model uses a direct-solution method to solve the partial-differential equations describing nonsteady, two-dimensional ground-water flow. The finite-element method involves subdividing the area to be modeled into subregions (called elements) having simple shapes and assuming that the solution to the partial-differential equation can be written as a linear combination of simple basis functions. See Desai and Abel (1972, pages 89-93, 114-117) and Pinder and Gray (1977, pages 99-101 and 115). By selecting the basis functions to be nonzero only over elements on which they are located, the computations are simplified. Associated with the basis functions are undetermined coefficients that are determined by applying the Galerkin scheme. This process results in a system of simultaneous equations where the unknowns are heads at points (called nodes) that are associated with the elements. This system of equations is solved using selected direct methods of matrix solutions.

The model is formulated to produce an approximate solution to the following partial-differential ground-water-flow equation:

$$\frac{\partial}{\partial x}\left(Kb\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(Kb\frac{\partial h}{\partial y}\right)=S\frac{\partial h}{\partial t}+Q \qquad (1)$$

where

- x and y are the coordinate axes [L];
- K is the hydraulic conductivity [Lt^{-1}];
- b is the saturated thickness [L];
- h is the hydraulic head [L];
- S is the storage coefficient [dimensionless];
- t is the time, [t]; and
- Q = Q (x, y, t) = net vertical flux into the aquifer from point or distributed sources (sinks), such as wells, evapotranspiration, ground-water percolation, or river-aquifer interaction [$^{L}/t$].

The model can be setup with the following options: steady-state or transient flow, water-table or confined aquifers, quadrangle or triangular elements, latitude-longitude or x, y coordinates, with or without stream-aquifer interaction, with or without drawdown calculations, with or without plot routines, and with or without evapotranspiration. The user controls the selection of these modeling options by defining eight true or false logical flags at the beginning of the data-input deck. The model is setup to calculate the location of interior nodes given the coordinates of the top and bottom grid nodes. An example of node arrangement and element numbering for a 20 x 20 node, triangular-element grid is shown in figure 20. Presently, the model has no option to allow the user to specify interior-node locations. The model can utilize any consistent set of length units; however, the unit of time is restricted to seconds, and precipitation, evapotranspiration, and soil capacity are entered in appropriate units of inches and months.

Boundary conditions in the model are specified for each node in the model as either interior, specified flux, or as specified head by the IBNODE array. Once defined in the IBNODE array, the specific flux or head values are given in the BQH array.

Stream-aquifer interaction is simulated in the model according to:

$$Q = \begin{cases} \frac{K'}{b'} (h_s - h_a) A, \quad h_a \geq SBA & \text{(2a)} \\ \text{or} \\ \frac{K'}{b'} (h_s - SBA) A, \quad h_a < SBA & \text{(2b)} \end{cases}$$

where

Q = rate of leakage $[L^3/t]$;

$\frac{K'}{b'}$ = streambed leakage, or ratio of hydraulic conductivity of streambed $[t^{-1}]$;

h_s = altitude of stream stage [L];

h_a = altitude of potentiometric surface in aquifer [L]; and

A = area of streambed reach $[L^2]$; and

SBA = streambed altitude.

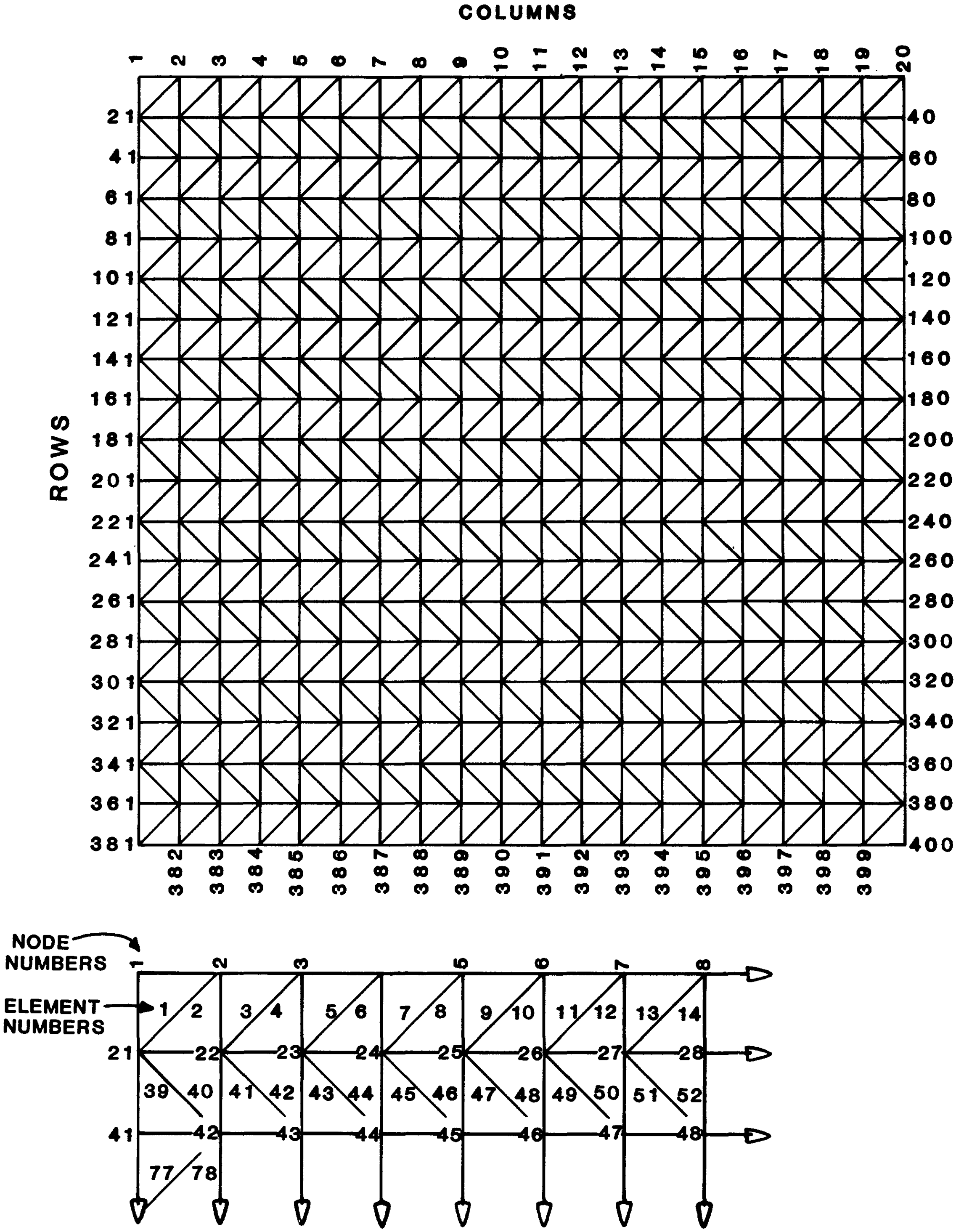

Figure 20.--Triangular nodal arrangement for finite-element grid and numbering of nodes and elements.

Streambed altitude, lengths, widths, reaches, and zones are specified for each riverbed node as part of the model input (fig. 21). The riverbed nodes are positioned such that the general path of the river channel is approximated by straight lines that link adjacent riverbed nodes. Streambed leakance is assigned by river zones, which may include more than one river node. The model simulates rates of streamflow for all riverbed nodes in an iterative, upstream-to-downstream method. Starting with input streamflow at the uppermost stream node and working downstream, the flow is calculated for each river reach on the basis of incoming flow (from the upstream reach) and the gain from or loss to the aquifer throughout the length of the reach. In addition, the model has been modified to allow for incoming streamflow from tributaries along the river. The model computes river stage for each reach using the stage-discharge relationship established for each reach by the user. The stream-aquifer gains and losses then are calculated as a function of streambed area and leakance and the gradient between the stream and the aquifer. The allowable head difference between the aquifer and the stream is limited when the aquifer head is below the base of the stream, as indicated in equation 2b. The algorithm for this is located in subroutine river, lines QRV 1010-1330.

The model uses a budget algorithm to account for water applied at the land surface (incident water), such as water from precipitation or irrigation. Incident water is accounted for in the model either as deep percolation (aquifer exchange) or as evapotranspiration. Direct runoff is not accounted for in the present program. The relative amounts of incident water that are simulated as eventually going to either deep percolation or evapotranspiration depend on the rate of incident water application, the rate of consumptive-use demand, and the moisture-holding capacity of the soil--all factors entered by the user. Simulated precipitation is distributed equally to all elements of the finite-element grid, and irrigation water originating from well pumpage is directed to elements as specified by the user.

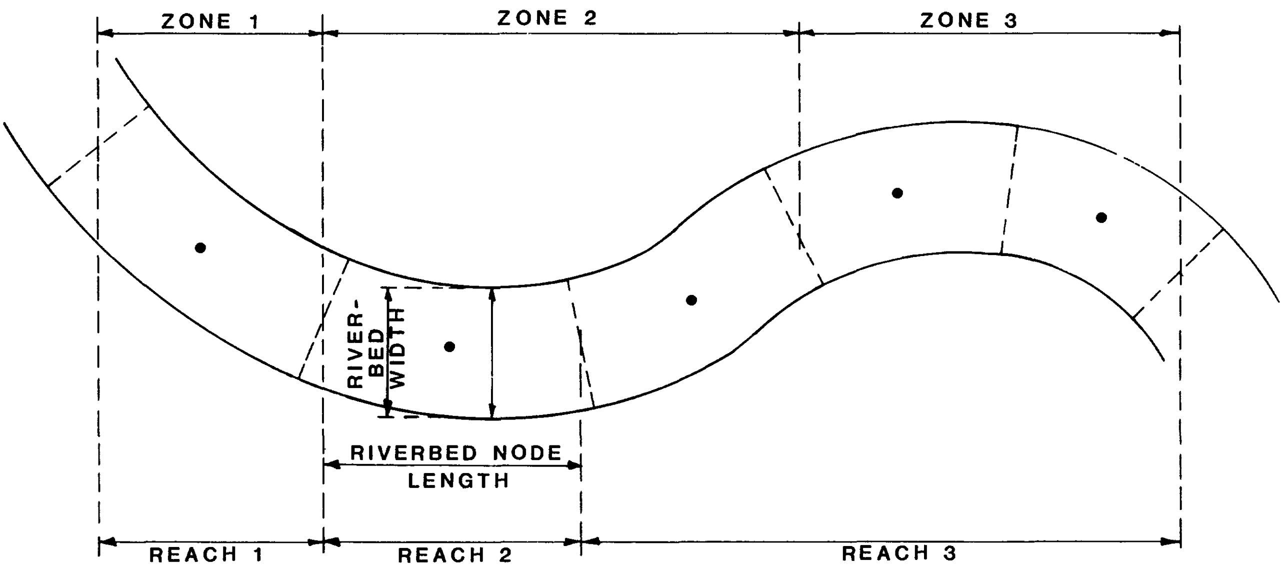

Figure 21.--Method of describing riverbed characteristics for model input.

The model uses a single composite consumptive-use demand for all model nodes for any given month of simulation. This value is determined outside the model utilizing appropriate methods, such as the Blaney-Criddle formula. The model computes the amount of water available to meet the consumptive water requirements for crops using an algorithm developed by the U.S. Department of Agriculture (1967, p. 27) and then determines evapotranspiration. In model areas where the ground-water levels are within a depth criteria set by the user, additional "surface-induced evapotranspiration" is calculated.

Output from the model consists of a water budget, constant-head and stream-aquifer fluxes, water levels and drawdowns from the starting water levels, streamflow by node, and, if selected, a plot file. A mass balance is computed for the model from all sources with the results expressed in two ways: (1) as rates for the current time step and (2) as a cumulative volume of water for each source from the start of the simulation. A mass residual is determined from the differences between the sum of sources and the sum of discharges. Printouts of constant-head and stream-aquifer fluxes by node have been added to the model. The plot-file output is in standard Calcomp[1/] format, except that the plot initiation statement has been changed to comply with the format required for a Zeta plotter.

Sample Problems

The 20 x 20 node grid shown in figure 20 of this attachment was utilized in the following sample problems (except for problem 5) with model setup changed for each problem to accommodate boundaries, rivers, and wells. Grid spacing is 1,000 feet.

Problem 1: Determine radial flow to a well in a confined aquifer for the case of an infinite aquifer with no leakage. A pumping well is located next to the node on row 11, column 10 (fig. 22). Aquifer properties are held constant, and no recharge or boundary-flow conditions are applied. The normal model boundaries are no-flow boundaries, unless altered with other model options. However, the aquifer is assumed to be infinite; therefore, the model boundaries were set at a distance to eliminate any significant effects on the results of the problem. An analytical solution originally by Theis (Lohman, 1972, p. 15) is used for comparison.

$$s = \frac{Q}{4\pi T} W(u) \qquad (3)$$

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1 The use of brand names in this report is for identification purposes only and does not imply endorsement by either the U.S. Geological Survey or the Kansas State Board of Agriculture.

where $u = \frac{r^2 S}{4Tt}$;

Q = constant discharge rate from well [L^3/t];

T = transmissivity [L^2/t];

r = distance from discharging well to point of observation [L];

S = storage coefficient [dimensionless];

t = time since pumping began [t];

s = drawdown [L]; and

$$W(u) = \int_{\mu}^{\infty} \left(\frac{e^{-\mu}}{u}\right) du.$$

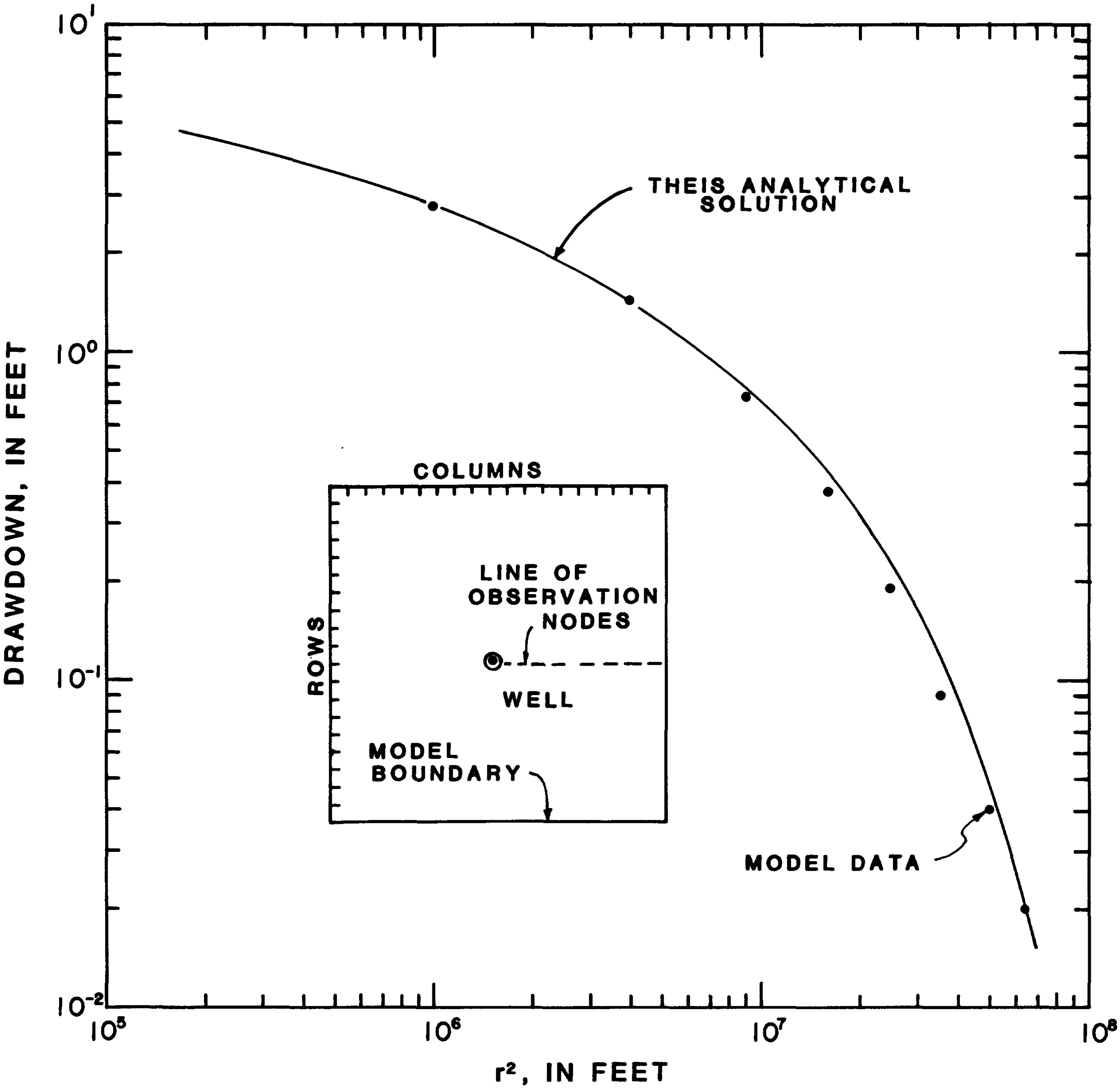


Figure 22.--Numerical simulation of infinite aquifer with Theis analytical-solution assumptions.

Aquifer and model properties are as follows:

Initial potentiometric surface	100 feet
Storage coefficient	0.01
Transmissivity	10,000 ft^2/d
Well pumping rate	1.3369×10^5 ft^3/d
Time step	1 day
Time of solution	6 days

Problem 2: Determine radial flow to a well in a confined aquifer for the case of an infinite aquifer with constant-head boundary and no leakage. A pumping well is located next to the node on row 2, column 10 (fig. 23) and is 2,000 feet from the constant-head boundary. The observation node is located on row 7, column 10. Aquifer properties are held constant. The aquifer is assumed to be infinite, except for the constant-head boundary, and the model boundaries were set at a distance to eliminate any significant effects on the results of the problem. Analytical solutions of the image-well theory (Lohman, 1972, p. 60) and of Theis for the case of an infinite aquifer, as described before, are used for comparison. As described by Lohman (1972), a solution of the single-boundary problem utilizing a discharging or recharging image well can be obtained as follows:

$$s_o = \frac{Q}{4\pi T} [W(u) \pm W(u_i)] \quad (4)$$

where

s_o = algebraic sum of the drawdown of the pumping and image well;

$u_p = \frac{r_p^2 S}{4Tt}$;

$u_i = \frac{r_i^2 S}{4Tt}$;

r_p = the distance from the pumped well to the observation well [L];

r_i = the distance from the observation well to the image well [L]; and

other variables are as defined before.

Aquifer model properties are as follows:

Initial potentiometric surface	200 feet
Storage coefficient	0.01
Transmissivity	5,000 ft^2/d
Well pumping rate	1.3369×10^5 ft^3/d
Time step	1 day
r_p	4,000 feet
r_i	8,000 feet

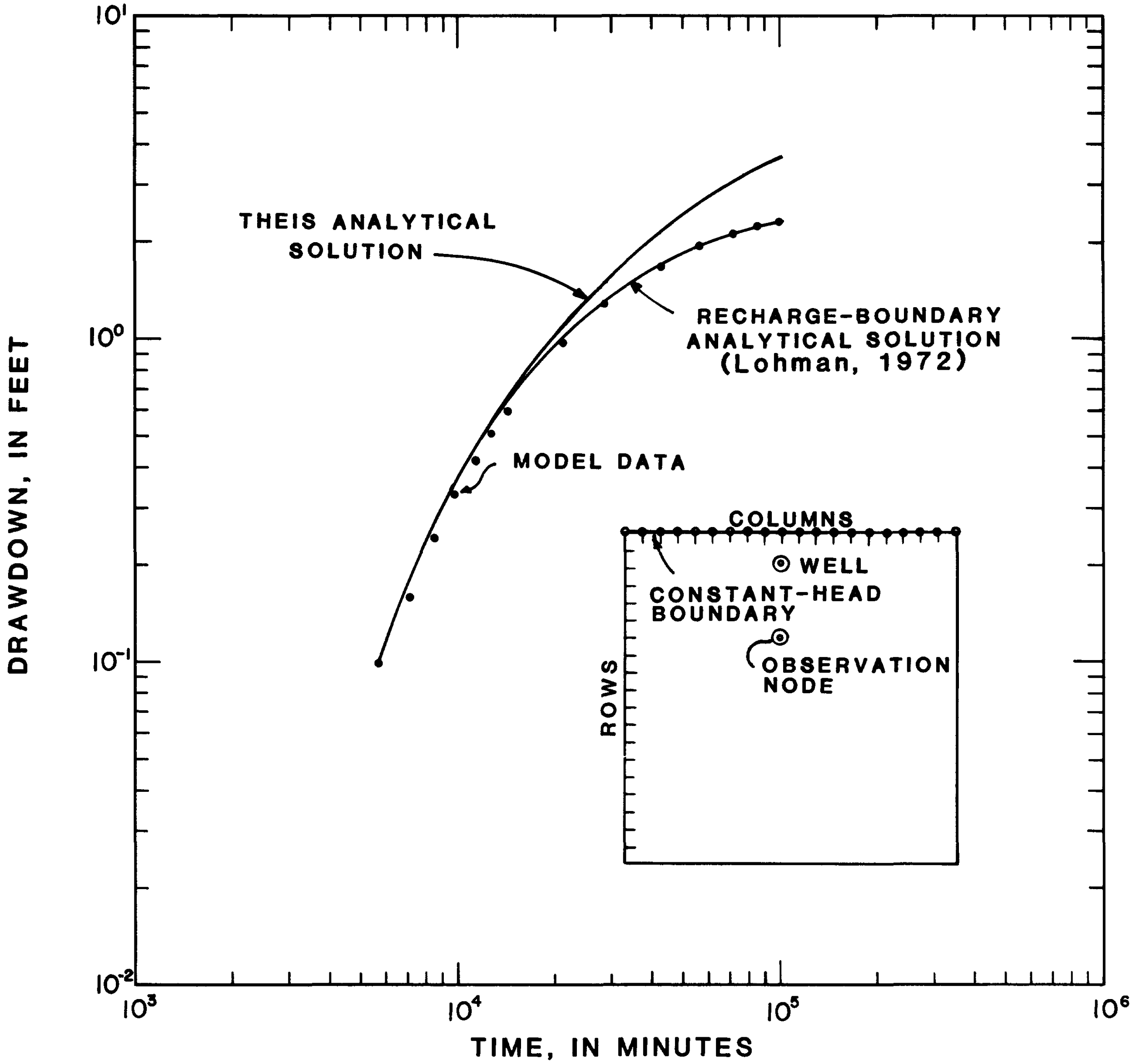


Figure 23.--Numerical simulation of a discharging well in an aquifer bounded with a constant-head boundary.

Problem 3: Determine radial flow to a well in a confined aquifer with an impermeable boundary and no leakage. A pumping well is located next to node on row 2, column 10 (fig. 24) and is located 2,000 feet from the boundary. The observation node is located on row 7, column 10. Aquifer properties are held constant. The upper boundary is a no-flow boundary. The remainder of the aquifer is assumed to be infinite in extent, and the other model boundaries are set at a distance to eliminate any significant effects on the results of the problem. Analytical solutions of Theis and of the image-well theory, as described previously, were used for comparison.

Aquifer and model properties are as follows:

Initial potentiometric surface	200 feet
Storage coefficient	0.01
Transmissivity	5,000 ft^2/d
Well pumping rate	1.3369×10^5 ft^3/d
Time step	1 day
r_p	4,000 feet
r_i	8,000 feet

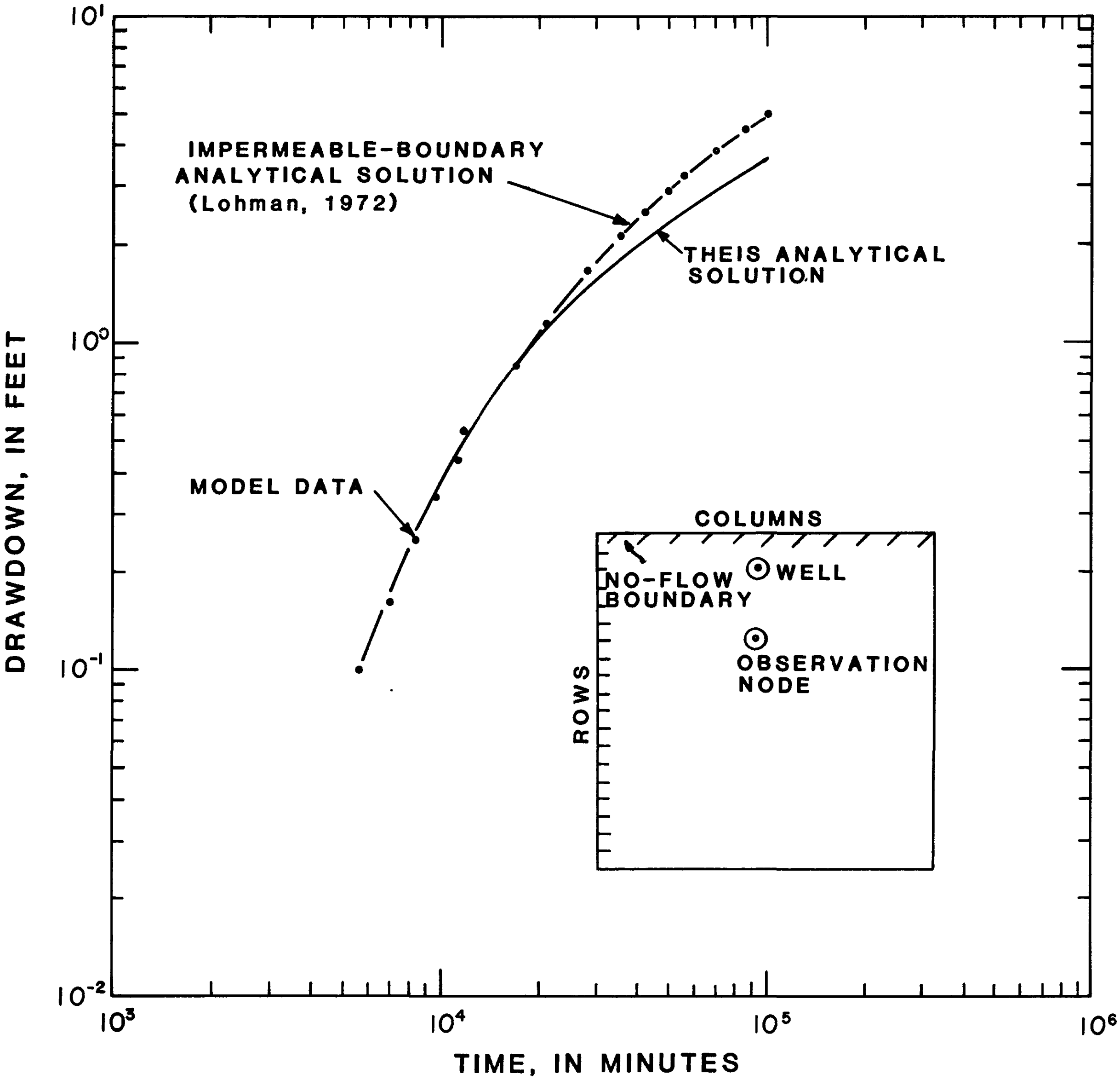


Figure 24.--Numerical simulation of a discharging well in an aquifer bounded with an impermeable boundary.

Problem 4: Determine radial flow to a well in a confined aquifer with induced infiltration from a stream (fig. 25). Pumping well is located next to a node on row 13, column 9. Stream is located along row 11. The observation node is located on row 17, column 9. Flow within the stream was set at a value much greater than the flow loss to the aquifer, and the stage-discharge rating was set so that any flow in the stream would maintain the same stage in the river.

In this case, a comparison of model results is made for a problem in which there is no exact analytical solution. Although an analytical solution to this problem is not available, it is believed that the exact unknown solution should be bounded by the two cases given below until the computed head changes are effected by the model no-flow boundaries. Model boundary conditions are not significant during the time simulated for the example.

Analytical solutions of Theis for the case of an infinite aquifer and of the image-well theory, as described previously, were used for comparison of results.

Aquifer and model properties are as follows:

Initial potentiometric surface	200 feet
Stream stage	200 feet
Storage coefficient	0.01
Transmissivity	10,000 ft^2/d
Well pumping rate	2.6738×10^5 ft^3/d
Time step	1 day
r_p	4,000 feet
r_i	8,000 feet
K'	1 ft/d
b'	1 foot
Riverbed elevation	199 feet
Stream width	100 feet

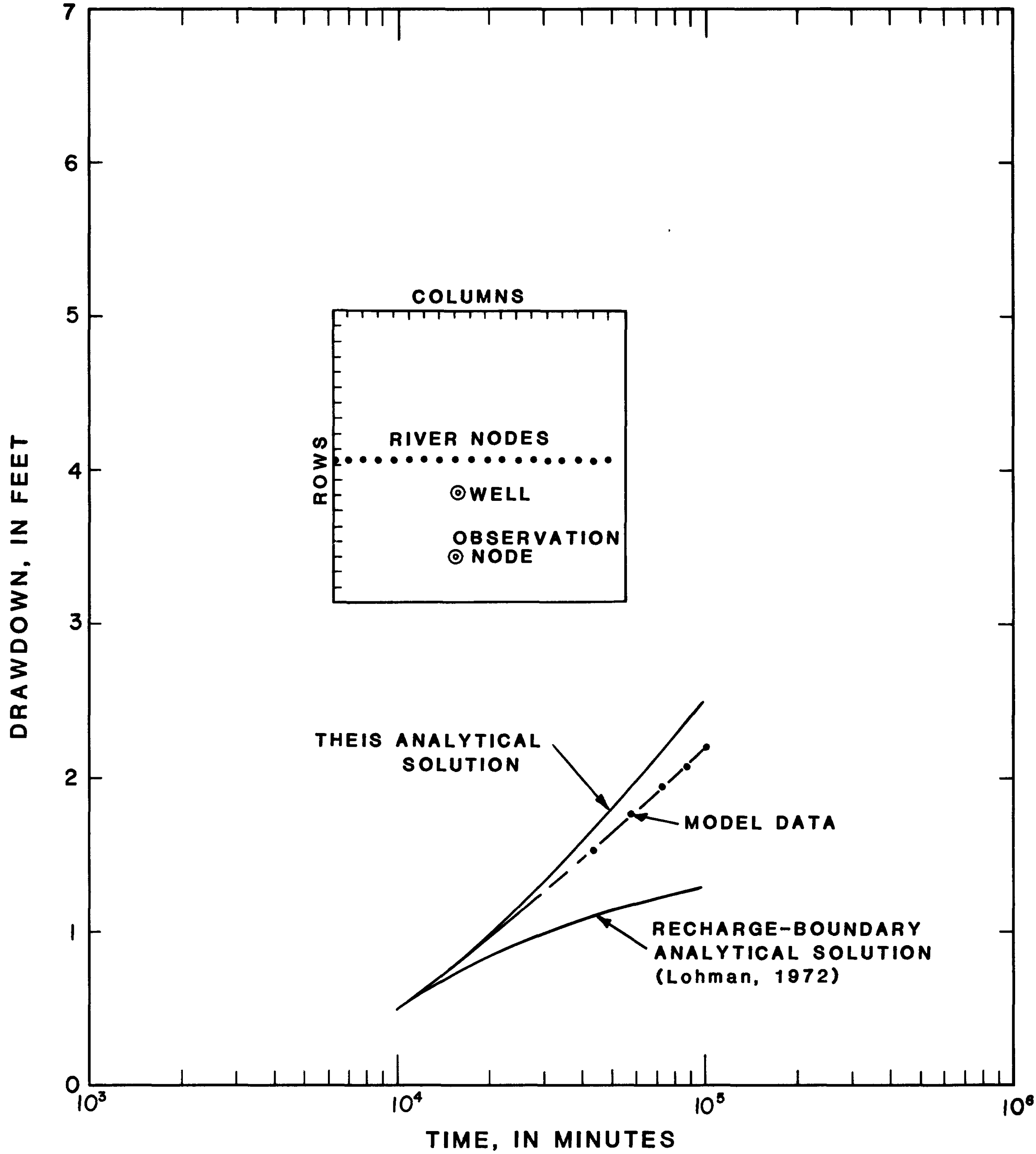


Figure 25.--Numerical simulation of a discharging well with induced infiltration.

Problem 5: Water-table aquifer with constant-head boundaries and constant recharge--steady-state conditions (fig. 26). Streams (constant-head boundaries in model) are located 16,000 feet apart. Aquifer is assumed to be homogeneous and isotropic.

Analytical solution for an aquifer under steady-state conditions, uniform recharge, and bounded on two sides by fully penetrating parallel streams of infinite length (fig. 27), as shown in Ferris and others (1962, p. 131), was used for comparison of results. The steady-state, ground-water-level profile is defined as:

$$h_o = \left(\frac{a^2 W}{2T}\right)\left(\frac{2x}{a} - \frac{x^2}{a^2}\right) , \qquad (5)$$

where

h_o = elevation of the water table at observation point x, with respect to the mean stream level [L];

W = constant rate of recharge to the water table [L/t];

a = distance from the stream to the ground-water divide [L]; and

x = distance from the stream to the observation point [L]. The stream on the left is assumed to be the reference point for x.

Aquifer and model properties are as follows:

Initial potentiometric surface	40 feet
Stream stage	40 feet
Transmissivity	34,560 ft^2/d
Recharge	8.06×10^{-3} ft/d
a	8,000 feet

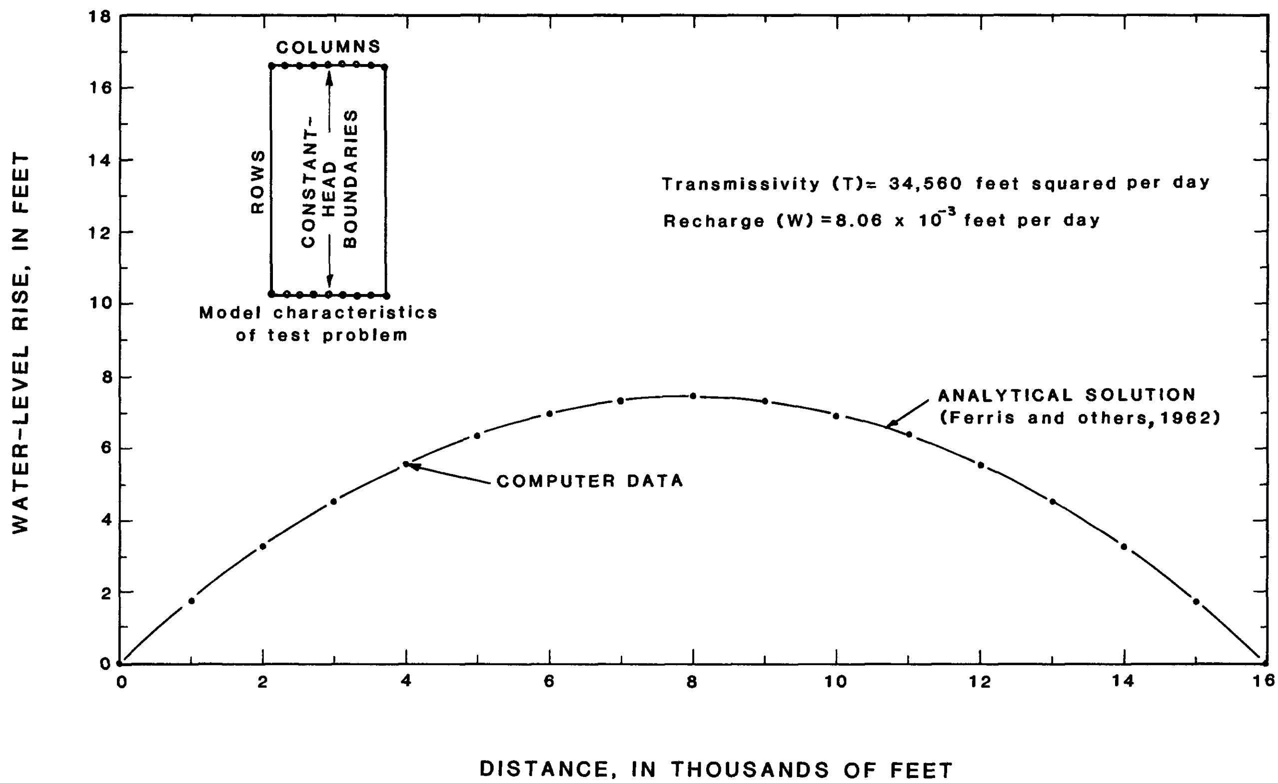


Figure 26.--Numerical simulation of water-table aquifer with constant-head boundaries and constant recharge.

Description of Program Routines

The finite-element areal-flow model consists of the main program and 25 subroutines. The Tracy model was modified from 16 subroutines with 10 entry points to 25 subroutines for use on the Prime computer. They are listed in the order that they are first called. The function of each routine is outlined following this list.

1. MAIN PROGRAM	10. LEMENQ	19. SSOLVE
2. DATAIN	11. LEMENT	20. ADCOMP
3. DATE	12. QRIVER	21. ASOLVE
4. NWDATE	13. RIVER	22. QZEE,
5. ARRAY	14. PTFNDR	23. PUMPNU
6. LAMBRT	15. BNDCON	24. LOADQR
7. PLTG	16. QBOUND	25. OUTPUT
8. PLTR	17. MASBAL	26. BLOCK DATA
9. PLTW	18. SDCOMP	

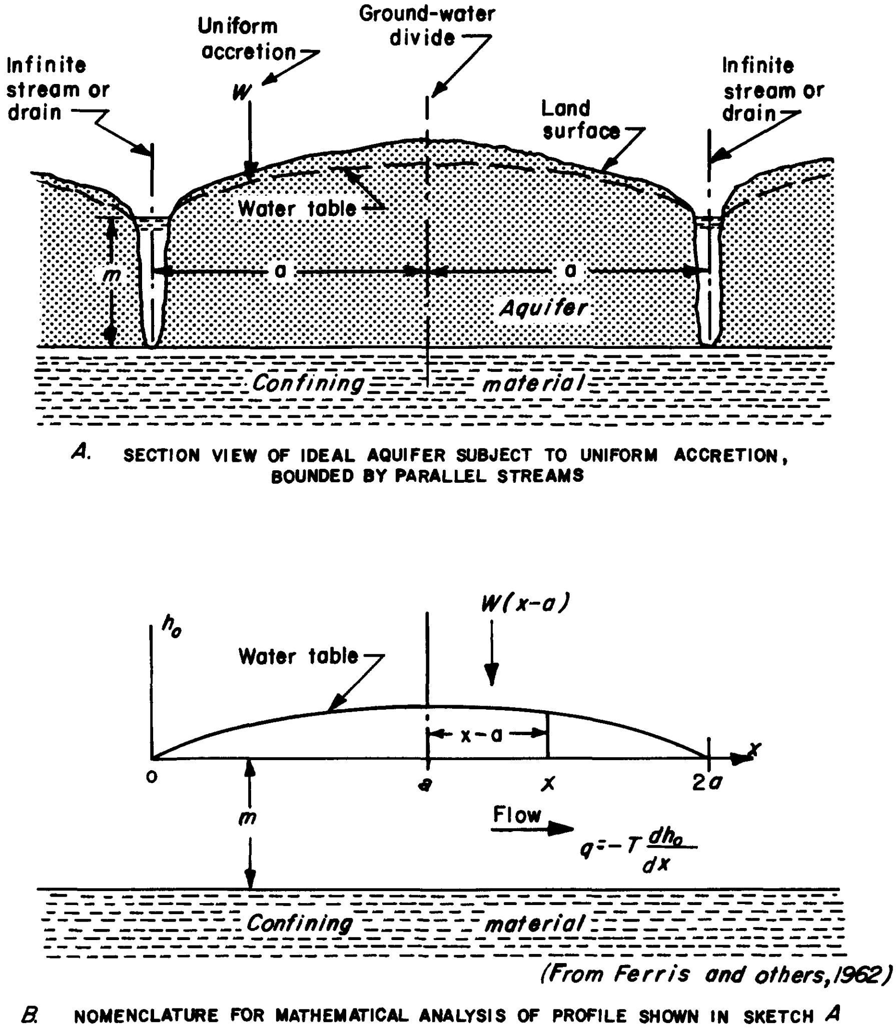


Figure 27.--Section views for analyzing steady-state flow in hypothetical aquifer of large thickness with uniform accretion from precipitation.

Main Program

This part of the model establishes the size of the arrays needed for the problem. It controls the logical flow of the program based on the options selected by the user and serves as the driver for all subsequent subroutines. The main program contains two principal loops. The first controls the progression through time in the transient-flow simulation. The second controls the iterative-solution technique for modeling stream-aquifer interaction.

Subroutine DATAIN

This subroutine handles all input and output related to the problem specification and aquifer properties. The required input data and format are detailed in the next section. The routine also generates the finite-element grid and calls the grid-plotting routines.

Called by: MAIN PROGRAM
Subroutines called: DATE, ARRAY, LAMBRT, PLTG

Subroutine DATE

The call to this routine initializes the data needed to keep track of calendar dates for the transient simulation.

Called by: DATAIN

Subroutine NWDATE

This routine updates the calendar dates at the end of each time step.

Called by: MAIN PROGRAM

Subroutine ARRAY

This routine reads in the arrays of aquifer properties that are defined at each node. It allows for flexibility as to where the data will be read from and the format required. More details can be found in the next section.

Called by: DATAIN

Subroutine LAMBRT

This routine converts all input data read in as latitude and longitude into x- and y-coordinate values. The algorithm uses a polynomial approximation to the Lambert conical projection with an origin of 39° latitude and 120° longitude.

Called by: DATAIN, QRIVER, PUMPNU

Subroutine PLTG

This subroutine uses standard CALCOMP calls to plot the finite-element grid based on the input data. Use of this routine is optional, but it is the easiest means of verifying the accuracy of the input.

Called by: DATAIN

Subroutine PLTR

This routine plots the river nodes on the finite-element grid.

Called by: QRIVER

Subroutine PLTW

This routine plots the wells on the grid.

Called by: PUMPNU

Subroutine LEMENQ

This routine performs the integration of the flow equation over a linear, quadrilateral finite element. The integrations for both the steady and transient terms are done using a four-point, Gaussian quadrature technique, and these terms then are loaded into the matrix A.

Called by: MAIN PROGRAM

Subroutine LEMENT

This routine performs the integration of the flow equation over a linear triangular element. The integrations are done analytically, and both the steady and transient terms are loaded into the matrix A.

Called by: MAIN PROGRAM

Subroutine QRIVER

This routine reads in all the data to be used in calculating stream-aquifer interaction. It also loads the leakance terms for the stream into the matrix A.

Called by: MAIN PROGRAM

Subroutine RIVER

This routine routes the daily inflow to the stream through the channel and determines the amount of leakage into or out of the stream based on the best values of aquifer head. As values of aquifer head at the next iteration level are determined with the river leakage handled implicitly, the routine is called again. This procedure is repeated until convergence is achieved.

Called by: MAIN PROGRAM

Subroutine PTFNDR

This routine determines the local coordinates and appropriate integrals of the basis function for a specified point within an element, given the global coordinates of the point and of the nodes defining the element. For triangular elements, the coordinates can be solved directly in terms of the basis functions. For the quadrilateral elements, the two quadratic equations of global position must be solved simultaneously to yield the local coordinates.

Called by: QRIVER, PUMPNU

Subroutine BNDCON

This routine saves the matrix equation, formulated in matrix A, for nodes having a specified head. It then applies the boundary condition to these nodes by zeroing out the row and column of the matrix and placing a 1.0 on the diagonal.

Called by: MAIN PROGRAM

Subroutine QBOUND

This routine adjusts the right-hand side of the matrix flow equation to correct for the zeroing out of the symmetric terms in the rows and columns of the A matrix when applying the specified-head boundary condition. The entry also adds the specified-flux boundary terms to the R.H.S.(QRE).

Called by: MAIN PROGRAM

Subroutine MASBAL

This routine is called after the flow equation is solved. It calculates the boundary fluxes at the specified-head nodes and the storage change as a check for mass balance. These terms are printed out along with all other flow budget items that are being accumulated and the residuals of both the time-step rates (L^3/T) and the cumulative volume (L^3).

Called by: MAIN PROGRAM

Subroutine SDCOMP

This subroutine performs the decomposition of the symmetric, banded matrix A. The routine is called when the nodal transmissivities are constant and only needs to be called once.

Called by: MAIN PROGRAM

Subroutine SSOLVE

This routine does the forward and backward substitution to solve for the new head values.

Called by: MAIN PROGRAM

Subroutine ADCOMP

This routine performs the decomposition of the A matrix when it is asymmetric. This routine is called when transmissivities are head dependent and is only called once.

Called by: MAIN PROGRAM

Subroutine ASOLVE

This routine does the forward and backward substitution to solve for the new head values when the A matrix is asymmetric.

Called by: MAIN PROGRAM

Subroutine QZEE

This routine reads in climatological and soil data necessary to compute recharge due to evapotranspiration and precipitation.

Called by: MAIN PROGRAM

Subroutine PUMPNU

This routine reads in the well data, including well locations, pumpage rates, seasonal variability factors, application rates, and types and areas of application.

Called by: MAIN PROGRAM

Subroutine LOADQR

This routine loads most of the stress terms into the right-hand side of vector QRE. These terms include pumpage, recharge due to precipitation and applied water, evapotranspiration, and changes in storage due to head variation. The entry also determines how much of the pumped water gets routed back into a river.

Called by: MAIN PROGRAM

Subroutine OUTPUT

This routine prints out the new head values, cumulative drawdowns from original head values, and the river stages at specified intervals.

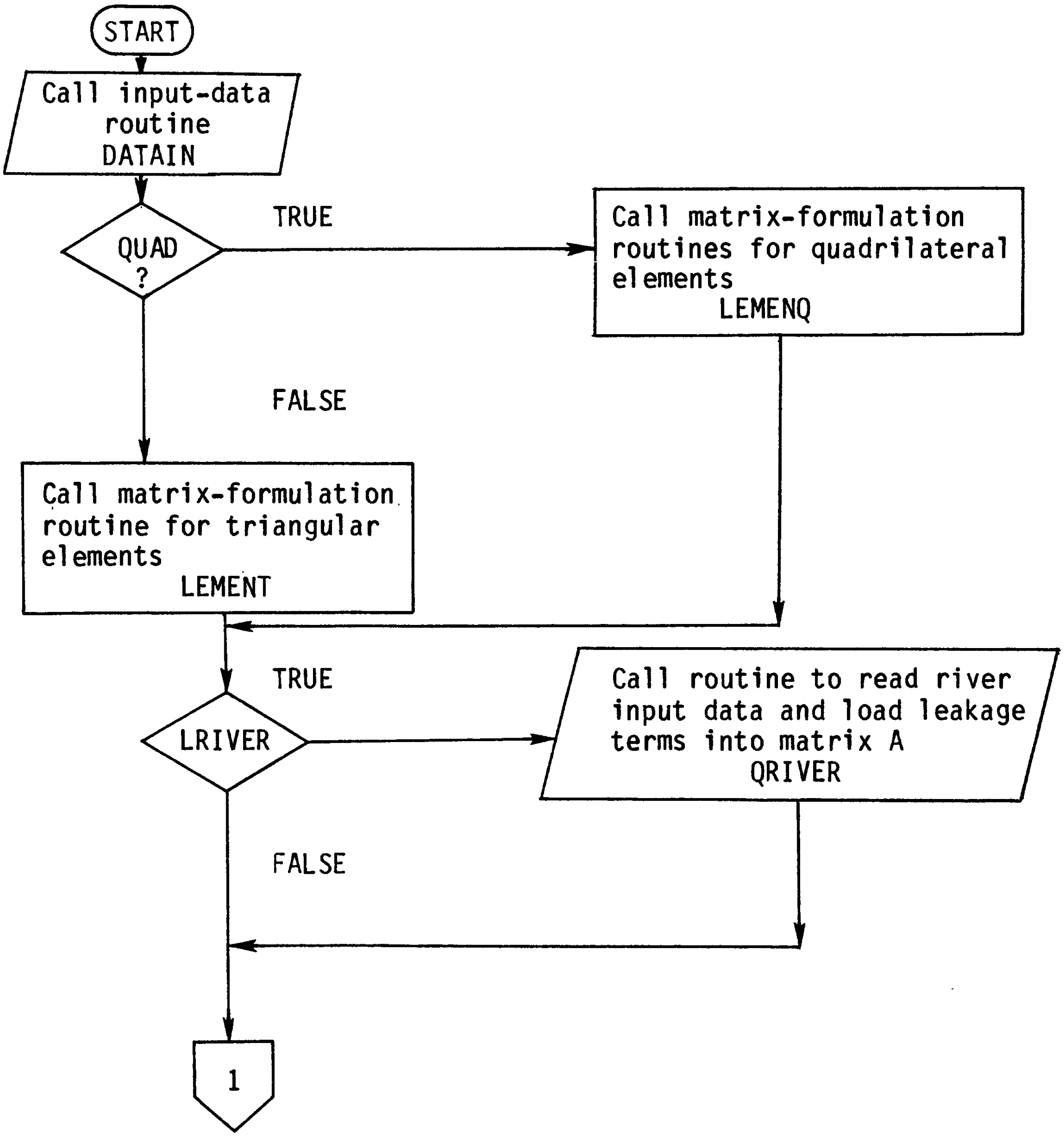
Called by: MAIN PROGRAM

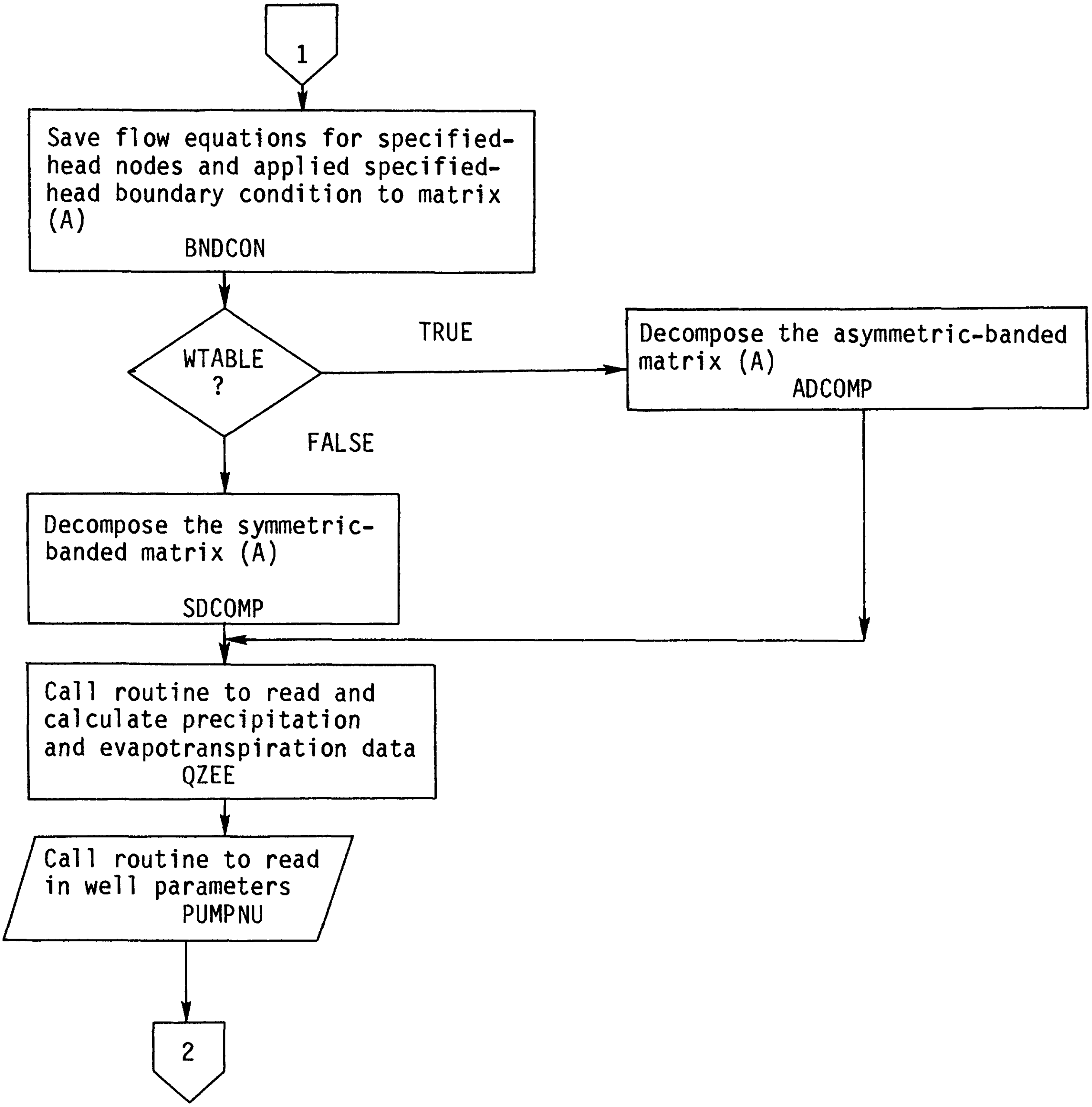
BLOCK DATA

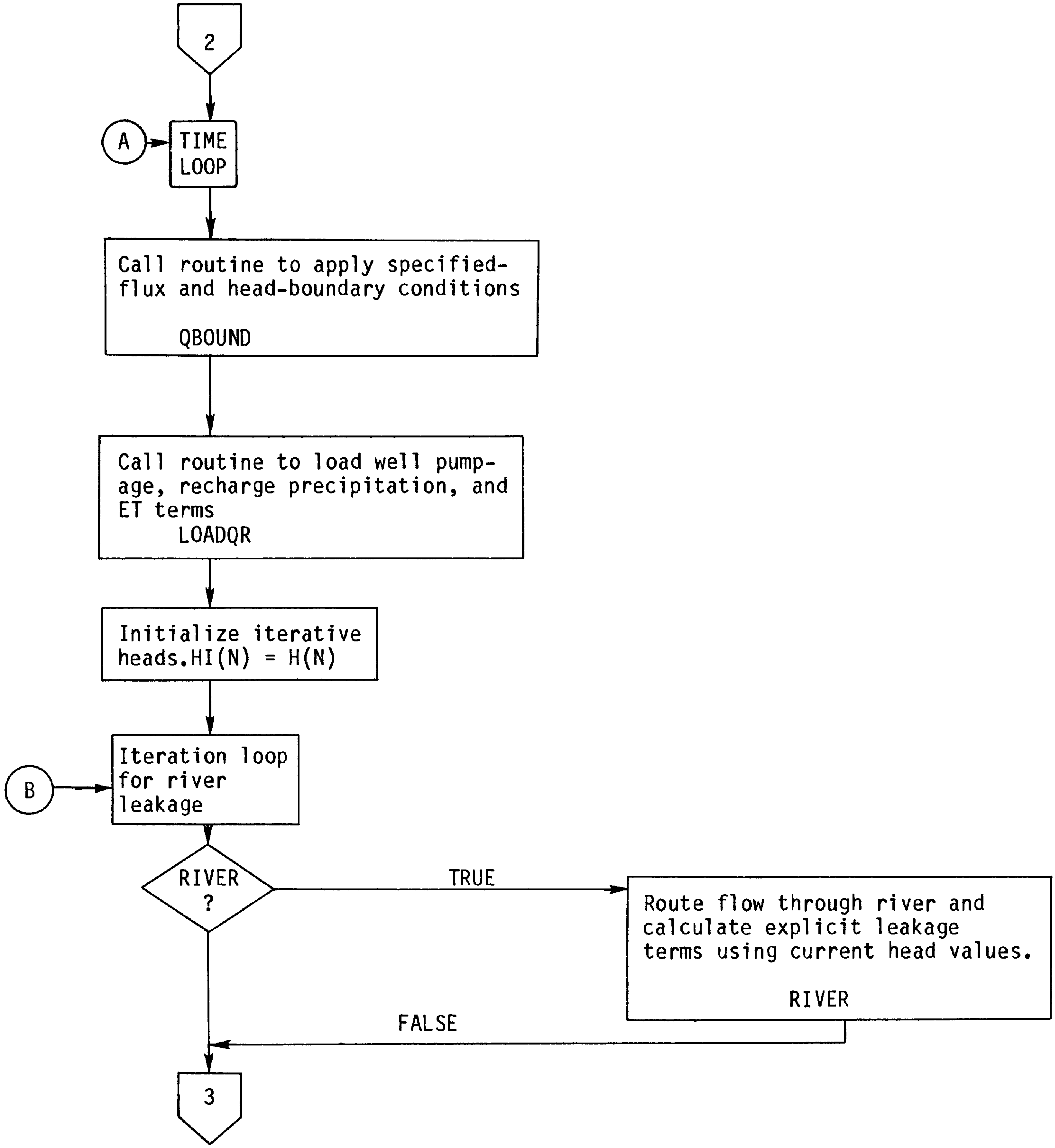
This routine is used to initialize a number of variables contained in common. These include the input and output units, evapotranspiration factors, budget-item titles, and default values for input variables that are optional.

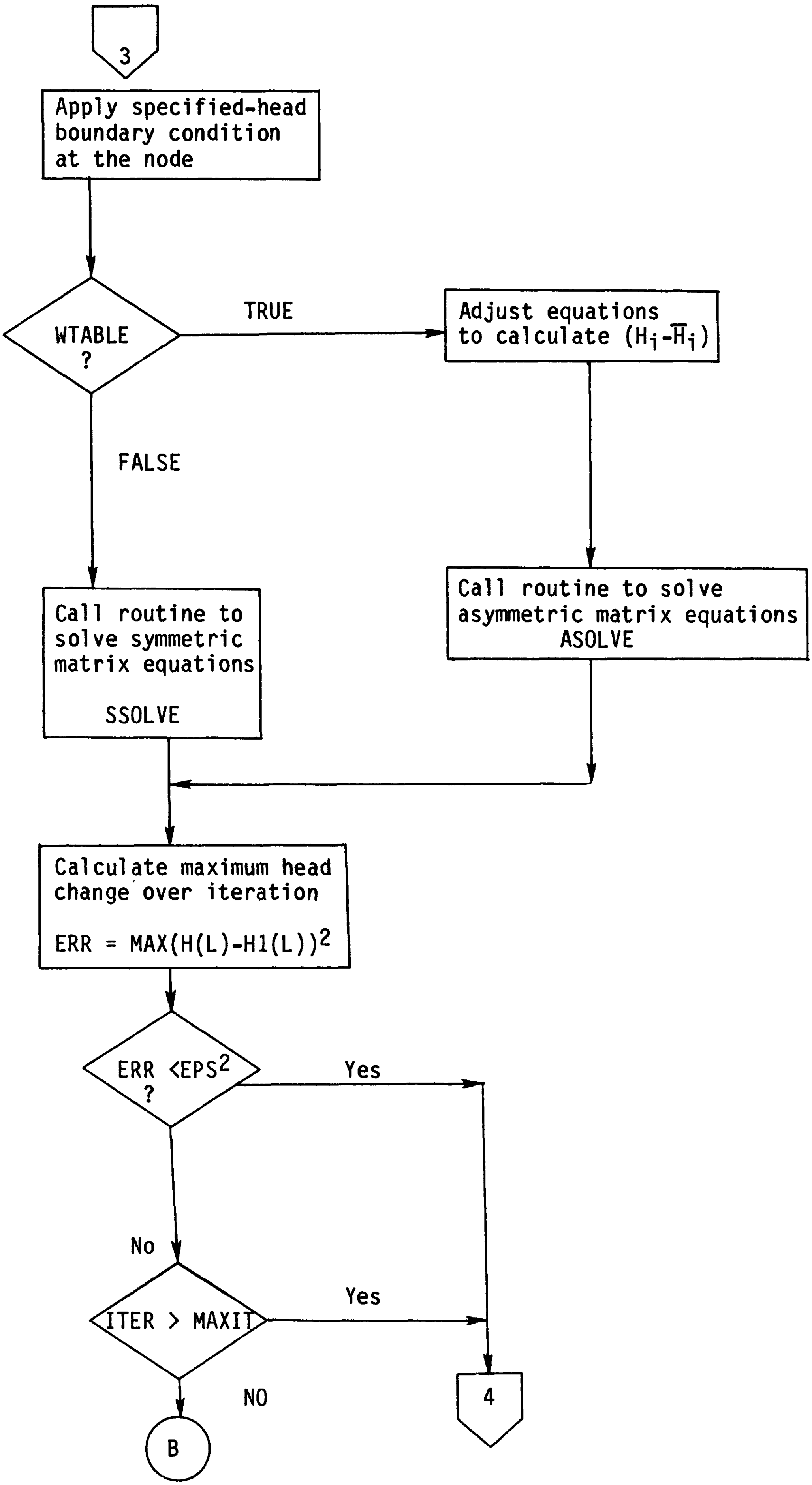
Generalized Flow Chart for Aquifer-Simulation Model

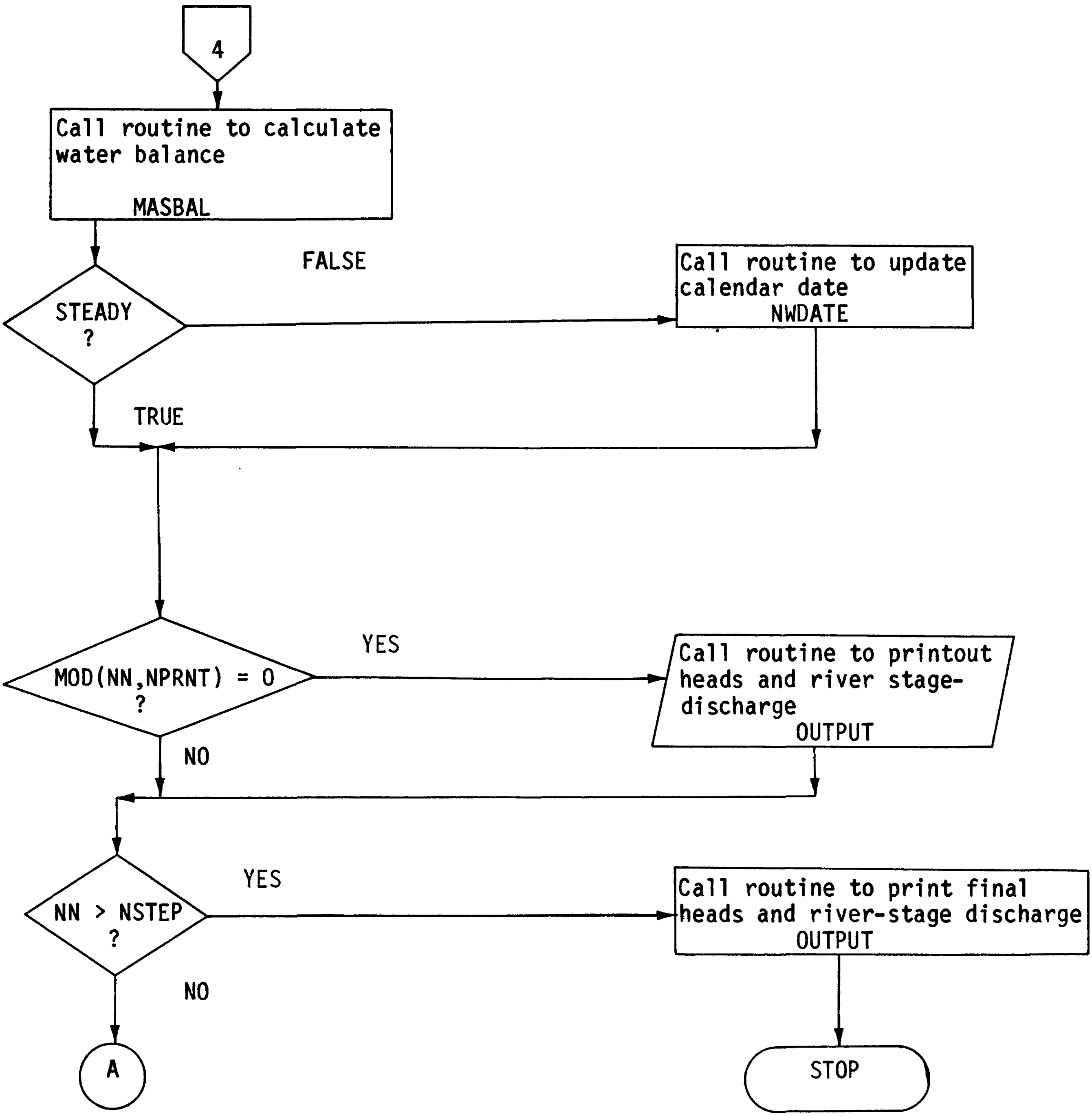
1 MAIN PROGRAM



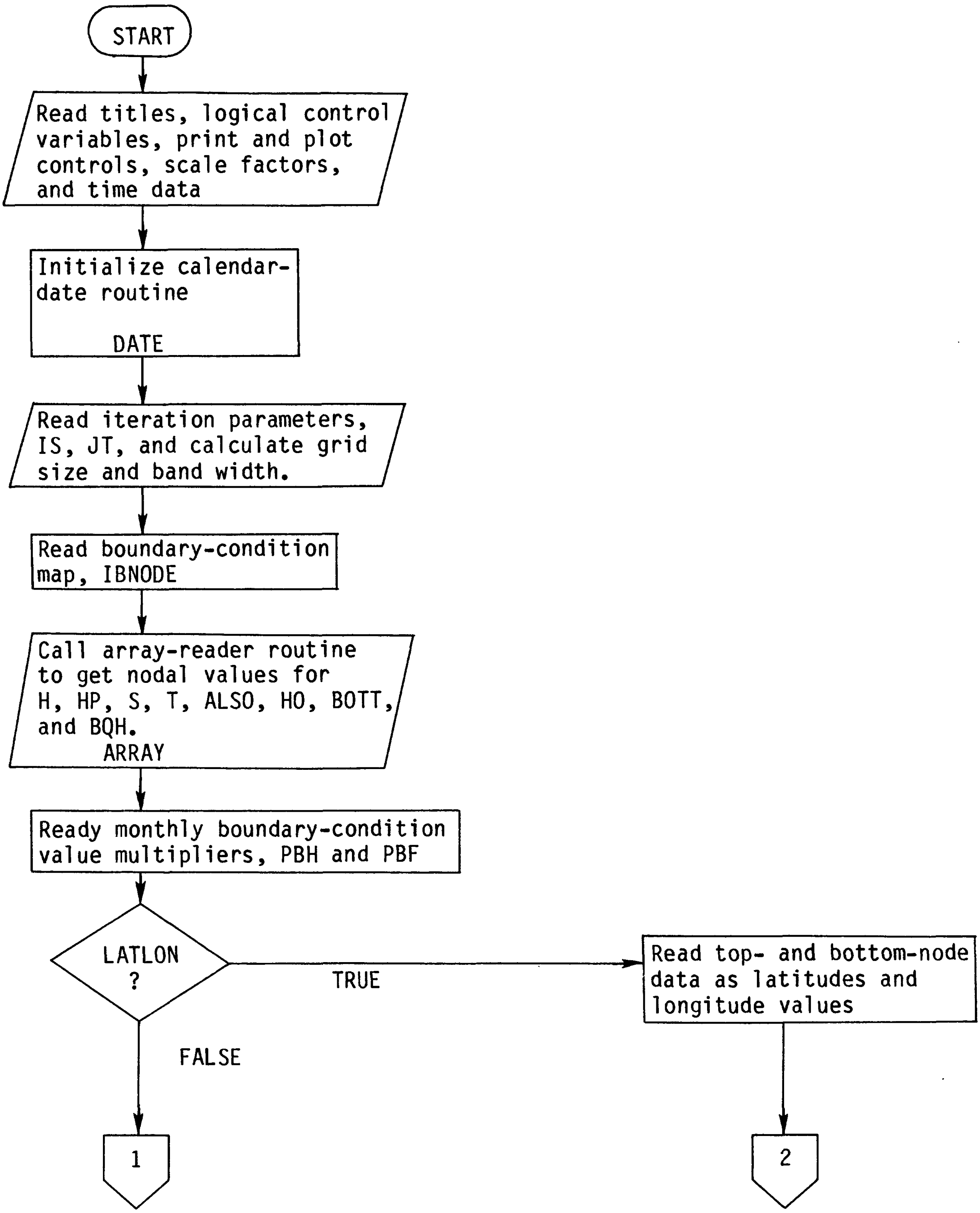

1
Save flow equations for specified-head nodes and applied specified-head boundary condition to matrix (A)
BNDCON
WTABLE ?
TRUE
Decompose the asymmetric-banded matrix (A)
ADCOMP
FALSE
Decompose the symmetric-banded matrix (A)
SDCOMP
Call routine to read and calculate precipitation and evapotranspiration data
QZEE
Call routine to read in well parameters
PUMPNU
2

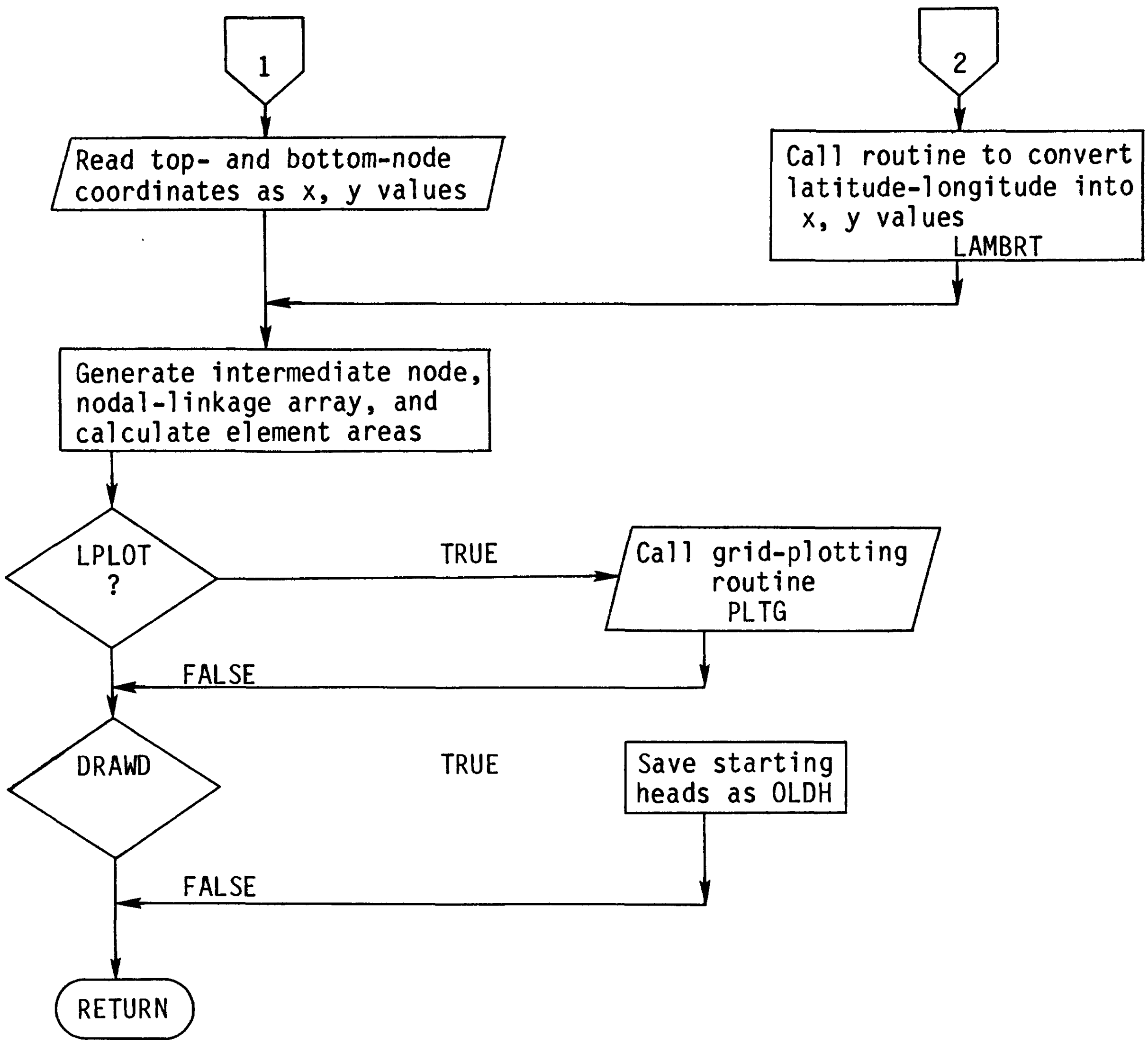

2
A
TIME LOOP
Call routine to apply specified-flux and head-boundary conditions
QBOUND
Call routine to load well pumpage, recharge precipitation, and ET terms
LOADQR
Initialize iterative heads.HI(N) = H(N)
B
Iteration loop for river leakage
RIVER ?
TRUE
Route flow through river and calculate explicit leakage terms using current head values.
RIVER
FALSE
3


3
Apply specified-head boundary condition at the node
WTABLE ?
TRUE
Adjust equations to calculate $(H_i-\overline{H}_i)$
FALSE
Call routine to solve symmetric matrix equations
SSOLVE
Call routine to solve asymmetric matrix equations
ASOLVE
Calculate maximum head change over iteration
ERR = MAX(H(L)-H1(L))^2
ERR <EPS^2 ?
Yes
No
ITER > MAXIT
Yes
NO
B
4

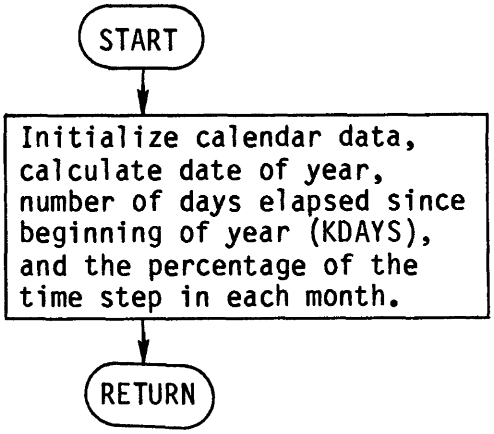

4
Call routine to calculate water balance
MASBAL
STEADY ?
FALSE
Call routine to update calendar date
NWDATE
TRUE
MOD(NN,NPRNT) = 0 ?
YES
Call routine to printout heads and river stage-discharge
OUTPUT
NO
NN > NSTEP ?
YES
Call routine to print final heads and river-stage discharge
OUTPUT
NO
A
STOP

SUBROUTINE DATAIN

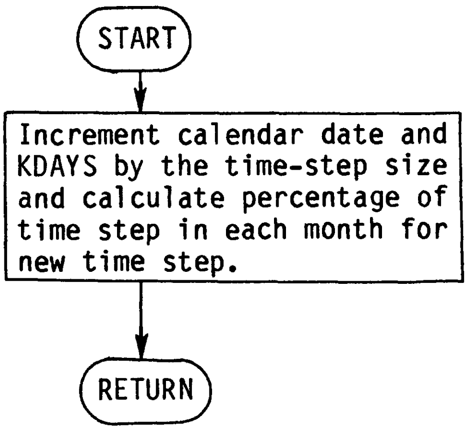



1
2
Read top- and bottom-node coordinates as x, y values
Call routine to convert latitude-longitude into x, y values
LAMBRT
Generate intermediate node, nodal-linkage array, and calculate element areas
LPLOT ?
TRUE
Call grid-plotting routine
PLTG
FALSE
DRAWD
TRUE
Save starting heads as OLDH
FALSE
RETURN

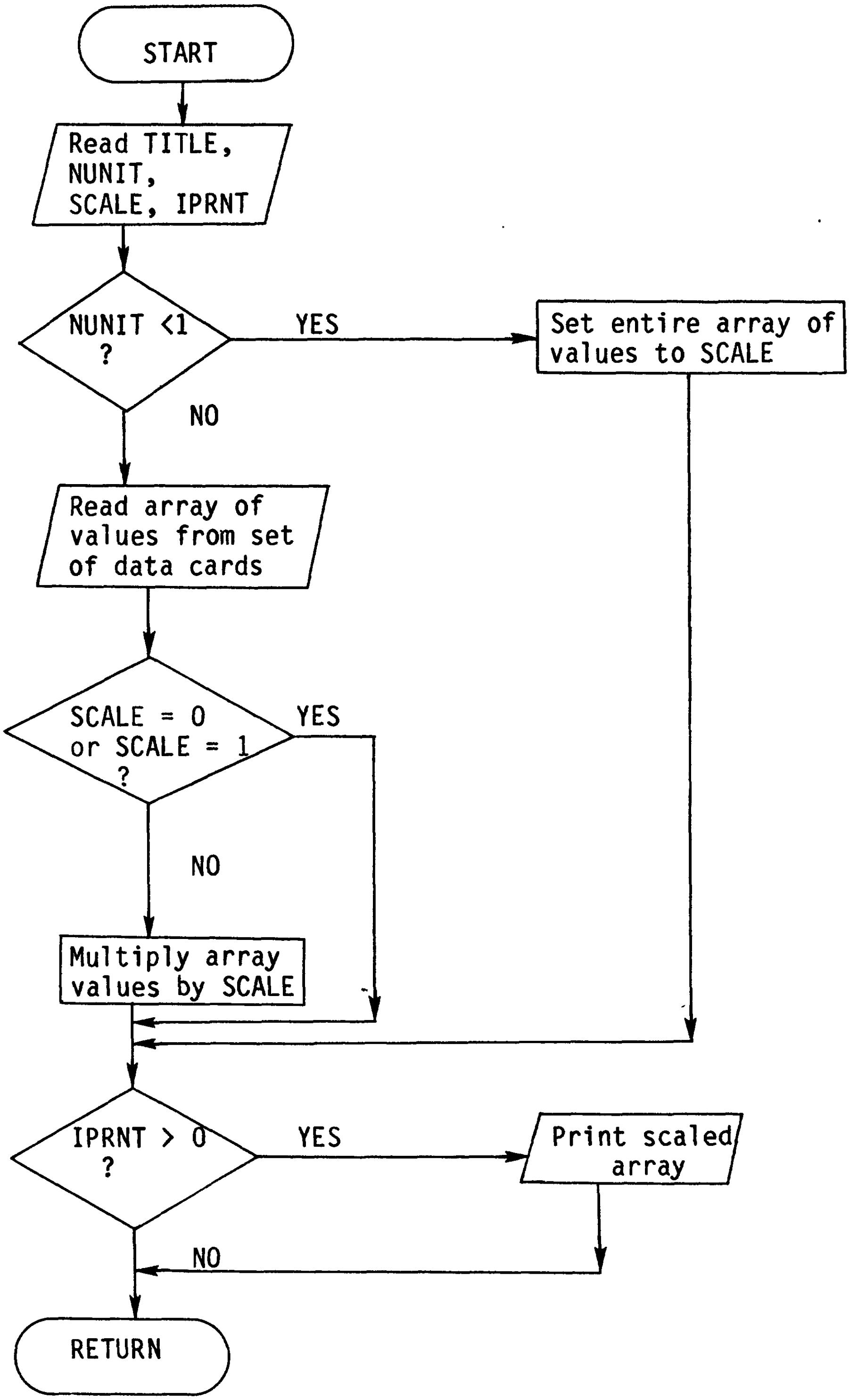
SUBROUTINE DATE



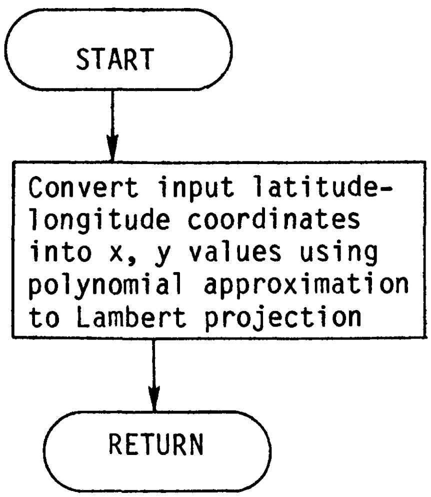
SUBROUTINE NWDATE



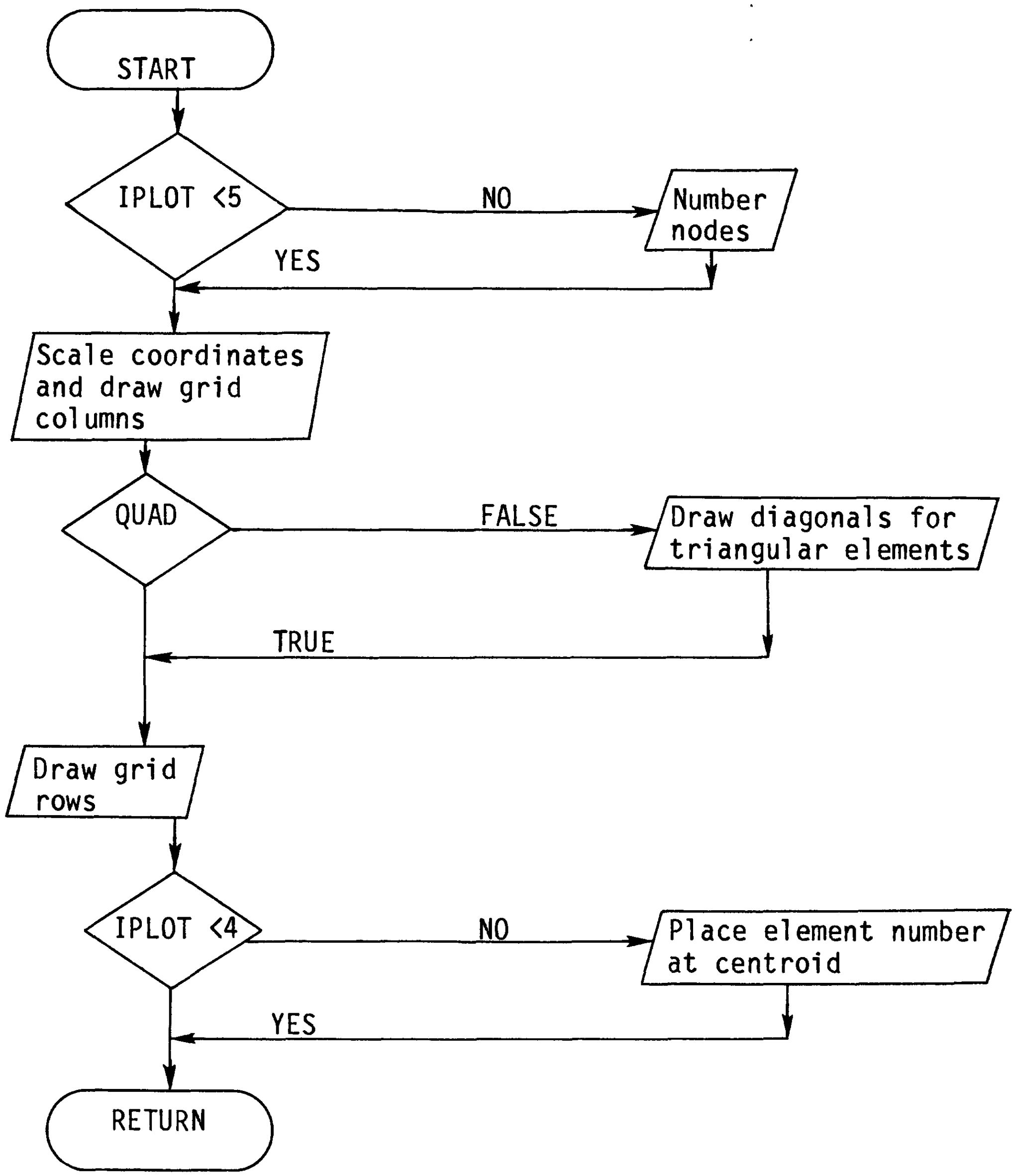
SUBROUTINE ARRAY



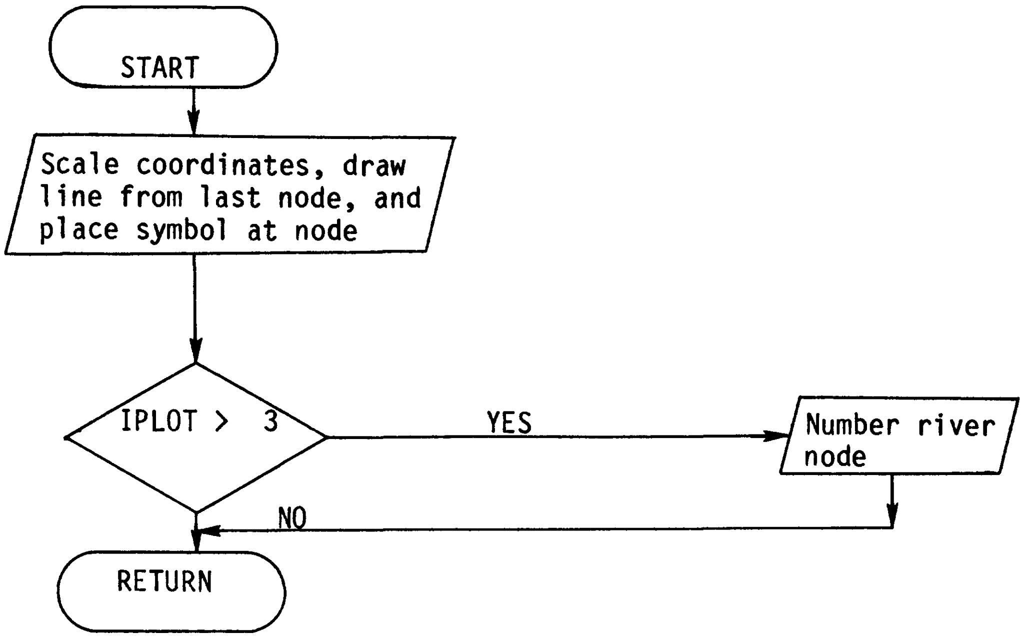
SUBROUTINE LAMBRT



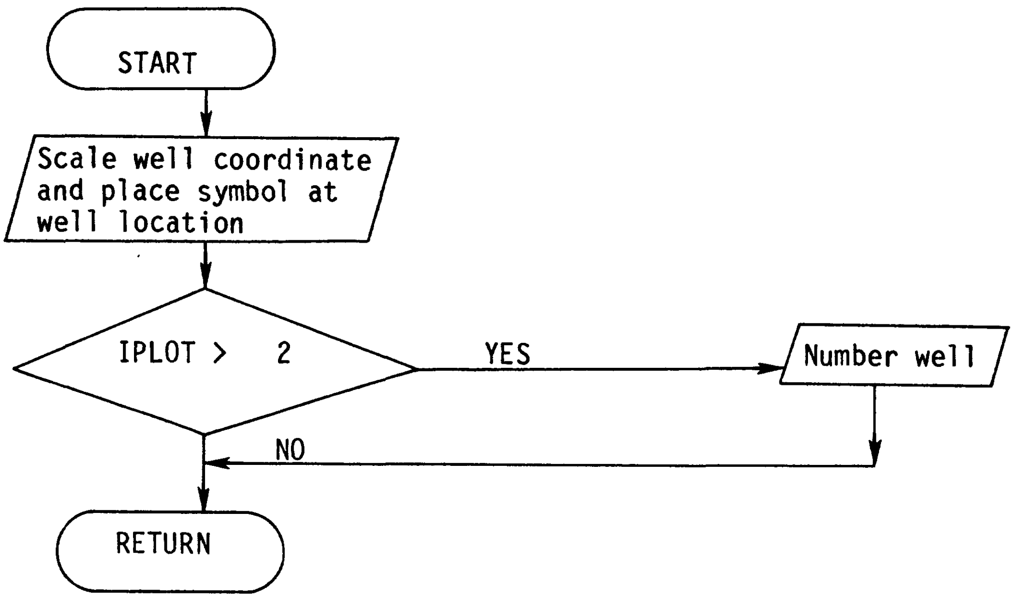
SUBROUTINE PLTG



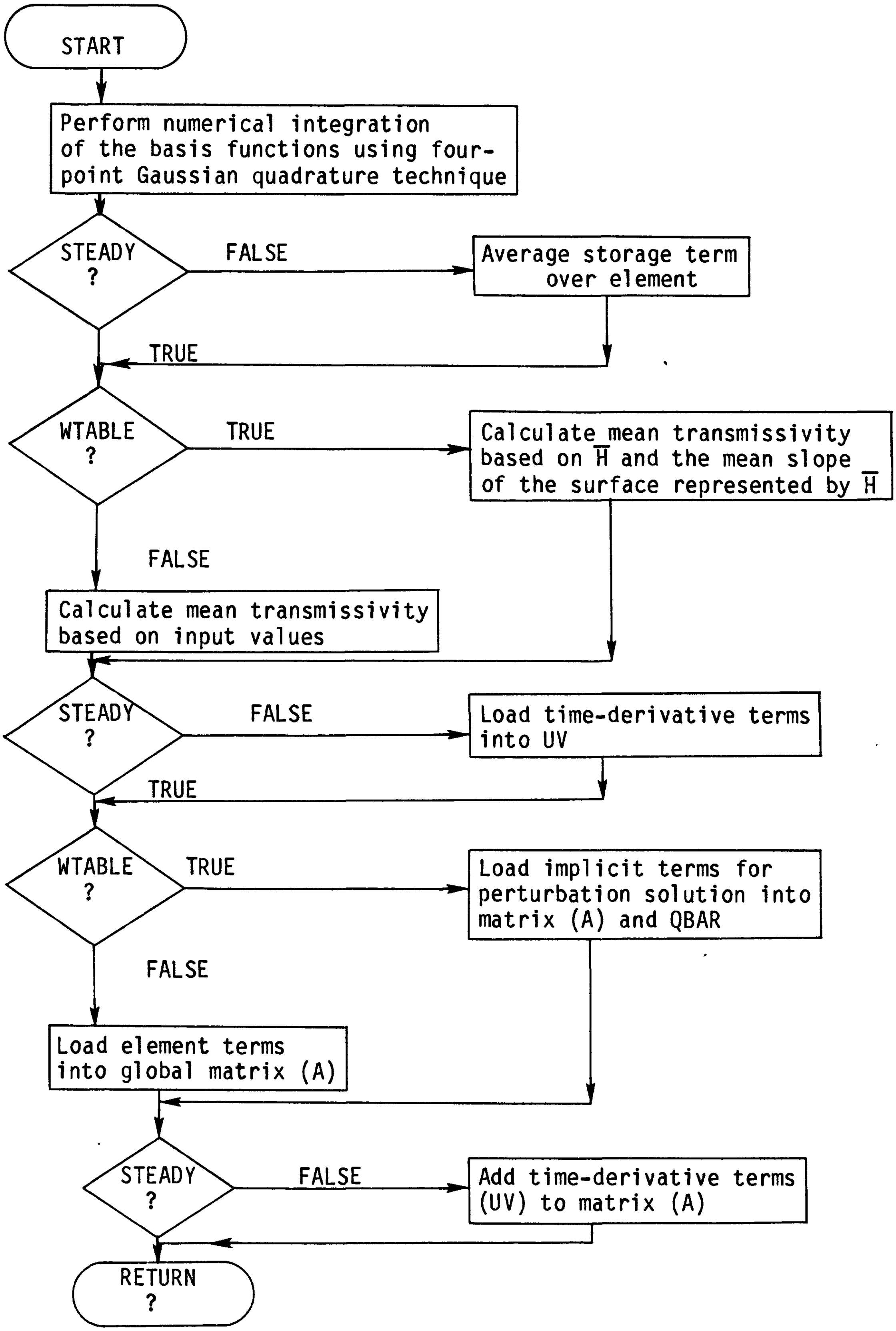
SUBROUTINE PLTR



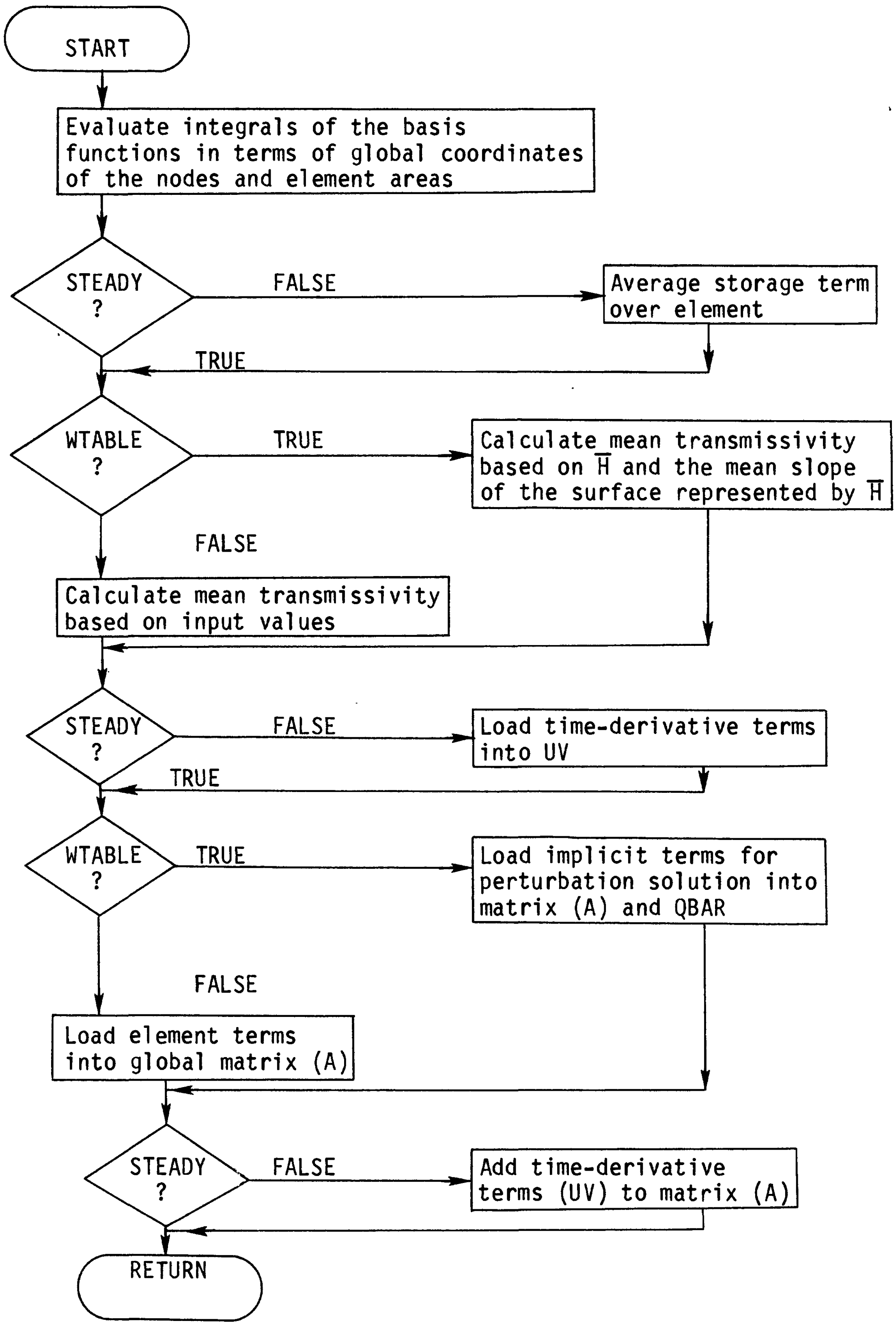
SUBROUTINE PLTW



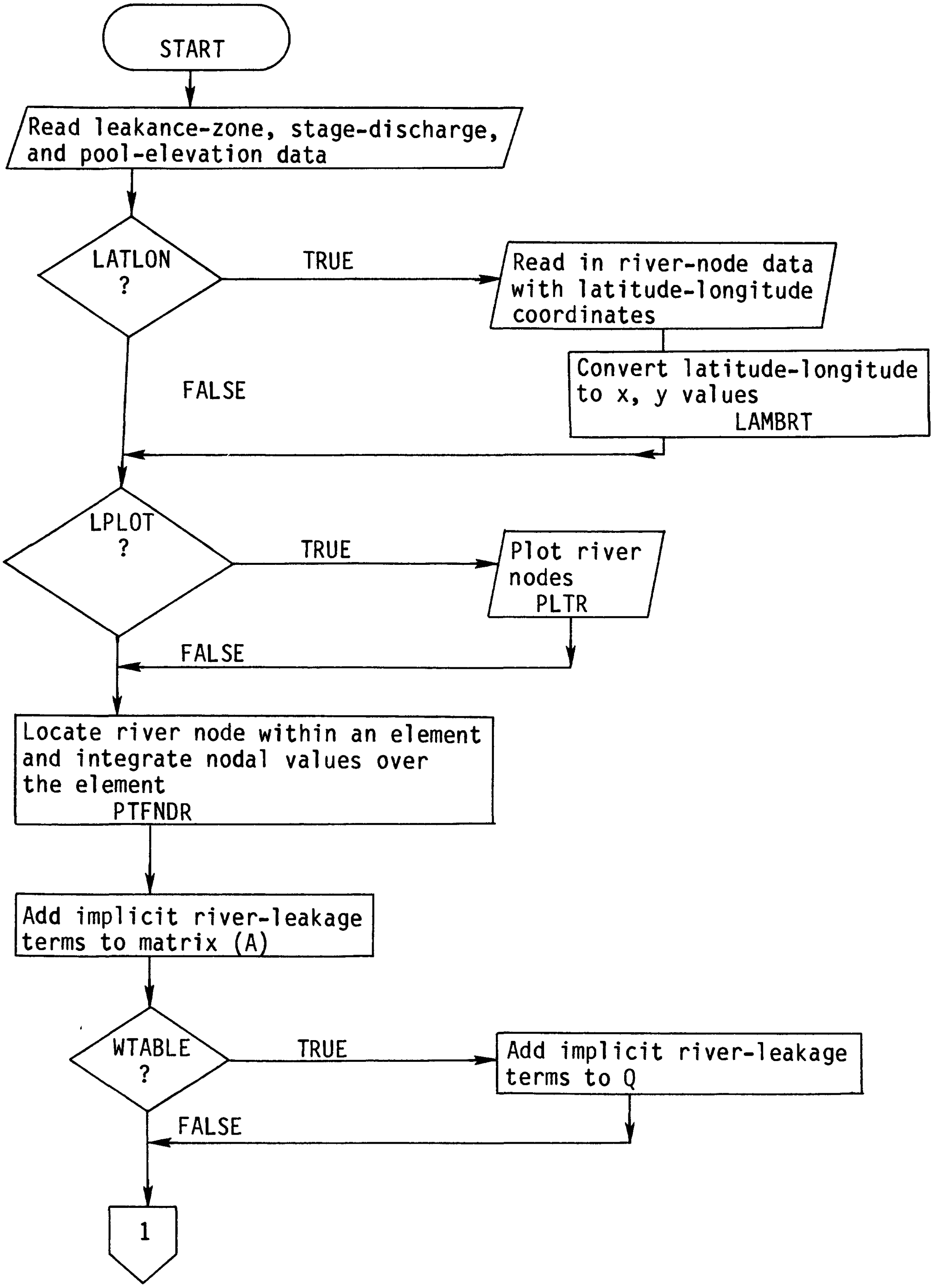
SUBROUTINE LEMENQ

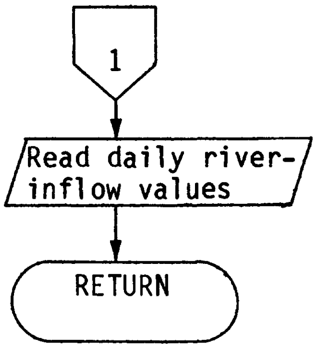


SUBROUTINE LEMENT

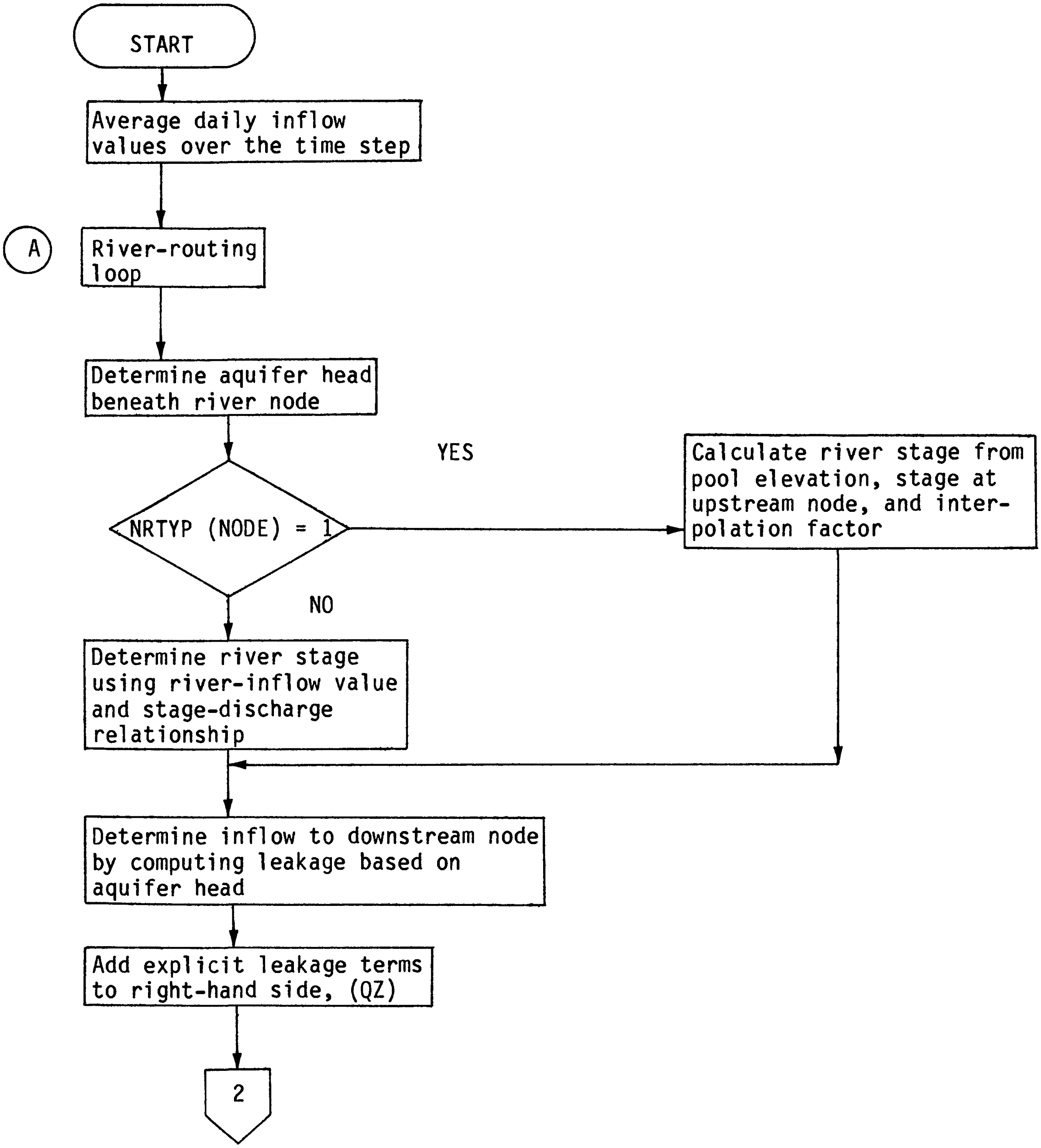


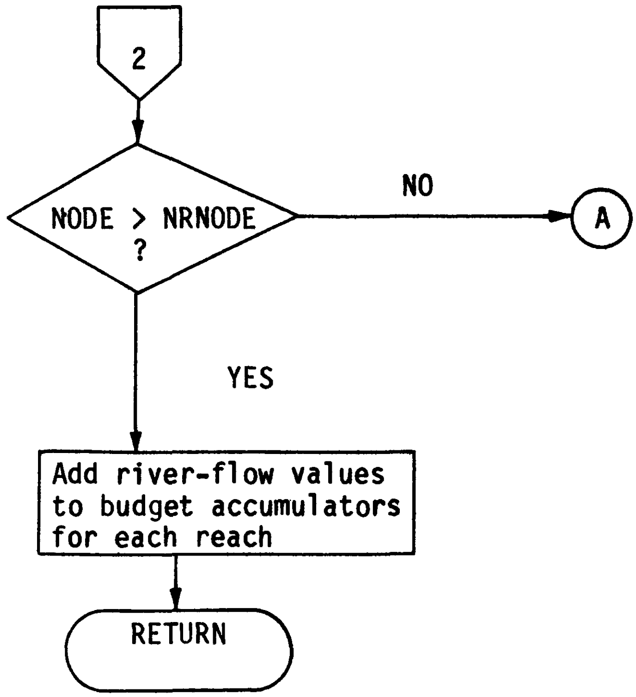
SUBROUTINE QRIVER



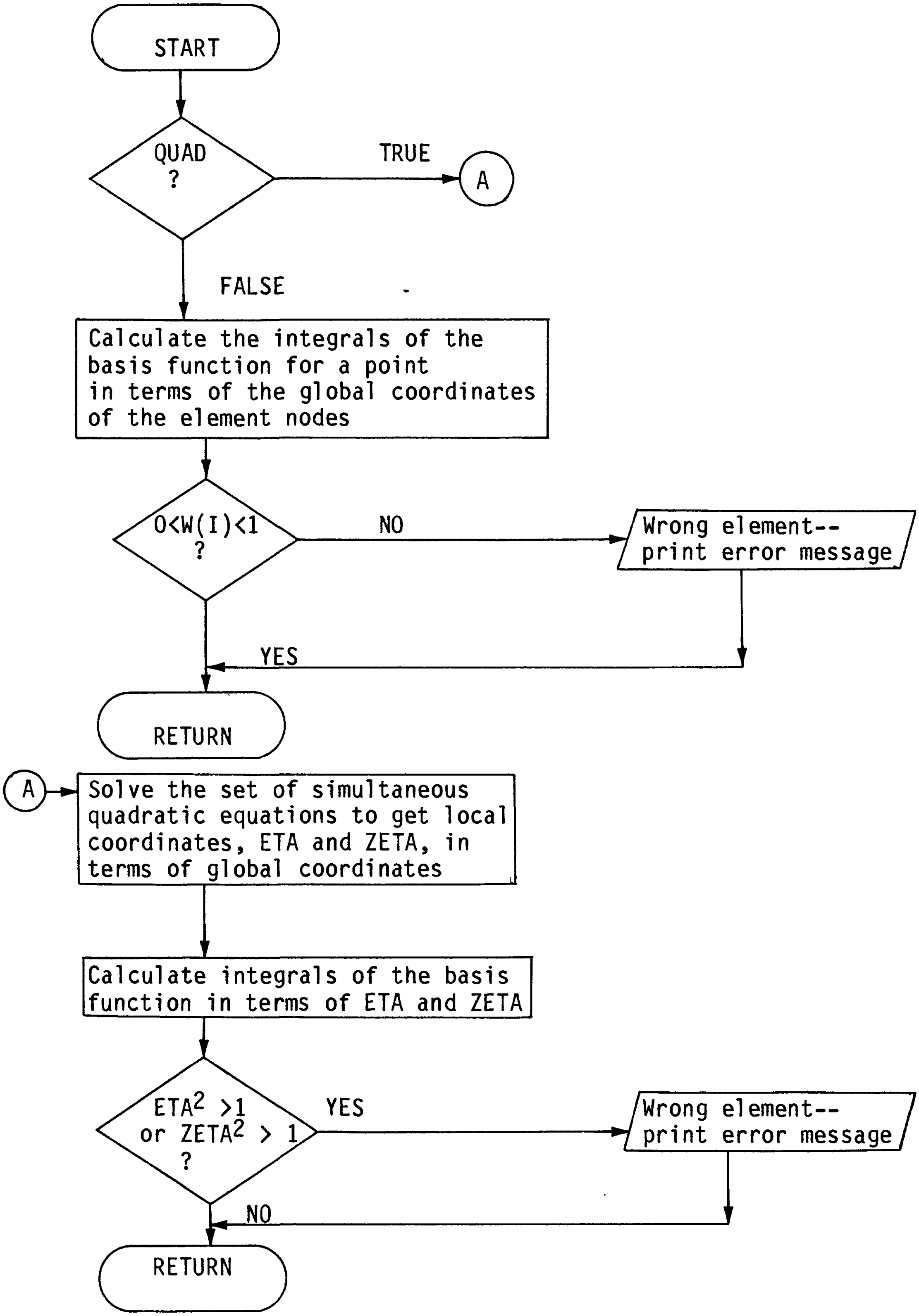


SUBROUTINE RIVER

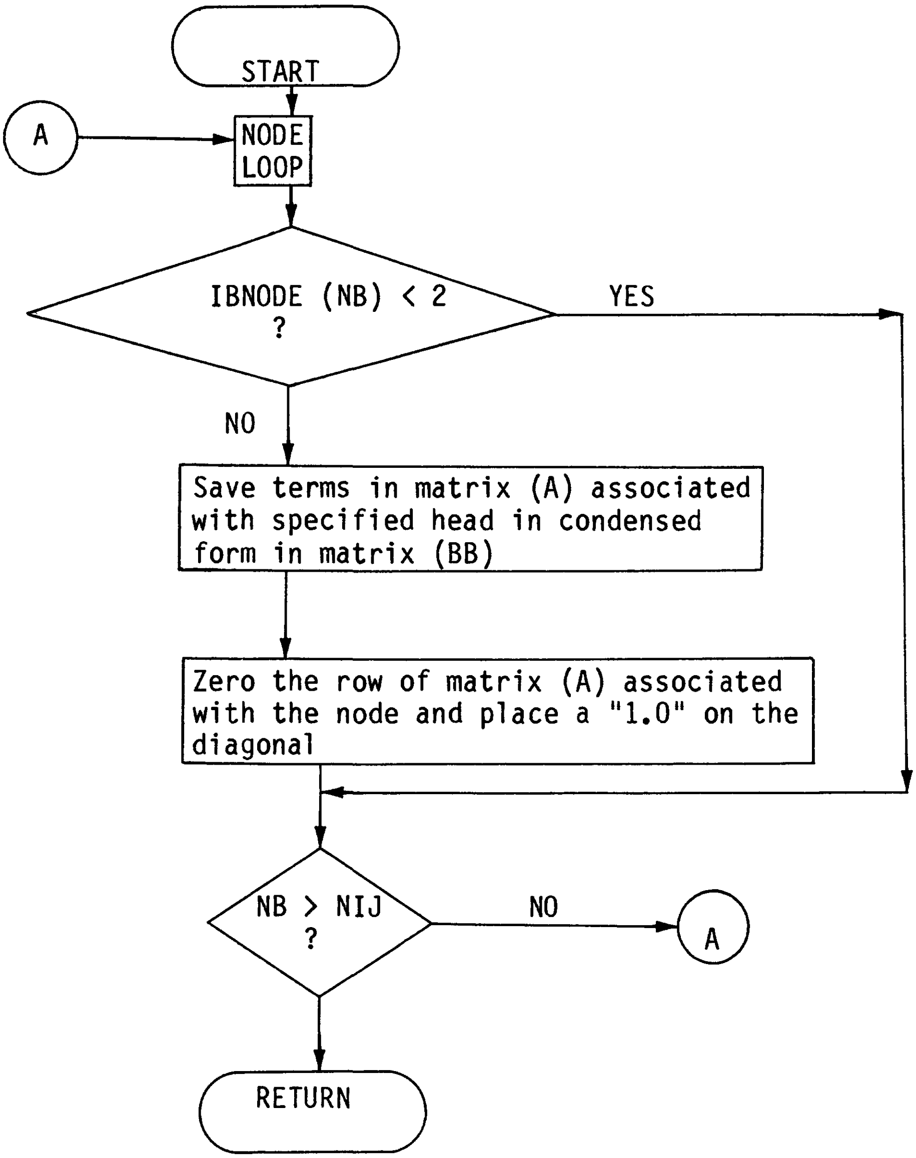



2
NODE > NRNODE ?
NO
A
YES
Add river-flow values to budget accumulators for each reach
RETURN

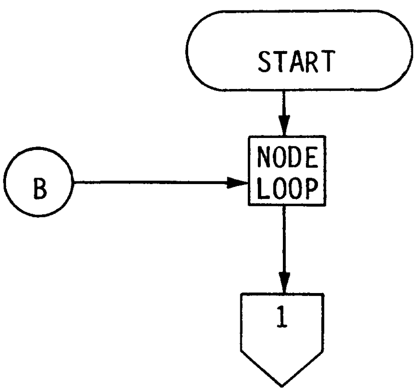
SUBROUTINE PTFNDR

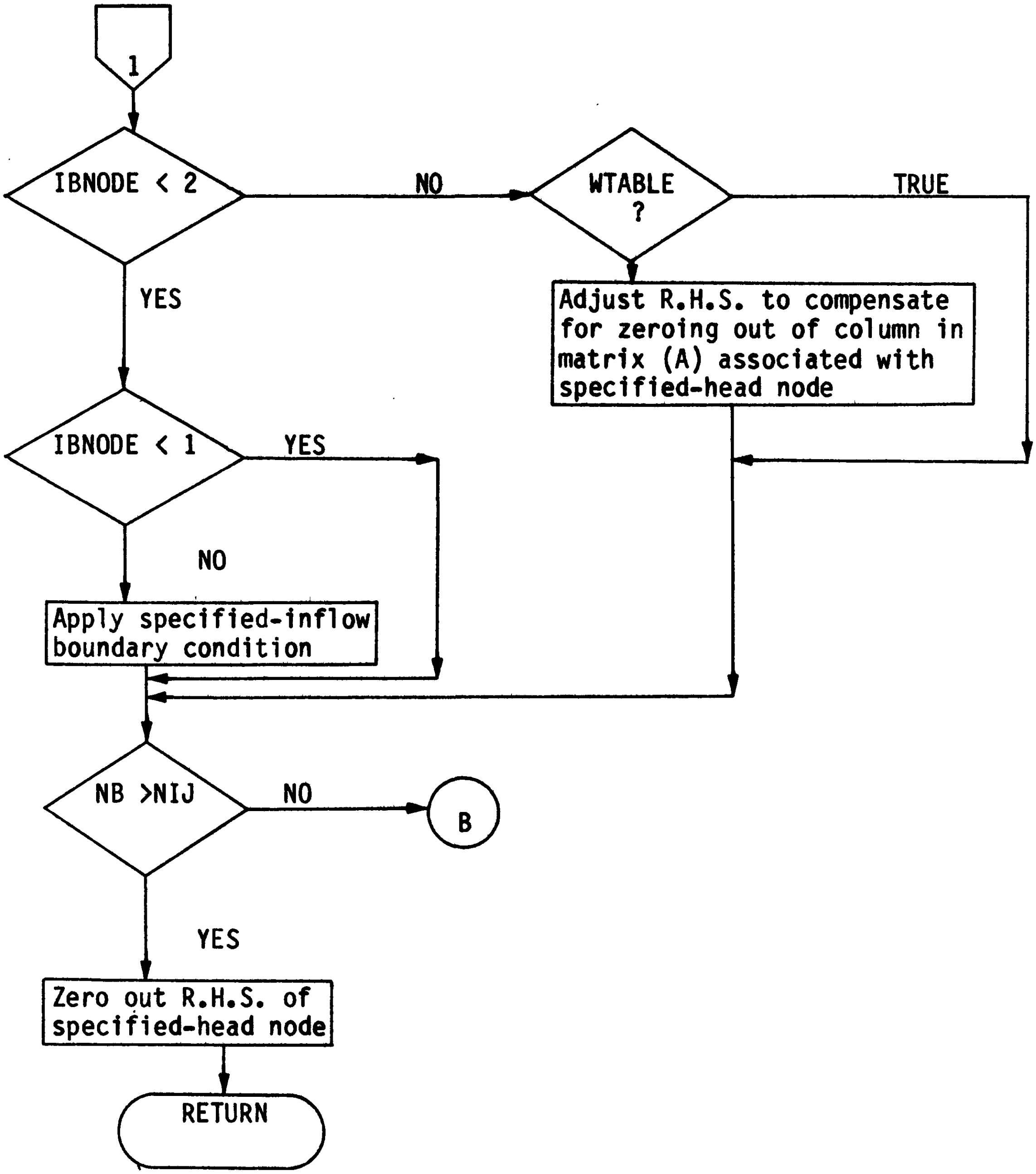


SUBROUTINE BNDCON

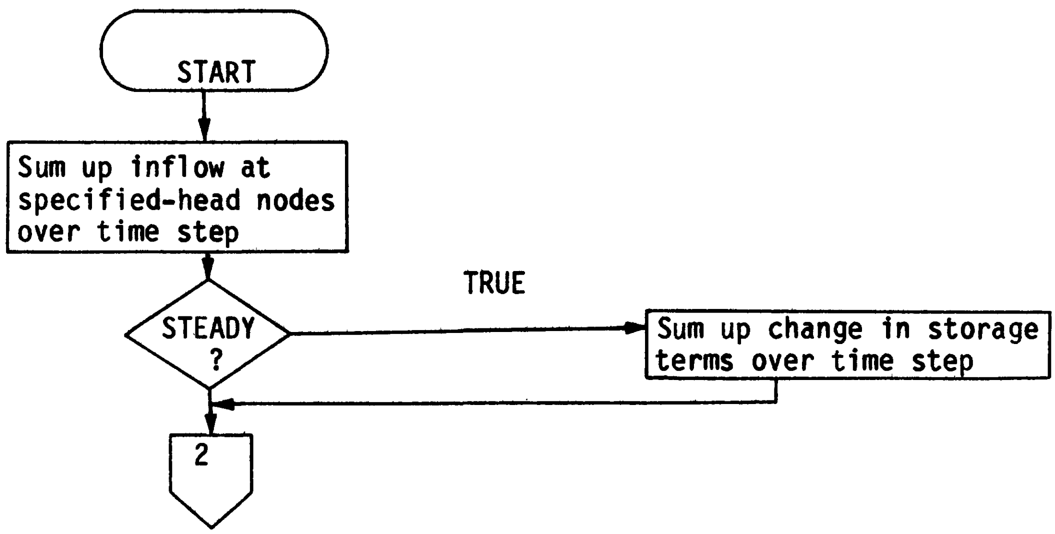


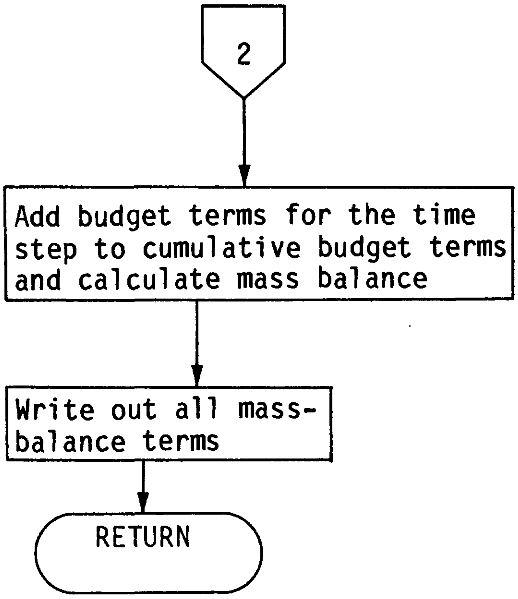
SUBROUTINE QBOUND



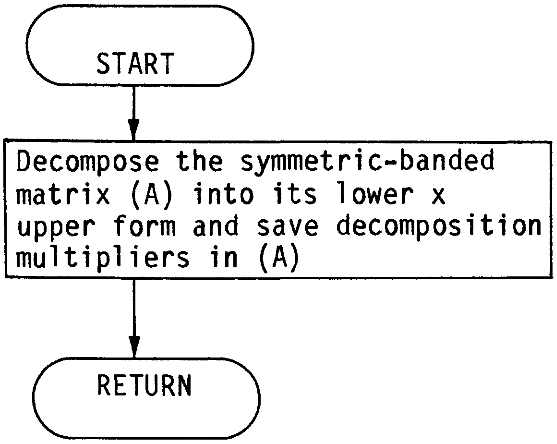


SUBROUTINE MASBAL

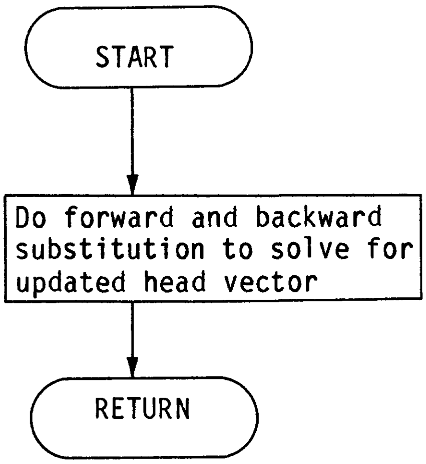



2
Add budget terms for the time step to cumulative budget terms and calculate mass balance
Write out all mass-balance terms
RETURN

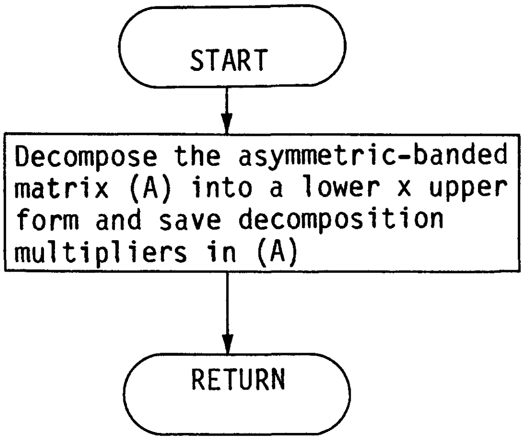
SUBROUTINE SDCOMP



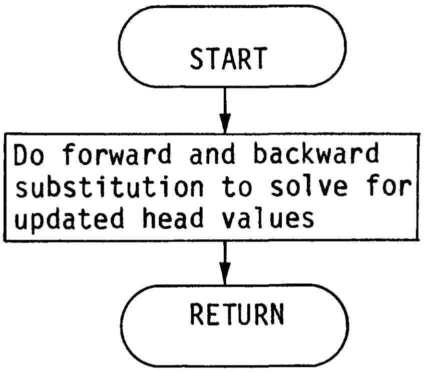
SUBROUTINE SSOLVE



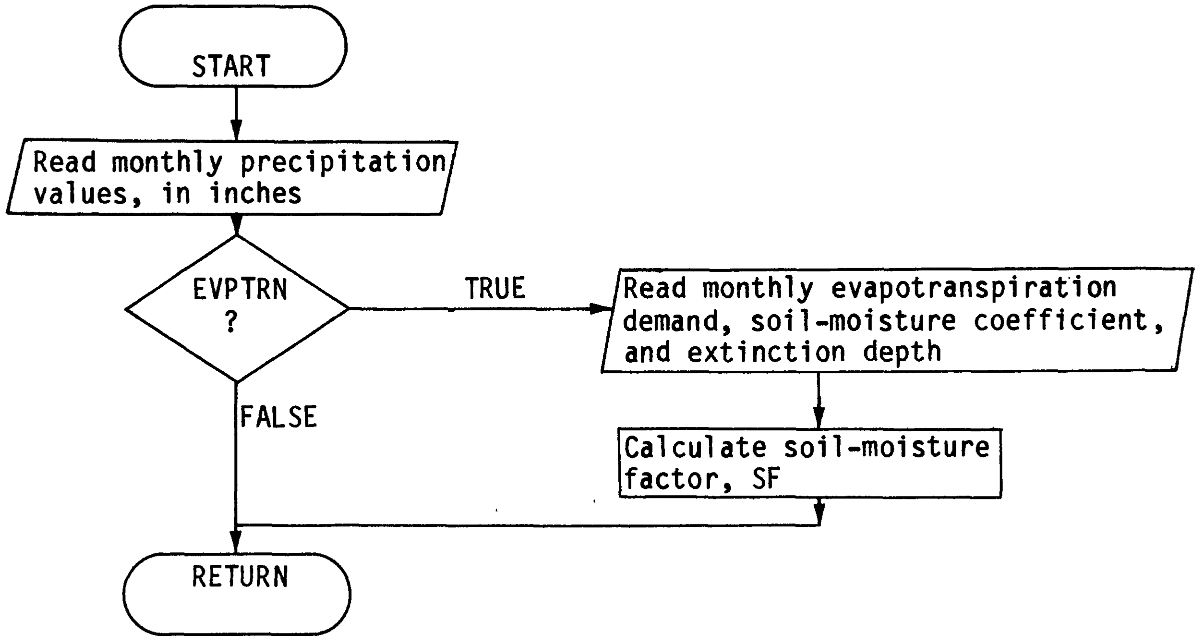
SUBROUTINE ADCOMP



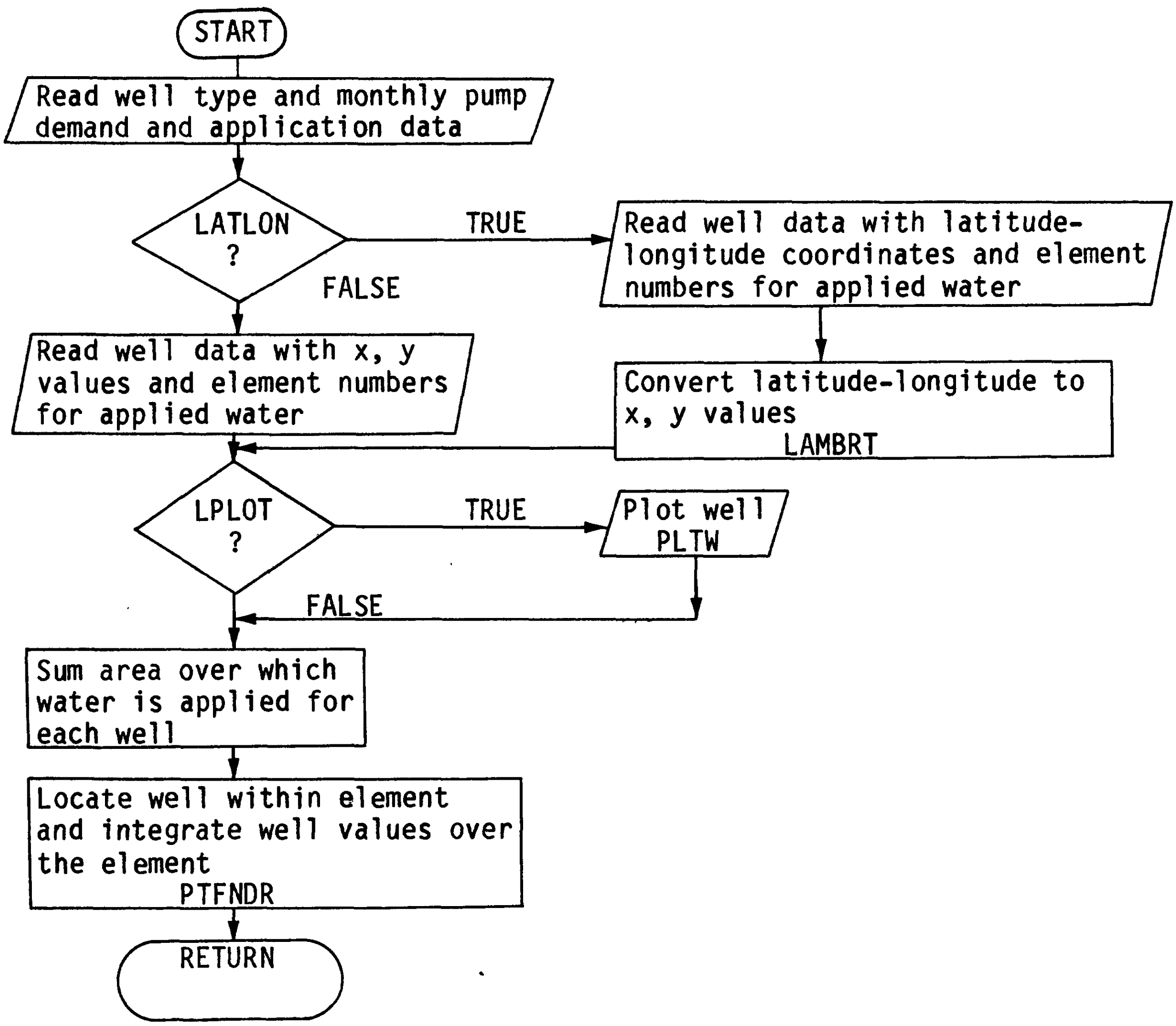
SUBROUTINE ASOLVE



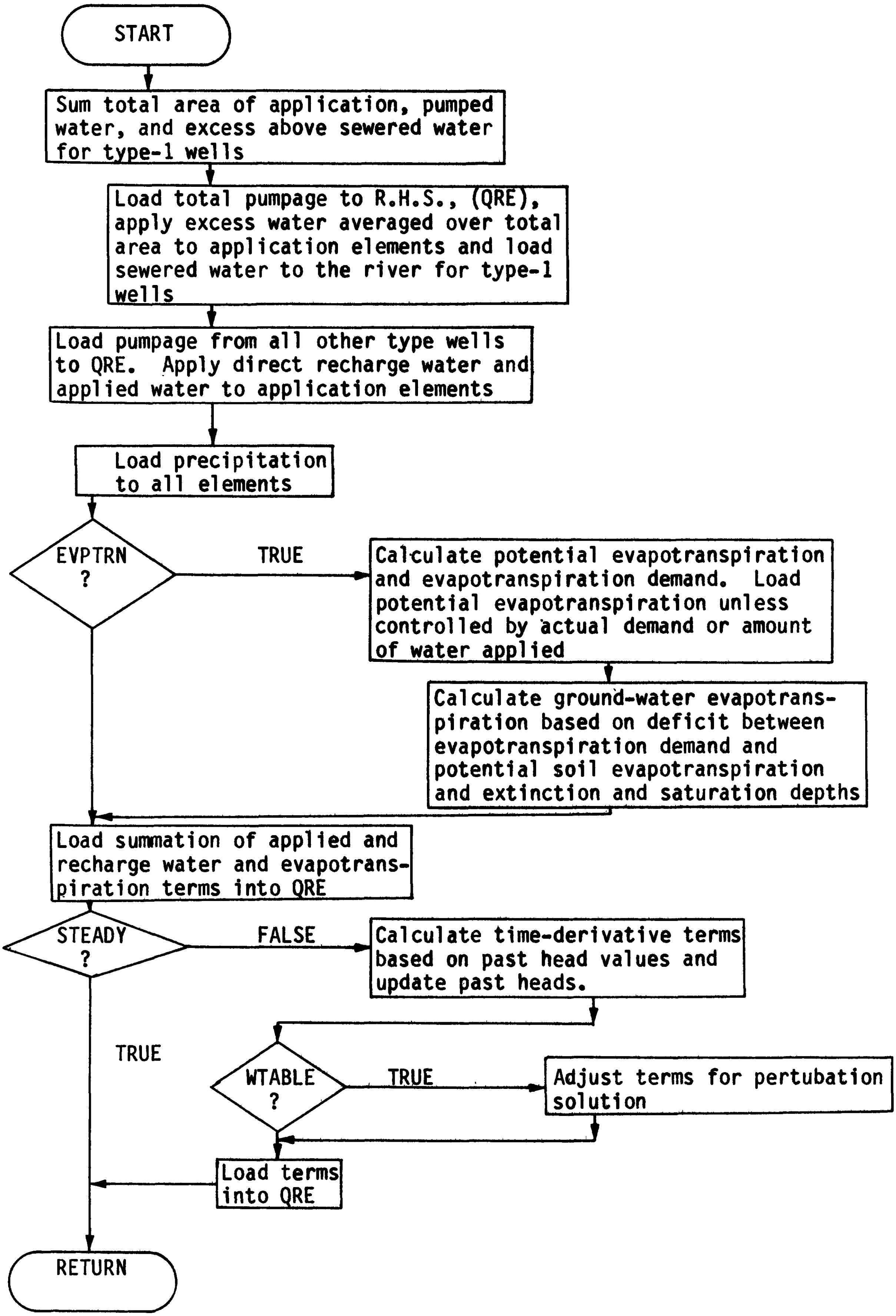
SUBROUTINE QZEE



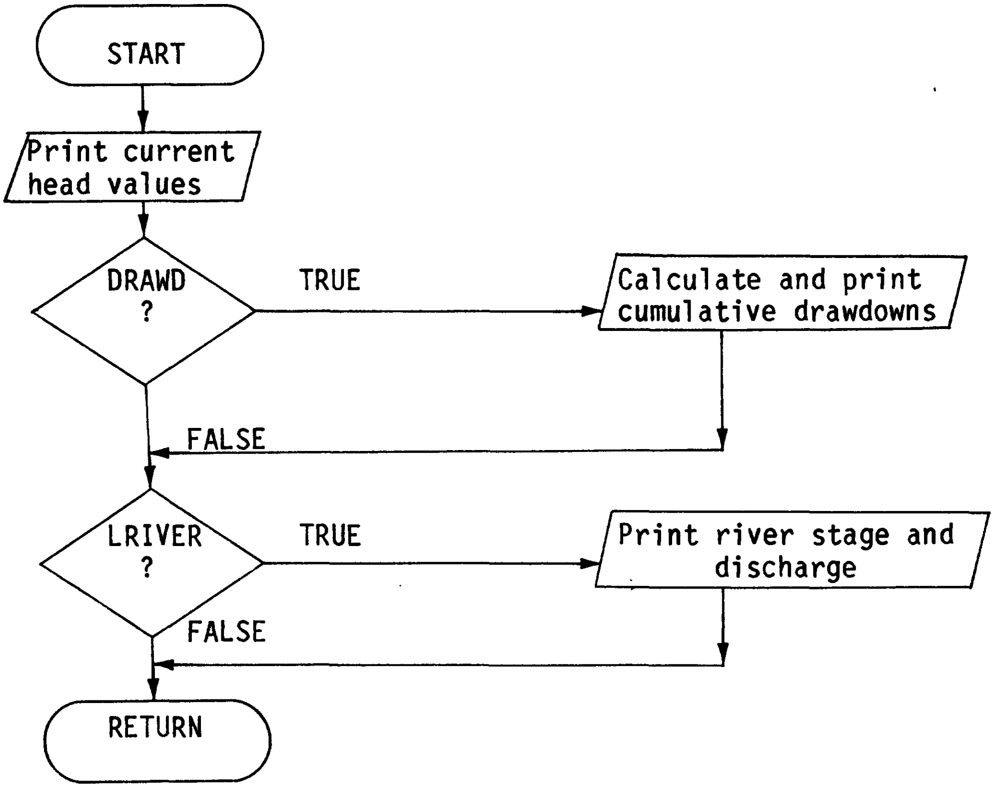
SUBROUTINE PUMPNU



SUBROUTINE LOADQR



SUBROUTINE OUTPUT



Model Input Setup

Group I: Title, Model Options, Printout and Plotter Control, and Problem Size

This group of cards is read in by the DATAIN subroutine. Integer variables, read in with I format, must be right-hand justified. Logical variables are read in with L format and must be left-hand justified. Real variables are read in with F format, but they can also be punched as E format (for example, 0.00004 can also be punched as 4.0E-05).

Card	Columns	Format	Variable	Definition
1	1-72	9A8	TITLE	First title card used as a heading to be printed on the output
2	1-72	9A8	TITLE	Second title card
3	1-4	L4	STEADY	Logical variable to specify program options
				.TRUE. - steady-state simulation
				.FALSE. - transient run
	7-10	L4	WTABLE	.TRUE. - transmissivities vary with head (water-table simulation)
				.FALSE. - transmissivities are constant
	13-16	L4	QUAD	.TRUE. - elements are shaped as quadrilaterals
				.FALSE. - Elements are triangular
	19-22	L4	LATLON	.TRUE. - coordinates for all points are given by their latitude and longitude
				.FALSE. - points are defined by their x, y value
	25-28	L4	LRIVER	.TRUE. - calculations will be done to account for stream-aquifer interaction
				.FALSE. - no stream calculations
	31-34	L4	DRAWD	.TRUE. - drawdown values from the starting heads will be calculated

				.FALSE. - only heads will be calculated
Card	**Columns**	**Format**	**Variable**	**Definition**
	37-40	L4	LPLOT	.TRUE. - Plotting routines will be called .FALSE. - No plotting will be done
	43-46	L4	EVPTRN	.TRUE. - Evapotranspiration will be accounted for .FALSE. - no evapotranspiration
Note:	If option space is left blank, it will be interpreted as .FALSE.			
4	1-4	14	IPRINT	Printout option control IPRINT $\geq$ 6, All nodal x, y coordinates are printed out IPRINT $\geq$ 5, Nodal linkages and element areas are printed IPRINT $\geq$ 4, River and well coordinates are printed IPRINT $\geq$ 3, All input data are echoed IPRINT $\geq$ 2, Critical input is echoed IPRINT $\geq$ 1, Minimum printout
	5-8	14	NPRNT	Number of time steps between printout of calculated heads and river stage
5	1-4	14	KYR	Starting year of simulation
	5-8	14	KMN	Starting month
	9-12	14	KDY	Starting day of month
	13-16	14	IDAY	Time-step, in days
	17-20	14	NSTEP	Total number of time steps to be taken
6	1-4	14	MAXIT	Maximum number of iterations allowed in river-stage head calculation
	5-14	F10.0	BETA	Convergence acceleration parameter (generally equal to 1.0 or greater)
	15-24	F10.0	EPS	Convergence criterion between iterations

NOTE: CARD 6 read only if LRIVER = .TRUE.

Card	Columns	Format	Variable	Definition
7	1-6	F6.0	XSCL	Scaling factor for x coordinates to convert them to model-length units
	7-12	F6.0	YSCL	Scaling factor for y coordinates
		NOTE: CARD 7 is read only if LATLON = .FALSE.		
8	1-4	I4	IPLOT	Control parameter for plot of the finite-element grid
				IPLOT $\geq$ 5, Nodes are numbered
				IPLOT $\geq$ 4, Elements are numbered
				IPLOT $\geq$ 3, River nodes are numbered
				IPLOT $\geq$ 2, Wells are numbered
				IPLOT $\geq$ 1, No numbering
	5-14	F10.0	XSCLP	Scaling factor to convert the x-coordinate values back to plotter inches
	15-24	F10.0	YSCLP	Scaling factor for y coordinates
		NOTE: CARD 8 is read only if LPLOT = .TRUE.		
9	1-4	I4	IS	Number of nodes in the row (long dimension)
	58	I4	JT	Number of nodes in the column (short dimension)

Group II: Array Data for the Aquifer

Each of the following data sets, except the first (IBNODE) and last two (PBH and PBF), are read in by the subroutine ARRAY and consist of a parameter card, and if the values are to be specified at each node, a set of data cards. All arrays (except the first) are real. Each parameter card has the following format:

Card	Columns	Format	Variable	Definition
1	1-8	A6	TITLE	Data-set name
	11-13	I2	NUNIT	Unit number from which additional data cards will be read. If NUNIT = 0, all nodes are set to a uniform value, and no additional data are read

Card	Columns	Format	Variable	Definition
	14-29	2A6	FMT	A character string describing the format to be used in the subsequent data set [for example, (8F10.5)]
	30-39	F10.0	SCALE	Scaling factor for values read in the data set. If NUNIT = 0, the entire array is set to SCALE
	40-43	14	IPRINT	Local printout control. If IPRNT >0, scaled values will be printed out

The arrays needed are determined by the logical control options specified. Those that are always read in are underlined. Those that are optional will be noted. Data-set one (IBNODE) is integer and read in by DATAIN. No parameter card is necessary. All data sets have IS number of cards with JT values per card.

Data card	Columns	Format	Variable	Definition
1	1-80	2014	IBNODE(I,J)	Integer describing boundary-condition type at each node IBNODE (I,J) = 0, Interior node with no specified influx IBNODE (I,J) = 1, Specified-flux type boundary IBNODE (I,J) = 2, Specified-head type boundary IS cards, JT values per card
2	1-80	FMT	H(I,J)	Starting nodal head values [L]
3	1-80	FMT	HP(I,J)	Head values at the last time step in a previous run [L] NOTE: Read in when STEADY = .FALSE.
4	1-80	FMT	S(I,J)	Nodal values for the storage coefficient [dimensionless] NOTE: Read in when STEADY = .FALSE. Data sets 3 and 4 are needed only for a transient simulation

Data card	Columns	Format	Variable	Definition
5	1-80	FMT	T(I,J)	If WTABLE = .TRUE., the array contains the nodal values of permeabilities [L/T] If WTABLE = .FALSE., the array contains the nodal values of transmissivities [L]
6	1-80	FMT	ALSD(I,J)	Elevation of the land surface above the datum used in calculating evapotranspiration [L] Note: Read in when EVPTRN = .TRUE.
7	1-80	FMT	HO(I,J)	Steady-state solution values for head, used in the perturbation-solution technique for variable transmissivities [L] Note: Read in when WTABLE = .TRUE.
8	1-80	FMT	BOTT(I,J)	Elevation of the aquifer bottom above the datum [L] Note: Read in when WTABLE = .TRUE. Data sets 7 and 8 are needed when doing a water-table aquifer simulation
9	1-80	FMT	BQH(I,J)	Array of values for specified head and fluxes at boundary nodes [L] or [L^3/T] Note: Boundary-condition type is determined by the IBNODE array
10	1-72	12F6.0	PBH(M)	Monthly multipliers for specified-head values. One card only. No parameter card needed.
11	1-72	12F6.0	PBF(M)	Monthly multipliers for specified flux values. One card only. No parameter card needed.

Group III: Finite-Element Grid Specifications

This data set contains the information necessary to generate the finite-element grid. Because the grid is regular, only the coordinates of the top and bottom nodes on a line need be specified. JT number of nodes will then be spaced equally along that line. The coordinates can be located by their latitude and longitude or by user determined x, y value. Both formats will be detailed below. The grid specification is the same whether the elements are quadrilaterals or triangular.

NOTE: if LATLON = .TRUE., data are read with the following format. There are IS number of cards in the data set.

Card	Columns	Format	Variable	Definition
1-IS	1-12	3I4	LONB	Values for degrees, minutes, and seconds of longitude for a node in the bottom row of the grid (left to right). Each value must be right-hand justified in its I4 field
	13-24	3I4	LATB	Degrees, minutes, and seconds of latitude for nodes in the bottom row
	31-42	3I4	LONT	Degrees, minutes, and seconds of longitude for corresponding nodes in the top row
	43-54	3I4	LATT	Degrees, minutes, and seconds of latitude for nodes in the top row

Note: if LATLON = .FALSE., data are read with the following format; values will be scaled by XSCL and YSCL.

Card	Columns	Format	Variable	Definition
1-IS	1-10	F10.0	X(NODBOT)	x coordinate of the bottom node [L]
	11-20	F10.0	Y(NODBOT)	y coordinate of the bottom node [L]
	21-30	F10.0	X(NODTOP)	x coordinate of the top node [L]
	31-40	F10.0	Y(NODTOP)	y coordinate of the top node [L]

Group IV: River Geometry, Leakance Values, Stage-Discharge Relationships, and Daily Inflow Values

This group contains data necessary to account for stream-aquifer interaction. This group is read only if LRIVER = .TRUE. and is read by subroutine QRIVER.

Card	Columns	Format	Variable	Definition
1	1-4	I4	NREACH	Number of reaches into which the river is divided

Card	Columns	Format	Variable	Definition
	5-8	I4	NRNODE	Number of river nodes
	9-12	I4	NRZ	Number of zones defined by river-leakance values
	13-16	I4	NTRIB	Number of river tributaries
2	1-72	7F10.0	QCOR(1)	Leakance (K'/b') values for each zone [1/T]. There are NRZ values, 12 values per card

There are three data sets to be read in the river-data group. The first set contains data for river-flow routing, including pool-elevation data and the stage-discharge relationship for each reach. There are three cards for each reach and NREACH groups of cards in the set. Data-set two contains river-node parameters, and there are NRNODE cards. Data-set three contains the daily inflow values at the upstream end of the river.

DATA-SET ONE: Pool-elevation and stage-discharge data

Card	Columns	Format	Variable	Definition
1	1-4	I4	NSTAGE(N)	Number of points used to approximate the stage-discharge relationship for this reach
	5-14	F10.0	HPOOL(N)	Pool elevation for this reach [L]
2	1-72	12F6.0	STAGE(L,N)	Values for the stage at selected points along the stage-discharge curve [L]. There are NSTAGE(N) values, 12 values per card
3	1-72	12F6.0	DSCHRG(L,N)	Corresponding values for discharge at selected points along the S-D curve [L^3/T]

DATA-SET TWO: River-node parameters

NOTE: If LATLON = .TRUE., data are read with the following format.

NRNODE cards

Card	Columns	Format	Variable	Definition
1	1-12	3I4	LON	Degrees, minutes, and seconds of longtude for each river node
	13-24	3I4	LAT	Degrees, minutes, and seconds of latitude for each river node

Card	Columns	Format	Variable	Definition
	25-28	I4	NRN(N)	Reach number of the node
	29-32	I4	IRZ	Leakance-zone number of the node
	33-36	I4	NER(N)	Number of the element in which the river node is located
	37-40	I4	NRTYP(N)	River-node type NRTYP(N) = 0, stage-discharge control node NRTYP(N) = 1, pool-backwater control node
	41-50	F10.0	LENGTH	Channel length associated with the river node [L]
	51-60	F10.0	WIDTH	Channel width at the river node [L]
	61-70	F10.0	ELVR(N)	Elevation of the riverbed above the datum at the river node [L]
	71-80	F10.0	XFACTR(N)	NRTYP(N) = 0, not used NRTYP(N) = 1, interpolation factor to determine stage from pool and previous river-node stage elevation

NOTE: If LATLON = .FALSE., data is read in with the following format; x and y values are scaled by XSCL and YSCL.

Card	Columns	Format	Variable	Definition
1	1-12	F12.0	XR	x coordinate of the river node [L]
	13-24	F12.0	YR	y coordinate of the river node [L]
	25-28	I4	NRN(N)	Reach number of river node
	28-32	I4	IRZ	Leakance-zone number
	33-36	I4	NER(N)	Element number of river node
	37-40	I4	NRTYP(N)	River-node type
	41-50	F10.0	LENGTH	Channel length [L]
	51-60	F10.0	WIDTH	Channel width [L]

Card	Columns	Format	Variable	Definition
	61-70	F10.0	ELVR	River elevation
	71-80	F10.0	XFACTR(N)	Interpolation factor
2	1-80	20I4	NODEIN (NTRIB)	River-node numbers of tributary-input point

DATA-SET THREE: Daily inflow values

Card	Columns	Format	Variable	Definition
1-31	1-72	12F10.0	FLOWIN(N)	Daily values for inflow at the upstream end of the river [L^3/T]. 365 or 366 values, 12 values per card

Group V: Precipitation and Evapotranspiration Data

This set of cards contains data used in calculating recharge due to precipitation and is read by subroutine QZEE. If EVPTRN = .TRUE., data used in calculating losses due to evapotranspiration are also read. Precipitation, evapotranspiration demand, and soil-moisture capacity are read with units of inches. NOTE: The first value on the card is assumed to be for the month of January.

Card	Columns	Format	Variable	Definition
1	1-72	12F6.0	PRECIP(M)	Monthly averaged value for precipitation [L]
2	1-72	12F6.0	U(M)	Monthly averaged value for evapotranspiration demand [L]
3	1-6	F6.0	SC	Soil-moisture capacity [L]
	7-12	F6.0	DEPTH	Extinction depth for soil-moisture loss to evapotranspiration [L]
				NOTE: Read only if EVPTRN = .TRUE.

Group VI: Well Parameters, Pumpage Demands, and Water Distribution

This group contains data needed to calculate the effects due to groundwater withdrawal and reapplication. Wells can be typed as to percentage of water that is applied in irrigation and seasonal pumpage variation. Sewered wells (type 1) are defined as those whose discharge is routed directly into the river (for example, municipal wells).

Card	Columns	Format	Variable	Definition
1	1-4	I4	NWELLS	Total number of wells
	5-8	I4	NSEWER	Number of type-1 wells whose outflow contributes directly to the river
	9-12	I4	NWTYP	Total number of well types

There are two additional data sets to be read. The first describes the monthly variation in the pump demand by type and the amount of water applied. The second set contains the well location, type, and withdrawal rate and which elements, if any, the water is applied over. Both data sets are read only if NWELLS > 0.

DATA-SET ONE: Monthly variation in pump demand and percentage applied

1	1-60	12F5.0	PMPDMD(N,M)	Monthly multipliers of pump demand by pumpage types. There are NWTYP cards in this data set.
	61-65	F5.0	PMPAPP(N)	Percentage of well water that is applied on land by pumpage types.

DATA-SET TWO: Well parameters

NOTE: If LATLON = .TRUE., the data set is read with the following format.

There are NWELLS sets of cards.

Card	Columns	Format	Variable	Definition
1	1-12	3I4	LON	Degrees, minutes, and seconds of longitude for each well
	13-24	3I4	LAT	Degrees, minutes, and seconds of latitude for each well
	25-28	I4	NEW(N)	The number of the element in which the well is situated
	29-32	I4	NTW(N)	Well-type number
	33-36	I4	NAPP(N)	The number of elements over which the applied water is distributed
	41-50	F10.0	QW(N)	Pumpage rate from the well [L^3/T]. For recharge wells, QW(N) must be negative

Card	Columns	Format	Variable	Definition
2	1-80	20I4	NEAPP(L,N)	Element numbers on which water is applied. Twenty values per card NOTE: This card is read only if NAPP(N) for the well is >0

NOTE: If LATLON = .FALSE., the data set is read with the following format. x- and y-coordinate values are scaled by XSCL and YSCL

Card	Columns	Format	Variable	Definition
1	1-12	F12.0	XW	x coordinate of the well [L]
	13-24	F12.0	YW	y coordinate of the well [L]
	25-28	14	NEW(D)	Number of the element containing the well
	29-32	14	NTW(N)	Well-type number
	33-36	14	NAPP(N)	Number of elements over which water is applied
	41-50	F10.0	QW(N)	Pumpage rate [L^3/T]
2	1-80	20I4	NEAPP(L,N)	Element numbers on which water is applied. Twenty values per card NOTE: This card is read only if NAPP(N) for the well is >0.

Model Input for Example Problem

A 20 x 20 node grid (fig. 28) is used to illustrate the model-input setup. Grid spacing is 1,000 feet. Model options included in the example problem are confined-aquifer conditions, precipitation, evapotranspiration, river, one injection well, one pumping well, constant-head boundary, and constant-flux boundary.

Aquifer and model properties are as follows:

Initial potentiometric surface	200 feet
Storage coefficient	0.01
Transmissivity	10,000 ft^2/d
Well injection rate	8.64 x 10^4 ft^3/d
Well pumping rate	1.34 x 10^5 ft^3/d
River: 18 nodes	
Bed elevation	199 feet
Stage-discharge:	
stage	0.0 1.0 2.0 feet
discharge	0.0 1.0 100.0 ft^3/s
Reach length	1,000 feet
Reach width	40 feet
Leakage	0.15 day^{-1}
Daily inflows	50 ft^3/s

Precipitation (January)	0.43 inch per month
Evapotranspiration demand (January)	0.49 inch per month
Soil-moisture storage capacity	6 inches
Extinction depth for evapotranspiration	10.0 feet
Constant-head boundary	200 feet
Constant-flux boundary	0.01 ft^3/s

A listing of model input (p. 160-162) and a partial listing of model output (p. 163-168) for the example problem shown in figure 28 are included at the end of this report. Line numbers are shown to facilitate reading the example but should not be included in actual model input. Also note that the model is presently setup to print 60 river nodes in pairs; however, only the nodes pertinent to the problem were retained in the example output.

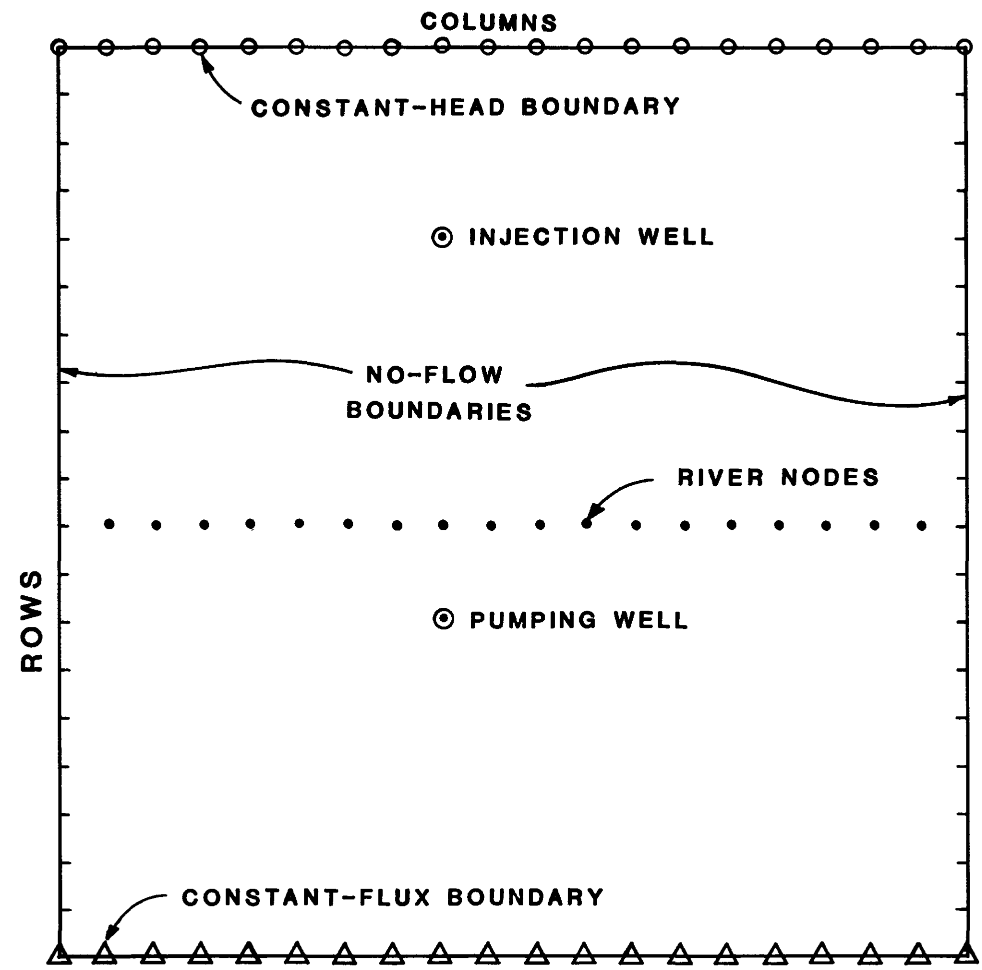


Figure 28.--Model characteristics for input example problem.

Description of Program Common Blocks

AQUIFER - Contains the element area array and all arrays associated with aquifer properties.

BNDRY - Contains all arrays used in applying model-boundary conditions.

BUDGET - Contains arrays used in computing the water balance for the model.

HEAD2 - Contains arrays to store original and iterative head values.

IOUNIT - Contains the variables defining the input and output units and the variables used as output control.

LOGIC - Contains the logical variables controlling program operation.

MATRIX - Contains the matrix used as the left-hand side of the flow equation and the matrix containing the time-derivative terms.

PLT - Contains variables used in the grid-plotting routines.

RIVERB - Contains all data and arrays associated with the stream being modeled.

SIZE - Contains all variables that detail the dimensions of the problem and that describe the element geometry.

TIME - Contains data used in keeping track of calendar time for transient simulations.

TIME2 - Contains control variables for the time and iteration loops.

WELLS - Contains all data relating to well pumpage and water application.

WETHER - Contains climate and evapotranspiration data.

WTBLE - Contains additional arrays used when transmissivities are head dependent (water-table simulation).

Array Dimensions by Common Blocks

Minimum dimensions for each array is given in terms of the integer variable that controls its size. Where a number is given, it indicates that the array dimension is fixed and never needs to be changed unless otherwise noted. More information about dimensioning of variables is given in the list of variable definitions.

Common Block			Variables	
AQUIFER:	ALSD	(NIJ)	QZ	(NIJ)
	AREA	(NEL)	S	(NIJ)
	H	(NIJ)	T	(NIJ)
	HP	(NIJ)	X	(NIJ)
	QRE	(NIJ)	Y	(NIJ)
BNDRY:	BB	(9,50)	PBF	(12)
	BQH	(NIJ)	PBH	(12)
	IBNODE	(NIJ)	QB	(NIJ)
BUDGET:	A	(NIJ, NBW)	NGL	(4, NEL)
	BUD	(NBUD)	NRN	(NRNODE)
	BUDTOT	(NBUD)	NRTYP	(NRNODE)
	BUDTTL	(2,NBUD)	NSTAGE	(NREACH)
	DISCHRG	(20,NREACH)	OLDH	(NIJ)
	ELVR	(NRNODE)	QCOMR	(NRNODE)
	FLOWIN	(366)	QCOR	(NRZ)
	FMON	(12)	RIVERH	(NRNODE)
	HI	(NIJ)	RIVERQ	(NRNODE)
	HPOOL	(NREACH)	RW	(4,NRNODE)
	IDMON	(12)	STAGE	(20,NREACH)
	MON	(12)	UV	(NIJ)
	NEND	(NREACH)	XFACTR	(NRNODE)
	NER	(NRNODE)		
WELLS:	AREAPP	(NWELLS)	PMPAPP	(NWTYP)
	ETFACT	(8)	PMPDMD	(NWTYP,12)
	NAPP	(WELLS)	QAPP	(NEL)
	NEAPP	(30,NWELLS)	QW	(NWELLS)
	NEW	(NWELLS)	REAPP	(NEL)
	NTW	(NWELLS)	U	(12)
	PRECIP	(12)	WW	(4,NWELLS)
WTBLE:	BOTT	(NIJ)		
	HO	(NIJ)		
	QBAR	(NIJ)		

Definitions of Program Variables

A(NIJ,NBW)	-	The banded matrix containing all terms on the left-hand side of the flow equation. When transmissivities are constant, the A matrix is symmetric, and only the upper half of the matrix is stored. When transmissivities are head dependent, the matrix is asymmetric, and the full band is stored.
ALSD(NIJ)	-	Array of land-surface elevations.
AREA(NEL)	-	Array of element areas.
AREAPP(NWELLS)	-	Total area of water application for each well.
BB(9,50)	-	Storage for full matrix equations at specified-head boundary nodes. The "9" is fixed, but the "50" should be increased if there are more than 50 specified-head nodes.
BETA	-	Acceleration or dampening factor used in controlling the iterative solution for river leakage.
BOTT(NIJ)	-	Elevations of the aquifer bottom measured at the nodes.
BQH(NIJ)	-	Boundary values of specified heads and fluxes.
BUD(NBUD)	-	Time-step flow rates of each budget item.
BUDTOT(NBUD)	-	Accumulated volume of flow for each budget item.
BUDTTL(2,NBUD)	-	Names of budget (water-balance) items. Size of array may be machine word-size dependent.
DELT	-	Size of the time step in seconds.
DEPTH	-	Evapotranspiration extinction depth (feet).
DRAWD	-	Controls whether cumulative drawdowns from starting head values will be calculated. .TRUE. for calculations to be done.
DSCHRG(20,NREACH)	-	Corresponding river-reach gage discharge of stage-discharge relationship.
ELVR(NRNODE)	-	Nodal river-bottom elevation array.
EPS	-	Convergence criterion for iterative procedure.

ETFACT(8)	-	Coefficients used in calculating evapotranspiration from demand and moisture capacity.
EVPTRN	-	Controls whether evapotranspiration will be considered. .TRUE. for evapotranspiration calculation.
FLOWIN(366)	-	Daily values for inflow at the first upstream river node.
FMON(12)	-	Percentages of days out of the time step that are spent each month.
FMT	-	The format with which the subsequent data will be read (NUNIT >0).
GRADX	-	Mean gradient in x-direction of 'HO' over an element.
GRADYY	-	Mean gradient in y-direction of 'HO' over an element.
H(NIJ)	-	Current value of calculated heads at each node.
HI(NIJ)	-	Array for storing head values at the current iteration level.
HO(NIJ)	-	The array of head values defining an approximate average head surface that satisfies the ground-water-flow equation.
HP(NIJ)	-	Calculated value of heads at the previous time step.
HPOOL(NREACH)	-	River-reach pool elevations.
IBNODE(NIJ)	-	Integer array defining boundary type at each node.
IDAY	-	Number of days per time step.
IDIAG	-	The location, within the A matrix, of the diagonal. (IDIAG = 1, for constant transmissivity; for variable transmissivity, IDIAG = JT + 2).
IDMON(12)	-	Array containing the number of days in each month.
IDYR	-	Total number of days in the year. Equal to 365 or 366.
IHALFB	-	The half-band width of matrix A, not including diagonal.

IHBP - The half-band width of matrix A, including diagonal.

IN - Unit number of input device.

IO - Unit number of output device. Both IN and IO may be machine dependent and are defined in BLOCK DATA.

IPLOT - Integer controlling the detail of the grid plot.

IPRINT - Printout control variable.

IS - An integer defining the number of nodes along the length of the finite-element grid.

JT - The number of nodes along the width of the grid.

KDY - Calendar day for transient simulation.

KDYS - Number of days from the beginning of the calendar year to the current calendar date in the simulation.

KMN - Calendar month for transient simulation.

KYR - Calendar year for transient simulation.

LATLON - Determines whether all points are specified by latitude and longitude or by x, y values. .TRUE. for latitude and longitude.

LPLOT - Determines whether plot routines will be called. .TRUE. for plotting.

LRIVER - Controls whether stream-aquifer interaction will be evaluated. .TRUE. if there is a contributing stream.

MAXIT - Maximum number of iterations allowed in river-leakage procedure.

MON(12) - Array of three-letter abbreviations of the month names.

NAPP(WELLS) - Array containing the total number of elements over which water is applied for each well.

NBUD - Number of budget items. Defined by the number of river reaches (NREACH) plus 12.

NBW - The matrix half-band width plus the diagonal (JT + 2) for the constant transmissivity case. The full-band width [2(JT + 2)-1] for the variable transmissivity problem.

NE - The element that the point is located within.

NEAPP(30, NWELLS) - Array containing the element numbers over which water is applied. Up to 30 elements are allowed per well.

NEL - Total number of elements the grid is composed of. [(IS-1) x (JT-1) for quadrilateral elements. Twice that amount for triangles].

NEND(NREACH) - The river-node number defining the downstream end of each reach.

NER(NRNODE) - An array containing the element in which each river node is located.

NETYP - An integer defining the number of nodes in the elements. (NETYP = 3 for triangular elements; for quadrilaterals, NETYP = 4).

NEW(NWELLS) - Array containing the element number in which each well is situated.

NGL(4,NEL) - The array defining the nodal linkages of each element. Nodes are linked counterclockwise around the element.

NIJ - The total number of nodes (IS x JT).

NO - The well or river-node number that the point represents.

NPRNT - Number of time steps between output of heads and river stages.

NREACH - An integer declaring the number of reaches the river is sectioned into.

NRN(NRNODE) - An array containing the reach number for all river nodes.

NRNODE - The number of river nodes.

NRTYP(NRNODE) - This array contains integer values declaring the node type for each river node. If NRTYP(N) = 0, the node is stage-discharge controlled. If NRTYP(N) = 1, it is pool-backwater controlled.

NRZ	-	The number of zones the river is divided into based on the value for leakance.
NSEWER	-	The number of type-1 wells.
NSTAGE(NREACH)	-	An array of integers defining the number of points used in describing the linearized stage-discharge relationship for each reach.
NSTEP	-	Total number of time steps to be taken in transient simulation.
NTW(NWELLS)	-	Integer-defining well type for each well. Well types are defined by user as to amount of applied water and seasonal variability. Type-1 wells, however, are defined as those whose excess water contributes directly to streamflow.
NUNIT	-	The unit number from which the subsequent data will be read. If NUNIT = 0, all nodes will be set to a uniform value.
NWELLS	-	The total number of wells.
NWTYP	-	The total number of well types.
OLDH(NIJ)	-	Array for storing starting head values.
PBF(12)	-	Multipliers for specified-flux values.
PBH(12)	-	Multipliers for specified-head values to account for monthly variations.
PIVOT	-	The diagonal term of each row.
PMPAPP(NWTYP)	-	Percentage of pumped water that is applied by well type.
PMPDMD(NWTYP,12)	-	Monthly adjustment values for pumpage rates by the type of well.
PRECIP(12)	-	Monthly averaged precipitation (inches).
QAPP(NEL)	-	Array of applied-water values that are subject to evapotranspiration losses averaged over the elements.
QB(NIJ)	-	Total fluxes to boundary nodes.
QBAR(NIJ)	-	The array of flux values that sustain the HO head surface.

QCOMR(NRNODE) - River-node leakage coefficient, equal to leakage factor of the zone the node is in times the river width and length associated with the node.

QCOR(NRZ) - The array of leakance values defined by leakance zones.

QRE(NIJ) - Nodal-recharge array without explicit river-leakage terms.

QUAD - Determines the type of finite element used. .TRUE. if quadrilateral, .FALSE. for triangles.

QW(NWELLS) - Annual average pumping rate at each well, in cubic feet per second.

QZ(NIJ) - Total nodal recharge array.

RADI - Conversion factor for degrees to radians.

RAIN - Monthly precipitation value, in feet per second.

REAPP(NEL) - Array of applied water that is direct recharge not subject to evapotranspiration, averaged over the elements.

RIVER(NRNODE) - Array for storing river-node stage elevations.

RIVERQ(NRNODE) - Array for storing nodal river-flow values.

RLATA - The latitude of origin of the Lambert projection.

RLONGA - The longitude of the origin of the Lambert projection.

RW(4,NRNODE) - Nodal values of leakage distribution from river nodes to element nodes.

S(NIJ) - Nodal storage array.

SC - Soil-column moisture capacity (inches).

SCALE - The scaling factor by which all nodes will be multiplied.

SEWAGE - Accumulated volume of pumped water to be routed downstream.

SF - Actual evapotranspiration.

STAGE(20,NREACH) - River-reach gage stage of stage-discharge relationship. Twenty points are allowed.

STEADY	-	Logical variable controlling whether run is steady state or transient. .TRUE. if steady state.
STOR	-	Mean storage term over an element.
T(NIJ)	-	Nodal transmissivity or permeability array.
TITLE	-	The name of the array of nodal values being read in.
TQH	-	Specified head or flux adjusted for monthly variability.
TRAN	-	Mean transmissivity over an element. (For a water-table aquifer transmissivity is average permeability times the thickness based on H).
U(12)	-	Monthly averaged evapotranspiration demand (inches).
UV(NIJ)	-	Storage for the time-derivative terms of the flow equation.
UET	-	Monthly values for evapotranspiration demand.
WTABLE	-	Controls whether transmissivities are constant or variable. .TRUE. if they are variable.
WW(4,NWELLS)	-	Distribution of pumpage from well points to element nodal points.
X(NIJ)	-	Array of nodal x coordinates.
XFACTOR(NRNODE)	-	Nodal value of nondimensional length from node to a downstream control or pool elevation.
XO	-	The x coordinate of the origin of the finite-element grid.
XP	-	The global coordinate of the point.
XR	-	The x coordinate of the origin of the Lambert projection.
XSCLP	-	Conversion factor for x coordinates back into plotter inches.
XW	-	Well x coordinate.
Y(NIJ)	-	Array of nodal y coordinates.

YO	-	The y coordinate of the origin of the finite-element grid.
YP	-	The global coordinate of the point.
YR	-	The y coordinate of the origin of the Lambert projection.
YSCLP	-	Conversion factor for y coordinates.
YW	-	Well y coordinate.

Tracy's Model Listing

```
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      REAL BUDTTL,XSCLP,YSCLP
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD
      COMMON/BNDRY/BQH(572),QB(572),PBH(12),PBF(12),BB(9,50),IBNODE(572)
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/WELLS/ QW(200),AREAPP(200),QAPP(1020),REAPP(1020),
     1WW(4,200),PMPDMD(5,12),PMPAPP(5),NEW(200),NTW(200),NAPP(200),
     2NEAPP(30,200),NWELLS,NSEWER,NWTYP
      COMMON /WETHER/ PRECIP(12),U(12),SC,DEPTH,SF,ETFAC(8)
      COMMON /PLT/ XSCLP,YSCLP,IPLOT
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT
      COMMON/MATRIX/ A(572,50),UV(572)
      COMMON/HEAD2/ HI(572),OLDH(572)
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT ,NN
      CHARACTER *20 JCNFIN,JCNFOUT,JCELPLT,EHEAD,JCPLOTD
      CHARACTER *20 JCRIVOUT,PORTOUT,STOROUT
C
         READ(1,1000)JCNFIN
         READ(1,1000)JCNFOUT
         READ(1,1000)JCELPLT
1000   FORMAT(A20)
              OPEN(UNIT=15,FILE= JCNFIN )
              OPEN(UNIT=16,FILE= JCNFOUT )
              OPEN(UNIT=18,FILE= JCELPLT )
C
C
```

```
C     READ IN INPUT DATA
C
      CALL DATAIN
C
C     FORMULATE THE GLOBAL ELEMENT MATRICES
C
      IF (QUAD) CALL LEMENQ (A,UV,NIJ,NBW)
      IF (.NOT.QUAD) CALL LEMENT (A,UV,NIJ,NBW)
C
C     FORMULATE THE RIVER MATRIX TERMS
C
      IF (LRIVER) CALL QRIVER (A,NIJ,NBW)
C     APPLY CONDENSATION OF SPECIFIED HEAD NODES TO MATRIX A
      CALL BNDCON (A,UV,NIJ,NBW)
C     DECOMPOSE THE FULL MATRIX A TO UT*U
      IF (.NOT.WTABLE) CALL SDCOMP (A,NIJ,NBW)
      IF (WTABLE) CALL ADCOMP(A,NIJ,NBW)
C     FORMULATE THE WELL  TERMS

      CALL QZEE (UV)
      CALL PUMPNU(UV)
      IF(LPLOT) CALL PLOT(0,0,999)
C
C     BEGIN TIME STEP LOOP
C
      DO 80 NN=1,NSTEP
      WRITE(IO,4000)
 4000 FORMAT (1H ,////,5X,60('-'))
      WRITE(IO,5000) NN
 5000 FORMAT(1HO,4X,'TIME STEP NUMBER ',I6,/)
      WRITE(IO,3000) MON(KMN),KDY,KYR
 3000 FORMAT(1H ,7X,'TIME STEP BEGINNING ',A3,I3,',',I5/)
C
      CALL QBOUND(A,UV,NIJ,NBW)
      CALL LOADQR(UV)
      TBH=0.0
      DO 15 IM=1,12
   15 TBH=TBH+PBH(IM)*FMON(IM)
```

```
C
C     INITIALIZE HI(I)
C
      DO 20 I=1,NIJ
      HI(I)=H(I)
   20 CONTINUE
C
C     BEGIN ITERATIVE LOOP
C
      DO 60 ITER=1,MAXIT
      DO 30 L=1,NIJ
      H(L)=HI(L)+BETA*(H(L)-HI(L))
      HI(L)=H(L)
   30 QZ(L)=QRE(L)
      IF (LRIVER) CALL RIVER(A,NIJ,NBW)
      DO 40 I=1,NIJ
      IF (WTABLE) QZ(I)=QZ(I)-QBAR(I)
      IF (IBNODE(I).LT.2) GO TO 40
      QB(I)=QZ(I)
C     IF(WTABLE) QB(I)=QB(I)+QBAR(I)
      QZ(I)=TBH*BQH(I)
      IF (WTABLE) QZ(I)=QZ(I)-HO(I)
   40 CONTINUE
      IF (.NOT.WTABLE) CALL SSOLVE (A,NIJ,NBW,QZ,H)
      IF (WTABLE) CALL ASOLVE (A,NIJ,NBW,QZ,H)
C
C
      ERR=0.0
      DO 50 L=1,NIJ
      IF (WTABLE) H(L)=H(L)+HO(L)
      HER=H(L)-HI(L)
      HERR=HER*HER
      IF (HERR.LE.ERR) GO TO 50
      ERR=HERR
      HMAX=HER
   50 CONTINUE
      IF (IPRINT.GE.2) WRITE (IO,6000) HMAX
      HERR=EPS*EPS
      IF (ERR.LT.HERR) GO TO 70
   60 CONTINUE
 70   WRITE(IO,8000)
```

```
C
8000  FORMAT(1H ,///)
      CALL MASBAL(A,UV,NIJ,NBW)
      IF (.NOT.STEADY) CALL NWDATE
      IF (IPRINT.GE.1.AND.MOD(NN,NPRNT).EQ.0) CALL OUTPUT (IPRINT)
   80 CONTINUE
      IF (IPRINT.GE.1) CALL OUTPUT (IPRINT)
 6000 FORMAT(1H ,8X,'HMAX =',F15.6)
200   CONTINUE
      STOP1
      END
C     ------------------------------------------------------------------
      SUBROUTINE DATAIN
C     ------------------------------------------------------------------
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     CC                                                              CC
C     CC         THIS SUBROUTINE READS IN INPUT DATA FOR GENERATING    CC
C     CC   THE F.E. GRID, AND FOR INITIAL AND BOUNDARY CONDITIONS. IT  CC
C     CC   PERFORMS AN ECHO CHECK OF ALL DATA AND CALLS THE GRID PLOT  CC
C     CC   ROUTINE IF REQUESTED.                                       CC
C     CC                                                              CC
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
       REAL BUDTTL,XSCLP,YSCLP
      INTEGER DAYNAME(4)
      INTEGER *2 HOURS(4)
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD
      COMMON/BNDRY/BQH(572),QB(572),PBH(12),PBF(12),BB(9,50),IBNODE(572)
      COMMON /MPSCL/ XSCL,YSCL ,XO,YO
      COMMON /PLT/ XSCLP,YSCLP,IPLOT
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT
      COMMON/HEAD2/ HI(572),OLDH(572)
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT ,NN
      DIMENSION TITLE(24),LATB(3),LONB(3),LATT(3),LONT(3)
```

```
C                                                                       DIN 290
C                                                                       DIN 300
C                                                                       DIN 310
C     READ AND PRINT TITLE                                              DIN 320
C     ---------------------------------------------------------------
C     STEADY - .TRUE. FOR STEADY-STATE CASE                             DIN 330
C     WTABLE - .TRUE. IF THE AQUIFER IS A WATER TABLE AQUIFER           DIN 340
C     QUAD - .TRUE. IF USING QUADRILATTERAL ELEMENTS                    DIN 350
C     LATLON - .TRUE. IF COORDINATES FOR ALL POINTS ARE READ AS LAT,LONGDIN 360
C     LRIVER - .TRUE. IF THERE IS A RIVER                               DIN 370
C     DRAWD - .TRUE. IF DRAWDOWNS ARE TO BE PRINTED INSTEAD OF HEADS    DIN 380
C     LPLOT - .TRUE. IF PLOTTER ROUTINES ARE TO BE USED                 DIN 390
C     EVPTRN - .TRUE. IF EVAPOTRANSPIRATION IS TO BE ACCOUNTED FOR      DIN 400
C     IPRINT - PRINTOUT CONTROL PARAMETER                               DIN 410
C     NPRNT - THE NUMBER OF TIME STEPS BETWEEN EXPANDED PRINTOUT        DIN 420
C     ---------------------------------------------------------------
C                                                                       DIN 430
      READ (IN,5020) (TITLE(L),L=1,24)                                  DIN 440
       WRITE(IO,6003)
C
        WRITE(IO,6005)
      WRITE (IO,6000) (TITLE(L),L=1,12),(TITLE(L),L=13,24)              DIN 450
C     WRITE DATE AND TIME OF MODEL RUN
      CALL TIME$A (HOURS)
      CALL DATE$A (DAYNAME)
      WRITE(IO,8555) DAYNAME, HOURS
8555    FORMAT(1H0,120('*'),/38X,'MODEL RUN DATE: ',2X,4A4,/,38X,
     $ 'MODEL RUN TIME: ',2X,4A2,/,120('*'),//)
       WRITE(IO,6005)
C
      READ (IN,5000)STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN DIN 460
      WRITE (IO,6020)STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRNDIN 470
      NETYP=3                                                           DIN 480
      IF (QUAD) NETYP=4                                                 DIN 490
      READ (IN,5030) IPRINT,NPRNT                                       DIN 500
      IF (IPRINT.GE.1) WRITE (IO,6030) IPRINT,NPRNT                     DIN 510
C                                                                       DIN 520
```

```
C       ----------------------------------------------------------------
C       KYR,KMN,KDY - DATE INFORMATION                                    DIN 530
C       DELT - TIME STEP                                                  DIN 540
C       BETA - CONVERGENCE ACCELERATION PARAMETER                         DIN 550
C       EPS - CONVERGENCE CRITERION                                       DIN 560
C       MAXIT - MAXIMUM NUMBER OF ITERATIONS FOR RIVER STAGE CALCULATION  DIN 570
C       IPLOT - PLOTTER CONTROL PARAMETER                                 DIN 580
C       ----------------------------------------------------------------
C                                                                         DIN 590
        READ (IN,5030) KYR,KMN,KDY,IDAY,NSTEP                             DIN 600
        IF (STEADY) NSTEP=1                                               DIN 610
        IF (STEADY) IDAY=1                                                DIN 620
        IF (IPRINT.GE.1) WRITE (IO,6050)MON(KMN),KDY,KYR,IDAY,NSTEP       DIN 630
        CALL DATE                                                         DIN 640
        DELT=86400.0*IDAY                                                 DIN 650
        IF (LRIVER) READ (IN,5040) MAXIT,BETA,EPS                         DIN 660
        IF (LRIVER.AND.IPRINT.GE.2) WRITE (IO,6060) MAXIT,BETA,EPS        DIN 670
        IF (.NOT.LATLON) READ (IN,5045) XSCL,YSCL                         DIN 680
        IF (.NOT.LATLON.AND.IPRINT.GE.2) WRITE (IO,6070) XSCL,YSCL        DIN 690
        IF (LPLOT) READ (IN,5040) IPLOT,XSCLP,YSCLP,IPLT2                 DIN 700
        IF (LPLOT.AND.IPRINT.GE.2) WRITE (IO,6080) IPLOT,XSCLP,YSCLP      DIN 710
        READ (IN,5030) IS,JT                                              DIN 720
C                                                                         DIN 730
C       ----------------------------------------------------------------
C       IS - NUMBER OF NODES IN X - DIRECTION                             DIN 740
C       JT - NUMBER OF NODES IN Y DIRECTION                               DIN 750
C       NIJ - NUMBER OF NODES                                             DIN 760
C       NEL - NUMBER OF ELEMENTS                                          DIN 770
C       NBW - HALF BANDWIDTH OF THE MATRIX FOR CONFINED AQUIFER           DIN 780
C                    OR FULL BANDWITH FOR WATERTABLE                      DIN 790
C       IDIAG - LOCATION OF THE DIAGONAL OF THE COEFFICIENT MATRIX        DIN 800
C       ----------------------------------------------------------------
C                                                                         DIN 810
        NIJ=JT*IS                                                         DIN 820
        NEL=((JT-1)*2)*(IS-1)                                             DIN 830
        IF (QUAD) NEL=NEL/2                                               DIN 840
        NBW=JT+2                                                          DIN 850
        IDIAG=1                                                           DIN 860
        IF (WTABLE) IDIAG=JT+2                                            DIN 870
        IF (WTABLE) NBW=2*(JT+1)+1                                        DIN 880
        IF(IPRINT.GE.1) WRITE(IO,6035)IS,JT
        IF (IPRINT.GE.1) WRITE (IO,6040) NIJ,NEL,NBW                      DIN 890
C                                                                         DIN 900
```

```
C
C     ---------------------------------------------------------------
C     IBNODE - PARAMETER DESCRIBING BOUNDARY CONDITION TO BE APPLIED AT DIN 910
C          0 - INTERIOR NODE                                           DIN 920
C          1 - SPEC. FLUX                                              DIN 930
C          2 - SPEC. HEAD                                              DIN 940
C     ---------------------------------------------------------------
C                                                                      DIN 950
      IF (IPRINT.GE.3) WRITE (IO,6090)                                 DIN 960
      IF(IPRINT.GE.3) WRITE(IO,6190)
      DO 10 I=1,IS                                                     DIN 970
      K=JT*(I-1)                                                       DIN 980
      READ (IN,5030) (IBNODE(K+J),J=1,JT)                              DIN 990
      IKK= K + 1
      IF(IPRINT.GE.3) WRITE(IO,6100) I,IKK,(IBNODE(K+J),J=1,JT)
   10 CONTINUE                                                         DIN1010
C                                                                      DIN1020
C     READ INITIAL NODAL VALUE ARRAYS                                  DIN1030
C     ---------------------------------------------------------------
C     H - CURRENT NODAL VALUES FOR HEAD                                DIN1040
C     HP - HEADS AT LAST TIME STEP (NON STEADY-STATE CASE)             DIN1050
C     S - NODAL STORAGE COEFFICIENTS (NON STEADY-STATE CASE)           DIN1060
C     T - NODAL TRANSMISSIVITY COEFFICIENTS (PERMEABILITY VALUE IF WATERDIN1070
C     ALSD - NODAL LAND SURFACE ELEVATIONS USED IN CALCULATING E.T.    DIN1080
C     HO - MEAN OR STEADY-STATE HEAD VALUES USED IN THE PERTERBATION TECDIN1090
C             FOR LINEARIZING THE WATER-TABLE AQUIFER PROBLEM          DIN1100
C     BOTT - ELEVATION FOR THE BOTTOM OF THE WATER-TABLE AQUIFER       DIN1110
C     BQH - BOUNDARY FLUXES OR FIXED HEAD VALUES                       DIN1120
C     PBH -  MULTIPLIER OF SPEC. HEAD VALUE TO ACCOUNT FOR MONTHLY VARIATDIN1130
C     PBF -  MULTIPLIER OF SPEC. FLUX VALUE TO ACCOUNT FOR MONTHLY VARIATDIN1131
C     ---------------------------------------------------------------
C                                                                      DIN1140
      CALL ARRAY (H,'HEAD')                                            DIN1150
      IF (.NOT.STEADY) CALL ARRAY (HP,'HP  ')                          DIN1160
      IF (.NOT.STEADY) CALL ARRAY (S,'STOR')                           DIN1170
      CALL ARRAY (T,'TRAN')                                            DIN1180
      IF (EVPTRN) CALL ARRAY (ALSD,'ALSD')                             DIN1190
      IF (WTABLE) CALL ARRAY (HO,'HO  ')                               DIN1200
      IF (WTABLE) CALL ARRAY (BOTT,'BOTT')                             DIN1210
      CALL ARRAY (BQH,'BQH ')                                          DIN1220
```

```
      READ (IN,5050) (PBH(I),I=1,12)                                    DIN1230
      IF (IPRINT.GE.3) WRITE (IO,6110) (PBH(I),I=1,12)                  DIN1240
      READ (IN,5050) (PBF(I),I=1,12)                                    DIN1241
      IF (IPRINT.GE.3) WRITE (IO,6111) (PBF(I),I=1,12)                  DIN1242
C                                                                       DIN1250
C     GENERATE F.E. GRID. ONLY X,Y OR LAT,LONG OF THE ENDPOINTS OF EACH DIN1260
C     VERTICAL LINE HAVE TO BE READ IN.                                 DIN1270
C                                                                       DIN1280
      JT1=JT-1                                                          DIN1290
      AVGLAT = 0.0
      DO 40 I=1,IS                                                      DIN1300
      NODBOT=(I-1)*JT+1                                                 DIN1310
      NODTOP=NODBOT+JT1                                                 DIN1320
      IF (LATLON) GO TO 20                                              DIN1330
      READ (IN,6010) X(NODBOT),Y(NODBOT),X(NODTOP),Y(NODTOP)            DIN1340
C     X(NODBOT)=X(NODBOT)*XSCL                                          DIN1350
C     Y(NODBOT)=Y(NODBOT)*YSCL                                          DIN1360
C     X(NODTOP)=X(NODTOP)*XSCL                                          DIN1370
C     Y(NODTOP)=Y(NODTOP)*YSCL                                          DIN1380
      GO TO 30                                                          DIN1390
   20 READ (IN,5010) LONB,LATB,LONT,LATT                                DIN1400
C
      PLONG=LONB(1)+(LONB(2)+(LONB(3))/60.)/60.                         DIN1410
      PLAT=LATB(1)+(LATB(2)+(LATB(3))/60.)/60.                          DIN1420
      AVGLAT = AVGLAT + PLAT/(2.0*IS)
      CALL LAMBRT (PLONG,PLAT,XP,YP)                                    DIN1430
      X(NODBOT)=XP                                                      DIN1440
      Y(NODBOT)=YP                                                      DIN1450
      PLONG=LONT(1)+(LONT(2)+(LONT(3))/60.)/60.                         DIN1460
      PLAT=LATT(1)+(LATT(2)+(LATT(3))/60.)/60.                          DIN1470
      AVGLAT = AVGLAT + PLAT/(2.0*IS)
      CALL LAMBRT (PLONG,PLAT,XP,YP)                                    DIN1480
      X(NODTOP)=XP                                                      DIN1490
      Y(NODTOP)=YP                                                      DIN1500
   30 IF (X(NODBOT).LT.XO) XO=X(NODBOT)                                 DIN1510
      IF (X(NODTOP).LT.XO) XO=X(NODTOP)                                 DIN1520
      IF (Y(NODBOT).LT.YO) YO=Y(NODBOT)                                 DIN1530
      IF (Y(NODTOP).LT.YO) YO=Y(NODTOP)                                 DIN1540
      DELX=(X(NODTOP)-X(NODBOT))/JT1                                    DIN1550
      DELY=(Y(NODTOP)-Y(NODBOT))/JT1                                    DIN1560
```

```
C                                                                       DIN1570
C     GENERATE INTERMEDIATE NODES BETWEEN ENDPOINTS                     DIN1580
C                                                                       DIN1590
      DO 40 J=2,JT1                                                     DIN1600
      NODE=NODBOT+J-1                                                   DIN1610
      X(NODE)=X(NODBOT)+DELX*(J-1)                                      DIN1620
      Y(NODE)=Y(NODBOT)+DELY*(J-1)                                      DIN1630
   40 CONTINUE                                                          DIN1640
      IF (LATLON)XSCL=1./(.99454+.02184*(AVGLAT-39.)*(AVGLAT-39.)/144.) DIN1635
      IF (LATLON)   YSCL = XSCL
      IF (LATLON)   XSCLP = XSCLP*XSCL
      IF (LATLON)   YSCLP = YSCLP*YSCL
C                                                                       DIN1650
C     SUBTRACT CONSTANT OFFSET                                          DIN1660
C                                                                       DIN1670
      IF (IPRINT.GE.2) WRITE (IO,6120) XO,YO                            DIN1680
      IF (IPRINT.GE.6) WRITE (IO,6130)                                  DIN1690
      DO 50 I=1,NIJ                                                     DIN1700
       X(I) = XSCL*(X(I)-XO)                                            DIN1710
       Y(I) = YSCL*(Y(I)-YO)                                            DIN1720
      IF (IPRINT.GE.6) WRITE (IO,6140) I,X(I),Y(I)                      DIN1730
   50 CONTINUE                                                          DIN1740
C                                                                       DIN1750
C     GENERATE NODAL INDICIES (COUNTER-CLOCKWISE) FOR EACH ELEMENT      DIN1760
C                                                                       DIN1770
      IS1=IS-1                                                          DIN1780
      JT1=JT-1                                                          DIN1790
      DO 80 I=1,IS1                                                     DIN1800
      IJ=(I-1)*JT                                                       DIN1810
      KEL=(I-1)*JT1                                                     DIN1820
      DO 80 J=1,JT1                                                     DIN1830
      NO=IJ+J                                                           DIN1840
      NE=KEL+J                                                          DIN1850
      IF (QUAD) GO TO 70                                                DIN1860
      NE=2*NE-1                                                         DIN1870
      IF (MOD(I,2).EQ.0) GO TO 60                                       DIN1880
      NGL(1,NE)=NO                                                      DIN1890
      NGL(2,NE)=NO+JT                                                   DIN1900
      NGL(3,NE)=NO+1                                                    DIN1910
      NE=NE+1                                                           DIN1920
      NGL(1,NE)=NO+1                                                    DIN1930
      NGL(2,NE)=NO+JT                                                   DIN1940
```

C

```
      NGL(3,NE)=NO+JT+1
      GO TO 80
   60 NGL(1,NE)=NO
      NGL(2,NE)=NO+JT
      NGL(3,NE)=NO+JT+1
      NE=NE+1
      NGL(1,NE)=NO
      NGL(2,NE)=NO+JT+1
      NGL(3,NE)=NO+1
      GO TO 80
   70 NGL(1,NE)=NO
      NGL(2,NE)=NO+JT
      NGL(3,NE)=NO+JT+1
      NGL(4,NE)=NO+1
   80 CONTINUE
C
C     CALCULATE ELEMENT AREAS
C
      SAREA=0.0
      IF (IPRINT.GE.5) WRITE (IO,6150)
      DO 100 NE=1,NEL
      N1=NGL(1,NE)
      N2=NGL(2,NE)
      N3=NGL(3,NE)
      IF (QUAD) GO TO 90
      AREA(NE)=0.5*((X(N2)-X(N1))*(Y(N3)-Y(N1))-(Y(N2)-Y(N1))*(X(N3)-X(N
     11)))
      IF (IPRINT.GE.5) WRITE (IO,6160) NE,N1,N2,N3,AREA(NE)
      GO TO 100
   90 N4=NGL(4,NE)
      AREA(NE)=0.5*((X(N1)-X(N3))*(Y(N2)-Y(N4))-(X(N2)-X(N4))*(Y(N1)-Y(N
     13)))
      IF (IPRINT.GE.5) WRITE (IO,6170) NE,N1,N2,N3,N4,AREA(NE)
  100 SAREA=SAREA+AREA(NE)
      IF (IPRINT.GE.2) WRITE (IO,6180) SAREA
C
C     CALL GRID PLOTTER
```

```
C                                                                       DIN2320
      IF (LPLOT) CALL PLTG                                              DIN2330
      IF (.NOT.STEADY) GO TO 120                                        DIN2340
C                                                                       DIN2350
C     SET PAST VALUES OF HEAD ARRAY TO PRESENT VALUE FOR STEADY-STATE CADIN2360
C                                                                       DIN2370
      DO 110 I=1,NIJ                                                    DIN2380
  110 HP(I)=H(I)                                                        DIN2390
C                                                                       DIN2400
C     SAVE ORIGINAL HEAD VALUES FOR CALCULATING CUMULATIVE DRAWDOWN     DIN2410
C                                                                       DIN2420
  120 IF (.NOT.DRAWD) RETURN                                            DIN2430
      DO 130 I=1,NIJ                                                    DIN2440
  130 OLDH(I)=H(I)                                                      DIN2450
      RETURN                                                            DIN2460
C                                                                       DIN2470
C     READ AND WRITE FORMATS                                            DIN2480
C                                                                       DIN2490
 5000 FORMAT (10(L4,2X))                                                DIN2500
 5010 FORMAT (6I4,6X,6I4)                                               DIN2510
 5020 FORMAT (12A6,8X)                                                  DIN2520
 5030 FORMAT (20I4)                                                     DIN2530
 5040 FORMAT (I4,2F10.0,4I4)                                            DIN2540

C



 5045 FORMAT (2F10.0)
 5050 FORMAT (12F6.0)                                                   DIN2550
 6000 FORMAT (1H0,25X,12A6,/25X,12A6)                                   DIN2560
 6003  FORMAT(1H1,/)
6005  FORMAT(1H ,130('-'))
 6010 FORMAT (8F10.0)                                                   DIN2570
 6020 FORMAT (1H0,30X,'LOGICAL CONTROL VARIABLES'/1H ,5X,'STEADY',3X,'WTDIN2580
     1ABLE',5X,'QUAD',3X,'LATLON',3X,'LRIVER',4X,'DRAWD',4X,'LPLOT',3X,'DIN2590
     2EVPTRN'/1H ,8X,8(L3,6X))                                          DIN2600
 6030 FORMAT (1H0,5X,'THE PRINTOUT CONTROL PARAMETER (IPRINT) = ',I4/1H DIN2610
     1,5X,'NUMBER OF TIME STEPS BETWEEN EXTENDED PRINTOUTS (NPRNT)',' = DIN2620
     2',I4)                                                             DIN2630
6035  FORMAT(1H0,5X,'NUMBER OF NODES IN ROW = ',I4,/6X,'NUMBER OF NODES
     1IN COLUMN = ',I4)
```

```
6040 FORMAT (1H0,5X,'NUMBER OF NODES (NIJ) = ',I5/1H ,5X,'NUMBER OF ', DIN2640
    1'ELEMENTS (NEL) = ',I5/1H ,5X,'HALF BANDWIDTH (NBW) = ',I3)       DIN2650
6050 FORMAT (1H0,5X,'THE STARTING DATE FOR THE SIMULATION IS : ',A3,I3,DIN2660
    1',',I5/1H ,5X,'NUMBER OF DAYS PER TIME STEP (IDAY) = ',I2/1H ,5X,'DIN2670
    2NUMBER OF TIME STEPS TO BE TAKEN (NSTEP) = ',I4)                  DIN2680
6060 FORMAT (1H0,30X,'ITERATION PARAMETERS FOR STREAMFLOW SOLUTION',' RDIN2690
    1OUTINE'/1H ,5X,'MAXIMUM NUMBER OF ITERATIONS (MAXIT) = ',I3/1H ,5XDIN2700
    2,'CONVERGENCE ACCELERATION PARAMETER (BETA) = ',F8.5/1H ,5X,'CONVEDIN2710
    3RGENCE CRITERION (EPS) = ',F8.6)                                  DIN2720
6070 FORMAT (1H0,5X,'SCALING FACTOR FOR X - COORDINATES (XSCL) = ',F12.DIN2730
    13/1H ,5X,'SCALING FACTOR FOR Y - COORDINATES (YSCL) = ',F12.3)    DIN2740
6080 FORMAT (1H0,5X,'PLOT CONTROL PARAMETER (IPLOT) = ',I2/1H ,5X,'PLOTDIN2750
    1 SCALING FACTOR IN X DIRECTION (XSCLP) = ',F10.3/1H ,5X,'PLOT SCALDIN2760
    2ING FACTOR IN Y DIRECTION (YSCLP) = ',F10.3)                      DIN2770
6090 FORMAT (1H1,30X,'BOUNDARY-CONDITION TYPE MAP'/1H ,35X,'0 - INTERIODIN2780
    1R NODE'/1H ,35X,'1 - SPECIFIED-FLUX BOUNDARY NODE'/1H ,35X,'2 - SPDIN2790
    2ECIFIED-HEAD BOUNDARY NODE'/)                                     DIN2800
6100  FORMAT(1H ,2X,I4,2X,I4,4X,(20I4))
6110 FORMAT (1H0,30X,'MONTHLY MULTIPLIERS OF SPECIFIED HEAD VALUES'/   DIN2820
    11H ,5X,12F8.2)                                                    DIN2830
6111 FORMAT (1H0,30X,'MONTHLY MULTIPLIERS OF SPECIFIED FLUX VALUES'/   DIN2831
    11H ,5X,12F8.2)                                                    DIN2832
6120 FORMAT (1H1,10X,'THE X AND Y OFFSETS FOR THE GRID ORIGIN ARE ',2F1DIN2840
    15.4)                                                              DIN2850
6130 FORMAT (1H0,30X,'NODAL X - Y COORDINATES'/)                       DIN2860
6140 FORMAT (1H ,5X,I4,2F12.4)                                         DIN2870
6150 FORMAT (1H1,30X,'GLOBAL INDICES AND ELEMENT AREAS'/)              DIN2880
6160 FORMAT (1H ,5X,4I4,F15.4)                                         DIN2890
6170 FORMAT (1H ,5X,5I4,F15.4)                                         DIN2900
6180 FORMAT (1H0,10X,'TOTAL MODEL AREA = ',1P1E15.5)                   DIN2910
6190   FORMAT(1H ,2X,' ROW',2X,'NODE')
     END                                                               DIN2920-
```

```
C     ------------------------------------------------------------------
      SUBROUTINE DATE                                                   DTE  00
C     ------------------------------------------------------------------
C                                                                       DTE  10
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC     DTE  20
C     CC                                                        CC     DTE  30
C     CC         THIS ROUTINE SETS UP THE DAY OF YEAR CONTROL.  CC     DTE  40
C     CC      IT ALSO CALCULATES THE NUMBER OF DAYS FROM THE    CC     DTE  50
C     CC      THE BEGINNING OF THE YEAR AND CHECKS WHETHER THE  CC     DTE  60
C     CC      FIRST TIME STEP EXTENDS OVER THE END OF A MONTH   CC     DTE  70
C     CC                                                        CC     DTE  80
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC     DTE  90
C                                                                       DTE 100
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               DTE 101
C
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      IDYR=365                                                          DTE 120
      IF (MOD(KYR,4).EQ.0) IDYR=366                                     DTE 130
      IDMON(2)=28                                                       DTE 140
      IF (MOD(KYR,4).EQ.0) IDMON(2)=29                                  DTE 150
      KDYS=0                                                            DTE 160
      IF (KMN.EQ.1) GO TO 30                                            DTE 170
      KM1=KMN-1                                                         DTE 180
      DO 20 KM=1,KM1                                                    DTE 190
   20 KDYS=KDYS+IDMON(KM)                                               DTE 200
   30 KDYS=KDYS+KDY                                                     DTE 210
      KD=KDY+IDAY                                                       DTE 220
      ID=IDAY                                                           DTE 230
      KM=KMN                                                            DTE 240
      P1=1.0                                                            DTE 250
   40 M2=0                                                              DTE 260
      IF (KD.GT.IDMON(KM)) M2=KD-IDMON(KM)                              DTE 270
      M1=ID-M2                                                          DTE 280
      FMON(KM)=(1.0*M1)/(1.0*IDAY)                                      DTE 290
      KM1=KM+1                                                          DTE 300
      IF (KM1.GT.12) KM1=KM1-12                                         DTE 310
      FMON(KM1)=P1-FMON(KM)                                             DTE 320
      IF (M2.LE.IDMON(KM)) GO TO 50                                     DTE 330
      ID=ID-M1                                                          DTE 340
      P1=P1-FMON(KM)                                                    DTE 350
```

```
      KM=KM1                                                            DTE 360
      KD=M2                                                             DTE 370
      GO TO 40                                                          DTE 380
   50 RETURN                                                            DTE 390
       END
C     -------------------------------------------------------------
       SUBROUTINE NWDATE
C     -------------------------------------------------------------
C                                                                       DTE 410
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC          DTE 420
C     CC                                                    CC          DTE 430
C     CC              THIS ENTRY DETERMINES THE DATE OF YEAR    CC          DTE 440
C     CC    AFTER THE TIME STEP IS INCREMENTED. ELAPSED TIME    CC          DTE 450
C     CC    FROM THE BEGINNING OF YEAR IS ALSO INCREMENTED,     CC          DTE 460
C     CC    AND A CHECK IS DONE TO SEE WHETHER THE TIME STEP    CC          DTE 470
C     CC    EXTENDS OVER THE END OF MONTH.                      CC          DTE 480
C     CC                                                    CC          DTE 490
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC          DTE 500
C                                                                       DTE 510
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               DTE 101
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      DO 60 I=1,12                                                      DTE 520
   60 FMON(I)=0.0                                                       DTE 530
      KDYS=KDYS+IDAY                                                    DTE 540
      KDY=KDY+IDAY                                                      DTE 550
   70 IF (KDY.LE.IDMON(KMN)) GO TO 80                                   DTE 560
      KDY=KDY-IDMON(KMN)                                                DTE 570
      KMN=KMN+1                                                         DTE 580
      IF (KMN.LE.12) GO TO 70                                           DTE 590
      KDYS=KDYS-IDYR                                                    DTE 600
      KMN=1                                                             DTE 610
      KYR=KYR+1                                                         DTE 620
      IDYR=365                                                          DTE 630
      IF (MOD(KYR,4).EQ.0) IDYR=366                                     DTE 640
      IDMON(2)=28                                                       DTE 650
```

```
C
      IF (MOD(KYR,4).EQ.0) IDMON(2)=29                                  DTE 660
      GO TO 70                                                          DTE 670
   80 KD=KDY+IDAY                                                       DTE 680
      ID=IDAY                                                           DTE 690
      KM=KMN                                                            DTE 700
      P1=1.0                                                            DTE 710
   90 M2=0                                                              DTE 720
      IF (KD.GT.IDMON(KM)) M2=KD-IDMON(KM)                              DTE 730
      M1=ID-M2                                                          DTE 740
      FMON(KM)=(1.0*M1)/(1.0*IDAY)                                      DTE 750
      KM1=KM+1                                                          DTE 760
      IF (KM1.GT.12) KM1=KM1-12                                         DTE 770
      FMON(KM1)=P1-FMON(KM)                                             DTE 780
      IF (M2.LE.IDMON(KM)) GO TO 100                                    DTE 790
      ID=ID-M1                                                          DTE 800
      P1=P1-FMON(KM)                                                    DTE 810
      KM=KM1                                                            DTE 820
      KD=M2                                                             DTE 830
      GO TO 90                                                          DTE 840
  100 RETURN                                                            DTE 850
      END                                                               DTE 860-
```

```
C     ----------------------------------------------------------------
      SUBROUTINE ARRAY (X,INAME)
C     ----------------------------------------------------------------
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     C
C     C          THIS ROUTINE IS CALLED TO READ IN THE ARRAYS OF     C
C     C    INITIAL NODAL VALUES HEAD,TRANS,STORAGE,ETC. IT IS SET UP   C
C     C    SO THAT BOTH THE UNIT NUMBER AND FORMAT USED IN THE READING C
C     C    OF DATA CAN BE SET EXTERNALLY BY THE USER. VALUES CAN BE    C
C     C    SCALED SY A SCALING PARAMETER ON THE FIRST CARD. ALSO, ALL  C
C     C    NODES CAN BE SET TO A UNIFORM VALUE FOR A PARTICULAR PARA-  C
C     C    METER WITHOUT HAVING TO READ ANY ADDITIONAL CARDS AFTER THE C
C     C    FIRST ONE.                                                  C
C     C                                                                C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      CHARACTER *4 INAME
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      DIMENSION X(1),FMT(2)
C
C     ----------------------------------------------------------------
C     TITLE - THE NAME OF THE ARRAY OF NODAL VALUES BEING READ IN
C     NUNIT - THE UNIT NO. FROM WHICH THE SUBSEQUENT DATA WILL BE READ
C                  IF NUNIT = 0, ALL NODES WILL BE SET TO A UNIFORM
C                  VALUE. ALL NECCESSARY INFORMATION WILL BE ON THIS
C                  CARD, SO NO FURTHER DATA WILL BE READ IN
C     FMT - THE FORMAT WITH WHICH THE DATA WILL BE READ OFF THE SUB -
C             SEQUENT CARDS (NUNIT > 0)
C     SCALE - THE SCALING FACTOR BY WHICH ALL NODES WILL BE MULTIPLIED.
C             IF NUNIT=0 , SCALE IS THE UNIFORM VALUE THAT ALL NODES
C             WILL BE SET TO.
C     IPRNT - LOCAL PRINTOUT CONTTROL PARAMETER. IF IPRNT > 0, DATA
C          WILL BE PRINTED OUT AFTER SCALING. NOT DONE IF NUNIT=0
C     ----------------------------------------------------------------
C
      READ (IN,5000) TITLE,NUNIT,FMT,SCALE,IPRNT
```

```
C
      WRITE (IO,6030) INAME
      NODE=0
      IF (NUNIT.LT.1) GO TO 40
C
C     READ IN ARRAY OF NODAL VALUES
C
      WRITE (IO,6000) TITLE,NUNIT,FMT,SCALE
      WRITE(IO,6035)
      DO 30 IR=1,IS
      READ (NUNIT,FMT) (X(NODE+L),L=1,JT)
      IF (SCALE.EQ.0..OR.SCALE.EQ.1.) GO TO 20
      DO 10 L=1,JT
      NODEL=NODE+L
   10 X(NODEL)=X(NODEL)*SCALE
 20   NNODE = NODE + 1
       IF(IPRNT.GT.0) WRITE(IO,6010) IR,NNODE,(X(NODE+L),L=1,JT)
      NODE=NODE+JT
   30 CONTINUE
      RETURN
   40 CONTINUE
C
C     SET ALL NODAL VALUES TO 'SCALE', AND READ NO OTHER CARDS
C
      DO 50 L=1,NIJ
   50 X(L)=SCALE
      WRITE (IO,6020) TITLE,SCALE
      RETURN
C
 5000 FORMAT (2X,1A6,3X,I2,2X,2A6,2X,F10.0,I4)
 6000 FORMAT (1H0,2X,1A6,20H WAS READ FROM UNIT ,I2,11H,ON FORMAT ,2A6,1
     16H, AND SCALED BY ,1P1E12.3/)
 6010 FORMAT(1H ,2X,I4,2X,I4,2X,(1P10E10.3))
 6020 FORMAT (1H0,2X,1A6,42H WAS NOT READ, ENTIRE MATRIX SET EQUAL TO ,1
     1P1E12.3)
 6030 FORMAT(1H1,30X,'INPUT DATA FOR ARRAY ',A6)
 6035   FORMAT(1H ,2X,' ROW',2X,'NODE')
      END
```

```
C     -------------------------------------------------------------
      SUBROUTINE LAMBRT (PLONG,PLAT,XP,YP)                          LMB  10
C     -------------------------------------------------------------
C                                                                   LMB  20
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCLMB  30
C     C                                                            CLMB  40
C     C       THIS SUBROUTINE CALCULATES X AND Y COORDINATES FROM  CLMB  50
C     C   A GIVEN LATITUDE AND LONGITUDE USING A LAMBERT PROJECTION.  CLMB  60
C     C   THE PROJECTION IS APPROXIMATED USING A 5TH-ORDER POLYNOMIAL  CLMB  70
C     C                                                            CLMB  80
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCLMB  90
C                                                                   LMB 100
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                           LMB 110
      DATA RLATA/0.68067840843/,RLONGA/1.6755160823/                LMB 120
      DATA XR/9842519.6851/,YR/32248287.402/                        LMB 130
      DATA RADI/0.017453292524/ ,DTHETA/0.63005/                    LMB 140
      DATA D/40867648.942/,DR1/-448390.54832/,DR2/2543.1733738/     LMB 150
      DATA DR3/-34.135521372/,DR4/0.26621187117/,DR5/-0.0016952301457/  LMB 160
C                                                                   LMB 170
C     -------------------------------------------------------------
C     XR - THE X COORDINATE OF THE ORIGIN OF THE LAMBERT PROJECTION  LMB 180
C     YR - THE Y COORDINATE OF THE ORIGIN OF THE LAMBERT PROJECTION  LMB 190
C     RLATA - THE LATITUDE OF ORIGIN OF THE LAMBERT PROJECTION      LMB 200

C

C     RLONGA - THE LONGITUDE OF THE ORIGIN OF THE LAMBERT PROJECTION  LMB 210
C     XO - THE X COORDINATE OF THE ORIGIN OF THE F.E. GRID          LMB 220
C     YO - THE Y COORDINATE OF THE ORIGIN OF THE F.E. GRID          LMB 230
C     RADI - CONVERSION FACTOR FOR DEGREES ===> RADIANS             LMB 240
C     D-DR5 - COEFFICIENTS FOR A 5TH ORDER POLYNOMIAL DESCRIBING THE  LMB 250
C               CHANGE OF THE PROJECTION RADIUS WITH LATITUDE       LMB 260
C     DTHETA - FACTOR FOR PROJECTION ANGLE AS A FUNCTION OF LONGITUDE  LMB 270
C     -------------------------------------------------------------
C                                                                   LMB 280
      R=D+(DR1+(DR2+(DR3+(DR4+DR5*PLAT)*PLAT)*PLAT)*PLAT)*PLAT      LMB 290
      PLONG=PLONG*RADI                                              LMB 300
      THETA=DTHETA*(RLONGA-PLONG)                                   LMB 310
      XP=XR+R*DSIN(THETA)                                           LMB 320
      THETA=0.5*THETA                                               LMB 330
      S=DSIN(THETA)                                                 LMB 340
      YP=YR-R*(1.0-2.0*S*S)                                         LMB 350
      RETURN                                                        LMB 360
      END                                                           LMB 370-
```

```
C     ------------------------------------------------------------
      SUBROUTINE PLTG
C     ------------------------------------------------------------
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     C                                                              C
C     C          THIS SUBROUTINE USES STANDARD CALCOMP CALLS TO PLOT C
C     C  THE FINITE-ELEMENT GRID GENERATED IN 'DATAIN'. THE FIRST CALL C
C     C  'CALL PLOTS (53,0,18)' MAY HAVE TO BE MODIFIED FOR THE      C
C     C  PARTICULAR FACILITY ON WHICH THE PROGRAM IS RUN.            C
C     C               NOTE: IPLOT CONTROLS PLOT PARAMETERS           C
C     C          IPLOT =>  1     F.E. GRID IS PLOTTED                C
C     C          IPLOT =>  4     ELEMENTS ARE NUMBERED               C
C     C          IPLOT =>  5     NODES ARE NUMBERED                  C
C     C  XSCLP,YSCLP - PLOT SCALING FACTORS (DEFINED IN BLOCK DATA)  C
C     C                                                              C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
       REAL XSCLP,YSCLP,XX,YY,FNN,XP,YP,XBAR,YBAR
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON /PLT/ XSCLP,YSCLP,IPLOT
C
C         INITIALIZE PLOT
C     UNIT 18 IS DEDICATED TO PLOT ROUTINE OUTPUT
C
       CALL PLOTS(53,0,18)
C     DRAW VERTICAL LINES
C
      DO 30 I=1,IS
      IF (IPLOT.LT.5) GO TO 20
      DO 10 J=1,JT
      IP=(I-1)*JT+J
      XX=X(IP)/XSCLP
      YY=Y(IP)/YSCLP
      FNN=IP*1.
      CALL NUMBER (XX,YY,.07,FNN,0.,-1)
   10 CONTINUE
```

```
C
   20 XP=X(I*JT)/XSCLP
      YP=Y(I*JT)/YSCLP
      CALL PLOT (XP,YP,3)
      XP=X((I-1)*JT+1)/XSCLP
      YP=Y((I-1)*JT+1)/YSCLP
      CALL PLOT (XP,YP,2)
   30 CONTINUE
C
C     DRAW BOTTOM LINE
C
      ISM=IS-1
      IP=ISM*JT+1
      XP=X(IP)/XSCLP
      YP=Y(IP)/YSCLP
      CALL PLOT (XP,YP,3)
      DO 40 J=1,ISM
      IP=IP-JT
      XP=X(IP)/XSCLP
      YP=Y(IP)/YSCLP
      CALL PLOT (XP,YP,2)
   40 CONTINUE
C
C     DRAW HORIZONTAL LINES
C
      DO 70 I=2,JT
      XP=X(I)/XSCLP
      YP=Y(I)/YSCLP
      CALL PLOT (XP,YP,3)
      DO 50 J=1,ISM
      IP=J*JT+I
      XP=X(IP)/XSCLP
      YP=Y(IP)/YSCLP
      CALL PLOT (XP,YP,2)
   50 CONTINUE
      IF (QUAD) GO TO 70
C
```

```
C     DRAW LINES FOR TRIANGULAR ELEMENTS
C
      IZ=JT*ISM+I
      IF (MOD(IS,2).EQ.0) IZ=IZ-1
      XP=X(IZ)/XSCLP
      YP=Y(IZ)/YSCLP
      CALL PLOT (XP,YP,3)
      DO 60 J=1,ISM
      ISP=IS-J
      KP=JT-1
      IF (MOD(ISP,2).EQ.0) KP=JT+1
      IZ=IZ-KP
      XP=X(IZ)/XSCLP
      YP=Y(IZ)/YSCLP
      CALL PLOT (XP,YP,2)
   60 CONTINUE
   70 CONTINUE
      IF (IPLOT.LT.4) RETURN
C
C     PUT ELEMENT NO. AT MIDPOINT
C
      DO 90 NE=1,NEL
      XBAR=0.0
      YBAR=0.0
C
      DO 80 J=1,NETYP
      N1=NGL(J,NE)
      XBAR=XBAR+X(N1)
      YBAR=YBAR+Y(N1)
   80 CONTINUE
      YBAR=YBAR/(1.0*NETYP*YSCLP)
      XBAR=XBAR/(1.0*NETYP*XSCLP)
      FNN=NE*1.
      CALL NUMBER (XBAR,YBAR,.07,FNN,0.,-1)
   90 CONTINUE
100    RETURN
      END
C
C
```

```
C     ------------------------------------------------------------
       SUBROUTINE PLTR(XR,YR,NODE)
C     ------------------------------------------------------------
C                                                                       PLT1150
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC PLT1160
C     C                                                              CC PLT1170
C     C             THIS ENTRY PLOTS THE RIVER.                      CC PLT1180
C     C             IF IPLOT => 3     RIVER NODES ARE NUMBERED       CC PLT1190
C     C                                                              CC PLT1200
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC PLT1210
C                                                                       PLT1220
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               PLT 170
       REAL XSCLP,YSCLP,XXR,YYR,FNN
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN       PLT 180
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),     PLT 200
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                          PLT 210
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP           PLT 220
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN PLT 230
      COMMON /PLT/ XSCLP,YSCLP,IPLOT                                    PLT 240
      CALL NEWPEN (3)                                                   PLT1230
      XXR=XR/XSCLP                                                      PLT1240
      YYR=YR/YSCLP                                                      PLT1250
      IF (NODE.EQ.1) CALL PLOT (XXR,YYR,3)                              PLT1260
      FNN=NODE*1.                                                       PLT1270
      CALL PLOT (XXR,YYR,2)                                             PLT1280
      CALL SYMBOL (XXR,YYR,.07,03,0.,-1)                                PLT1290
      IF (IPLOT.GE.3) CALL NUMBER (XXR,YYR,.07,FNN,45.,-1)              PLT1300
      CALL PLOT (XXR,YYR,3)                                             PLT1310
100   RETURN
       END
```

```
C                                                                              PLT1330
C                                                                              PLT1340
C     ------------------------------------------------------------------
       SUBROUTINE PLTW(XW,YW,N)
C     ------------------------------------------------------------------
C                                                                              PLT1360
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC       PLT1370
C     C                                                              CC       PLT1380
C     C          THIS ENTRY PLOTS THE WELLS.                         CC       PLT1390
C     C          IF IPLOT =>  2    WELL NODES ARE NUMBERED           CC       PLT1400
C     C                                                              CC       PLT1410
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC       PLT1420
C                                                                              PLT1430
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                                      PLT 170
       REAL XSCLP,YSCLP,XXW,YYW,FNN
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN              PLT 180
C
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),            PLT 200
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                                 PLT 210
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP                  PLT 220
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN PLT 230
      COMMON /PLT/ XSCLP,YSCLP,IPLOT                                           PLT 240
      CALL NEWPEN(4)
      XXW=XW/XSCLP                                                             PLT1450
      YYW=YW/YSCLP                                                             PLT1460
      FNN=N*1.                                                                 PLT1470
      CALL SYMBOL (XXW,YYW,.07,10,0.,-1)                                       PLT1480
      IF (IPLOT.GE.2) CALL NUMBER (XXW,YYW,.07,FNN,90.,-1)                     PLT1490
110    RETURN
CADD VPLOT
CADD GPCP
       END
```

```
C     ------------------------------------------------------------------
      SUBROUTINE LEMENQ (A,UV,NIJD,NBWD)
C     ------------------------------------------------------------------
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT
      COMMON /WTBLE/ QBAR(572),BOTT(572),HO(572)
      DIMENSION A(NIJD,NBWD),UV(1),W(4),WX(4),WY(4),N(4),E(4),Z(4)
      DATA E(1),E(2),E(3),E(4)/-.57735,.57735,.57735,-.57735/
      DATA Z(1),Z(2),Z(3),Z(4)/-.57735,-.57735,.57735,.57735/
C
C     ZERO THE ARRAYS
C
      DO 10 J=1,NBW
      DO 10 NI=1,NIJ
   10 A(NI,J)=0.0
      DO 20 NI=1,NIJ
      QBAR(NI)=0.0
   20 UV(NI)=0.
      DO 60 NE=1,NEL
      N1=NGL(1,NE)
      N2=NGL(2,NE)
      N3=NGL(3,NE)
      N4=NGL(4,NE)
      N(1)=N1
      N(2)=N2
      N(3)=N3
      N(4)=N4
      X13=X(N1)-X(N3)
      Y13=Y(N1)-Y(N3)
      X24=X(N2)-X(N4)
      Y24=Y(N2)-Y(N4)
      X34=X(N3)-X(N4)
      Y34=Y(N3)-Y(N4)
      X12=X(N1)-X(N2)
      Y12=Y(N1)-Y(N2)
      X23=X(N2)-X(N3)
      Y23=Y(N2)-Y(N3)
      X14=X(N1)-X(N4)
      Y14=Y(N1)-Y(N4)
      AREA2=2.0*AREA(NE)
```

```
C

      DO 50 IP=1,4
      ETA=E(IP)
      ZETA=Z(IP)
      DJ=AREA2+ETA*(X34*Y12-X12*Y34)+ZETA*(X23*Y14-X14*Y23)
      DJAC=0.125*DJ
      DJ=1./DJ
C     F1 = 1.-ETA
C     F2 = 1.+ETA
C     F3 = 1.-ZETA
C     F4 = 1.+ZETA
C     W(1) = .25*F1*F3
C     W(2) = .25*F2*F3
C     W(3) = .25*F2*F4
C     W(4) = .25*F1*F4
      W(1)=0.25
      W(2)=0.25
      W(3)=0.25
      W(4)=0.25
      WY(1)=(-X24+X34*ETA+X23*ZETA)*DJ
      WY(2)=(X13-X34*ETA-X14*ZETA)*DJ
      WY(3)=(X24-X12*ETA+X14*ZETA)*DJ
      WY(4)=(-X13+X12*ETA-X23*ZETA)*DJ
      WX(1)=(Y24-Y34*ETA-Y23*ZETA)*DJ
      WX(2)=(-Y13+Y34*ETA+Y14*ZETA)*DJ
      WX(3)=(-Y24+Y12*ETA-Y14*ZETA)*DJ
      WX(4)=(Y13-Y12*ETA+Y23*ZETA)*DJ
      TRAN=0.0
      GRADX=0.0
      GRADY=0.0
      STOR=0.0
      DO 30 I=1,NETYP
      NI=N(I)
      WI=W(I)
      IF (.NOT.STEADY) STOR=STOR+S(NI)*WI
      TR=T(NI)*WI
      IF (.NOT.WTABLE) GO TO 30
      TR=TR*(HO(NI)-BOTT(NI))
      GRADX=GRADX+HO(NI)*WX(I)
      GRADY=GRADY+HO(NI)*WY(I)
```

```
 30 TRAN=TRAN+TR
    TRAN=TRAN*DJAC
    STOR=STOR*DJAC
    DO 50 I=1,NETYP
    NI=N(I)
    WI=W(I)
    WXI=WX(I)
    WYI=WY(I)
    IF (.NOT.STEADY) UV(NI)=UV(NI)+STOR*WI
    DO 50 J=1,NETYP
    NJ=N(J)
    IF (WTABLE) GO TO 40
    IF (NJ.LT.NI) GO TO 50
    NJB=NJ-NI+IDIAG
    A(NI,NJB)=A(NI,NJB)+TRAN*(WXI*WX(J)+WYI*WY(J))
    GO TO 50
 40 WJ=W(J)
    WXJ=WX(J)
    WYJ=WY(J)
    TR=TRAN*(WXI*WXJ+WYI*WYJ)
    NJB=NJ-NI+IDIAG
C
    A(NI,NJB)=A(NI,NJB)+TR+T(NJ)*WJ*(GRADX*WXI+GRADY*WYI)*DJAC
    QBAR(NI)=QBAR(NI)+TR*HO(NJ)
 50 CONTINUE
 60 CONTINUE
    IF (STEADY) RETURN
    RDT=0.5/DELT
    DO 70 IJ=1,NIJ
    UV(IJ)=RDT*UV(IJ)
 70 A(IJ,IDIAG)=A(IJ,IDIAG)+3.*UV(IJ)
    RETURN
    END
```

```
C     ------------------------------------------------------------------
      SUBROUTINE LEMENT (A,UV,NIJD,NBWD)
C     ------------------------------------------------------------------
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     C
C     C               THIS SUBROUTINE FORMULATES THE GLOBAL COEFFICIENT
C     C       MATRIX 'A', THE TIME VECTOR 'UV'. FOR THE WATER-TABLE CASE
C     C       THE VECTOR 'QBAR' WHICH IS THE INFLOW NEEDED TO SUSTAIN
C     C       THE HEADS IN 'HO' AND THE ASYMMETRIC TERMS ADDED TO THE 'A'
C     C       MATRIX ARE ALSO COMPUTED. THE INTEGRATION OVER THE ELEMENTS
C     C       IS EXACT AND A MASS-LUMPING SCHEME IS USED FOR THE TIME
C     C       TERMS.
C     C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      DIMENSION A(NIJD,NBWD),UV(1),W(3),WX(3),WY(3),N(3)
C
C
C     ZERO OUT THE MATRICIES
C
      DO 10 I=1,NIJ
      QBAR(I)=0.0
   10 UV(I)=0.0
      DO 20 J=1,NBW
      DO 20 I=1,NIJ
      A(I,J)=0.0
   20 CONTINUE
C
C     ELEMENT LOOP
```

```
C
      DO 60 NE=1,NEL
      N1=NGL(1,NE)
      N2=NGL(2,NE)
      N3=NGL(3,NE)
      N(1)=N1
      N(2)=N2
      N(3)=N3
      X23=X(N2)-X(N3)
      Y23=Y(N3)-Y(N2)
      X31=X(N3)-X(N1)
C
      Y31=Y(N1)-Y(N3)
      X12=X(N1)-X(N2)
      Y12=Y(N2)-Y(N1)
      DJAC=AREA(NE)
      DJ=0.5/DJAC
      W(1)=1.0/3.0
      W(2)=1.0/3.0
      W(3)=1.0/3.0
      WY(1)=X23*DJ
      WY(2)=X31*DJ
      WY(3)=X12*DJ
      WX(1)=Y23*DJ
      WX(2)=Y31*DJ
      WX(3)=Y12*DJ
C
C     ----------------------------------------------------------------
C     TRAN - MEAN TRANSMISSIVITY OVER AN ELEMENT (FOR A WATER-TABLE
C     AQUIFER, TRAN IS AVG. PERMEABILITY TIMES THE THICKNESS BASED ON 'H
C     STOR - MEAN STORAGE TERM OVER AN ELEMENT
C     GRADX - MEAN GRADIENT IN X OF 'HO' OVER AN ELEMENT
C     GRADY - MEAN GRADIENT IN Y OF 'HO' OVER AN ELEMENT
C     ----------------------------------------------------------------
```

```
C
      TRAN=0.0
      GRADX=0.0
      GRADY=0.0
      STOR=0.0
      DO 30 I=1,NETYP
      NI=N(I)
      WI=W(I)
      IF (.NOT.STEADY) STOR=STOR+S(NI)*WI
      TR=T(NI)*WI
      IF (.NOT.WTABLE) GO TO 30
      TR=TR*(HO(NI)-BOTT(NI))
      GRADX=GRADX+HO(NI)*WX(I)
      GRADY=GRADY+HO(NI)*WY(I)
   30 TRAN=TRAN+TR
      TRAN=TRAN*DJAC
      STOR=STOR*DJAC
C
C     LOAD LOCAL ELEMENT TERMS INTO GLOBAL COEFFICIENT MATRICES. FOR
C     CONFINED AQUIFER, LOAD ONLY THE SYMMETRIC HALFBAND.
C
      DO 50 I=1,NETYP
      NI=N(I)
      WI=W(I)
      WXI=WX(I)
      WYI=WY(I)
      IF (.NOT.STEADY) UV(NI)=UV(NI)+STOR*WI
      DO 50 J=1,NETYP
      NJ=N(J)
      IF (WTABLE) GO TO 40
      IF (NJ.LT.NI) GO TO 50
      NJB=NJ-NI+IDIAG
      A(NI,NJB)=A(NI,NJB)+TRAN*(WXI*WX(J)+WYI*WY(J))
      GO TO 50
   40 WXJ=WX(J)
      WYJ=WY(J)
      TR=TRAN*(WXI*WXJ+WYI*WYJ)
      NJB=NJ-NI+IDIAG
```

```
C
      A(NI,NJB)=A(NI,NJB)+TR+T(NJ)*(GRADX*WXI+GRADY*WYI)*DJAC
      QBAR(NI)=QBAR(NI)+TR*HO(NJ)
   50 CONTINUE
   60 CONTINUE
      IF (STEADY) RETURN
C
C     FOR TRANSIENT CASE, LOAD TIME VECTOR INTO GLOBAL 'A' MATRIX
C
      RDT=0.5/DELT
      DO 70 I=1,NIJ
      UV(I)=UV(I)*RDT
      A(I,IDIAG)=A(I,IDIAG)+3.0*UV(I)
   70 CONTINUE
      RETURN
      END
C     ------------------------------------------------------------------
      SUBROUTINE QRIVER (A,NIJD,NBWD)
C     ------------------------------------------------------------------
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      REAL BUDTTL,LENGTH
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON /MPSCL/ XSCL,YSCL ,XO,YO
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT
      DIMENSION A(NIJD,NBWD),LON(3),LAT(3)
C
```

```
C          RIVER CONTROL INTEGERS                                       QRV 210
C     ------------------------------------------------------------
C     NREACH - THE NUMBER OF REACHES THE RIVER IS DIVIDED INTO          QRV 220
C     NRNODE - TOTAL NO. OF RIVER NODES                                 QRV 230
C     NRZ - THE NUMBER OF ZONES THE RIVER IS DIVIDED INTO BASED ON THE  QRV 240
C               THE VALUE FOR LEAKANCE. THE ZONES DO NOT HAVE TO BE CONTQRV 250
C     QCOR - LEAKANCE VALUE FOR A ZONE ( K'/B' )                        QRV 260
C     NSTAGE -                                                          QRV 270
C     HPOOL - THE POOL ELEVATION OF THE RESEVIOR (ONE PER REACH)        QRV 280
C     STAGE,DSCHRG - POINTS DESCRIBING THE LINEAR APPROXIMATION OF THE  QRV 290
C                    STAGE-DISCHARGE RELATIONSHIP FOR THE REACH         QRV 300
C     ------------------------------------------------------------
C                                                                       QRV 310
C     READ (IN,5000) NREACH,NRNODE,NRZ                                  QRV 320
      READ (IN,5000) NREACH,NRNODE,NRZ,NTRIB                            QRV 320*
      IF (IPRINT.GE.2) WRITE (IO,6000) NREACH,NRNODE,NRZ                QRV 330
      NBUD=12+NREACH                                                    QRV 340
      IF (IPRINT.GE.2) WRITE (IO,6010)                                  QRV 350
      READ (IN,5025) (QCOR(I),I=1,NRZ)                                  QRV 360
      IF (IPRINT.GE.2) WRITE (IO,6020) (I,QCOR(I),I=1,NRZ)              QRV 370
      IF (IPRINT.GE.2) WRITE (IO,6030)                                  QRV 380
      DO 20 N=1,NREACH                                                  QRV 390
      READ (IN,5010) NSTAGE(N),HPOOL(N)                                 QRV 400
      IF (IPRINT.GE.2) WRITE (IO,6040) N,NSTAGE(N),HPOOL(N)             QRV 410

C


      NSTAGN=NSTAGE(N)                                                  QRV 420
      READ (IN,5020) (STAGE(L,N),L=1,NSTAGN)                            QRV 430
      READ (IN,5020) (DSCHRG(L,N),L=1,NSTAGN)                           QRV 440
      IF (IPRINT.GE.2) WRITE (IO,6050) (STAGE(L,N),L=1,NSTAGN)          QRV 450
   20 IF (IPRINT.GE.2) WRITE (IO,6060) (DSCHRG(L,N),L=1,NSTAGN)         QRV 460
      NR=0                                                              QRV 470
      IF (IPRINT.GE.4) WRITE (IO,6070)                                  QRV 480
C     DO 60 NODE=1,NRNODE                                               QRV 490
      DO 50 NODE=1,NRNODE                                               QRV 490*
      IF (LATLON) GO TO 30                                              QRV 500
      READ (IN,5040)XR,YR,NRN(NODE),IRZ,NER(NODE),NRTYP(NODE),LENGTH,WIDQRV 510
     1TH,ELVR(NODE),XFACTR(NODE)                                        QRV 520
C     XR=XR*XSCL                                                        QRV 530
```

```
C     YR=YR*YSCL                                                        QRV 540
      GO TO 40                                                          QRV 550
   30 READ (IN,5030)LON,LAT,NRN(NODE),IRZ,NER(NODE),NRTYP(NODE),LENGTH,WQRV 560
     1IDTH,ELVR(NODE),XFACTR(NODE)                                      QRV 570
      PLONG=LON(1)+(LON(3)/60.+LON(2))/60.                              QRV 580
      PLAT=LAT(1)+(LAT(3)/60.+LAT(2))/60.                               QRV 590
      CALL LAMBRT (PLONG,PLAT,XR,YR)                                    QRV 600
   40 QCOMR(NODE)=QCOR(IRZ)*LENGTH*WIDTH                                QRV 610
      XR = XSCL*(XR-XO)                                                 QRV 620
      YR = YSCL*(YR-YO)                                                 QRV 630
      IF (LPLOT) CALL PLTR (XR,YR,NODE)                                 QRV 640
      NERN=NER(NODE)                                                    QRV 650
      IF (IPRINT.GE.4) WRITE (IO,6080)NODE,XR,YR,NRN(NODE),IRZ,NERN,NRTYQRV 660
     1P(NODE),LENGTH,WIDTH,ELVR(NODE),XFACTR(NODE)                      QRV 670
      CALL PTFNDR (XR,YR,NERN,RW,NODE,1)                                QRV 680
C                                                                       QRV 690
      QCOMRN=QCOMR(NODE)                                                QRV 700
      DO 50 I=1,NETYP                                                   QRV 710
      NI=NGL(I,NERN)                                                    QRV 720
      RWI=RW(I,NODE)                                                    QRV 730
      DO 50 J=1,NETYP                                                   QRV 740
      NJ=NGL(J,NERN)                                                    QRV 750
      IF (.NOT.WTABLE.AND.NJ.LT.NI) GO TO 50                            QRV 760
      NJB=NJ-NI+IDIAG                                                   QRV 770
      A(NI,NJB)=A(NI,NJB)+QCOMRN*RWI*RW(J,NODE)                         QRV 780
      IF (WTABLE) QBAR(NI)=QBAR(NI)+QCOMRN*RWI*RW(J,NODE)*HO(NJ)        QRV 790
   50 CONTINUE                                                          QRV 800
C     IF (NRN(NODE).LT.(NR+2)) GO TO 60                                 QRV 810*
C     NR=NR+1                                                           QRV 820*
C     NEND(NR)=NODE                                                     QRV 830*
C  60 CONTINUE                                                          QRV 840*
C     NEND(NR+1)=NRNODE+1                                               QRV 850*
      IF (NTRIB.LT.1)    RETURN                                         QRV 810*
      READ (IN,5000) (NODEIN(N),N=1,NTRIB)                              QRV 820$
      WRITE(IO,5005) (NODEIN(N),N=1,NTRIB)                              JEC 825
      DO 60 N=1,NTRIB                                                   QRV 830*
C                                                                       QRV 840*
C                                                                       QRV 850*
C     READ DAILY INFLOW
      READ (IN,5015) (FLOWIN(L,N),L=1,366)                              QRV 870*
      IF (IPRINT.GE.2) WRITE (IO,6090) N                                QRV 880*
   6C IF (IPRINT.GE.2) WRITE (IO,6100) (FLOWIN(L,N),L=1,366)            QRV 890*
```

```
C     READ (IN,5015) (FLOWIN(N),N=1,366)                                QRV 870
C     IF (IPRINT.GE.2) WRITE (IO,6090)                                  QRV 880
C     IF (IPRINT.GE.2) WRITE (IO,6100) (FLOWIN(N),N=1,366)              QRV 890
 5000 FORMAT (20I4)                                                     QRV1490
5005  FORMAT(1H0,5X,'RIVER-NODE LOCATION OF TRIBUTARIES  ',20I4,/)      JEC1495

C

 5010 FORMAT (I4,F10.0)                                                 QRV1500
 5015 FORMAT (12F10.0)
 5020 FORMAT (12F6.0)
 5025 FORMAT (7F10.0)
 5030 FORMAT (10I4,4F10.0)                                              QRV1520
 5040 FORMAT (2F12.0,4I4,4F10.0)                                        QRV1530
 6000 FORMAT (1H1/1H ,30X,'RIVER PARAMETERS'/1H0,5X,'NUMBER OF ','RIVER QRV1540
     1REACHES = ',I3/1H ,5X,'NUMBER OF RIVER NODES = ',I4/1H ,5X,'NUMBERQRV1550
     2 OF RIVER-LEAKANCE ZONES = ',I3)                                  QRV1560
 6010 FORMAT (1H0,30X,'RIVER-LEAKANCE VALUES BY ZONE (QCOR(N))')        QRV1570
 6020 FORMAT (1H ,5X,'ZONE ',I2,2X,1P1E12.5)                            QRV1580
 6030 FORMAT (1H0,30X,'RIVER-REACH PARAMETERS')                         QRV1590
 6040 FORMAT (1H ,10X,'REACH NUMBER ',I2/1H ,5X,I3,' POINTS USED IN',' SQRV1600
     1TAGE - DISCHARGE RELATIONSHIP'/1H ,5X,'POOL ELEVATION = ',F10.3)  QRV1610
 6050 FORMAT (1H ,5X,'  STAGE  ',12F9.3)                                QRV1620
 6060 FORMAT (1H ,5X,'DISCHARGE',12F9.3)                                QRV1630
 6070 FORMAT (1H0,30X,'RIVER-NODE DATA'/1H0,5X,'NODE',4X,'X-COORD',4X,'YQRV1640
     1-COORD',3X,'REACH',2X,'ZONE',2X,'ELEM.',2X,'TYPE',5X,'LENGTH',5X,'QRV1650
     2WIDTH',5X,'ELEVATION',5X,'XFACTOR')                               QRV1660
 6080 FORMAT (1H ,5X,I3,2F12.3,4I6,5X,4F10.3)                            QRV1670
C6090 FORMAT (1H0,30X,'DAILY INFLOW VALUES (FLOWIN(N))'/)               QRV1680
 6090 FORMAT (1H0,30X,'DAILY INFLOW VALUES (FLOWIN(N))',3X,I2)          QRV1680*
 6100 FORMAT (1H ,12F10.2)                                              QRV1690
      RETURN                                                            QRV 900
       END
```

```
C     ------------------------------------------------------------       QRV 910
       SUBROUTINE RIVER (A,NIJD,NBWD)
C      -------------------------------------------------------------
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                                QRV  20
      REAL BUDTTL,LENGTH
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN        QRV  30
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),      QRV  60
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                           QRV  70
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)                          QRV  80
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD               QRV  90
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),       QRV 100
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),                       QRV 110
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),      QRV 120*
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP            QRV 140
      COMMON /MPSCL/ XSCL,YSCL ,XO,YO                                    QRV 150
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN QRV 170
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                 QRV 180
      DIMENSION A(NIJD,NBWD),LON(3),LAT(3)                               QRV 190
C     ZERO RIVER FLOW ARRAY                                              QRV 921*
      DO 65 I=1,NRNODE                                                   QRV 922*
   65 RIVERQ(I) = 0.0                                                    QRV 923*
C     ZERO REACH BUDGET ARRAY                                            QRV 924*
      DO 66 L=1,NREACH                                                   QRV 925*
   66 BUD(12+L) = 0.0                                                    QRV 926*
      IF (NTRIB.LT.1)   GO TO 77                                         QRV 927*
      DO 75 N=1,NTRIB                                                    QRV 928*
      I = NODEIN(N)                                                      QRV 929*
      RQ1=0.                                                             QRV 930
      JDAY=KDYS-1                                                        QRV 940
      DO 70 L=1,IDAY                                                     QRV 950
      JDAY=JDAY+1                                                        QRV 960
      IF (JDAY.GT.IDYR) JDAY=JDAY-IDYR                                   QRV 970
C  70 RQ1=RQ1+FLOWIN(JDAY)                                               QRV 980
```

```
C
C     RIVERQ(1)=RQ1/(1.0*IDAY)                                          QRV 990
   70 RQ1=RQ1+FLOWIN(JDAY,N)                                            QRV 980*
   75 RIVERQ(I)=RQ1/(1.0*IDAY)                                          QRV 990*
C                                                                       QRV1000
C     ROUTE THE WATER THROUGH EACH NODE                                 QRV1010
C     DO 170 NODE=1,NRNODE                                              QRV1020
   77 DO 170 NODE=1,NRNODE                                              QRV1020*
      NERN=NER(NODE)                                                    QRV1030
      L=NRN(NODE)                                                       QRV1040
C                                                                       QRV1050
C                                                                       QRV1060
      B=-ELVR(NODE)                                                     QRV1070
C                                                                       QRV1080
      HAQ=0.0                                                           QRV1090
      DO 80 I=1,NETYP                                                   QRV1100
   80 HAQ=HAQ+H(NGL(I,NERN))*RW(I,NODE)                                 QRV1110
      B=B+HAQ                                                           QRV1120
      IF (B.GT.0.) B=0.                                                 QRV1130
      IF (NRTYP(NODE).EQ.0) GO TO 90                                    QRV1140
      RIVERH(NODE)=HPOOL(L)+(RIVERH(NODE-1)-HPOOL(L))*XFACTR(NODE)      QRV1150
      GO TO 150                                                         QRV1160
   90 RIVERH(NODE)=ELVR(NODE)                                           QRV1170
C     DETERMINE THE NODE STAGE FROM THE RIVER INFLOW ( RIVERQ )         QRV1180
      LOW=1                                                             QRV1190
      MAX=NSTAGE(L)                                                     QRV1200
  100 IF ((MAX-LOW).LT.2) GO TO 140                                     QRV1210
      MP=LOW+(MAX-LOW)/2                                                QRV1220
      IF (RIVERQ(NODE)-DSCHRG(MP,L)) 110,130,120                        QRV1230
  110 MAX=MP                                                            QRV1240
      GO TO 100                                                         QRV1250
  120 LOW=MP                                                            QRV1260
      GO TO 100                                                         QRV1270
  130 LOW=MP                                                            QRV1280
  140 RIVERH(NODE)=RIVERH(NODE)+STAGE(LOW,L)+(STAGE(MAX,L)-STAGE(LOW,L))QRV1290
     1*(RIVERQ(NODE)-DSCHRG(LOW,L))/(DSCHRG(MAX,L)-DSCHRG(LOW,L))       QRV1300
C     DETERMINE THE INFLOW TO THE DOWN STREAM NODE BY COMPUTING THE LEAKQRV1310
```

```
  150 Q=(RIVERH(NODE)+B-HAQ)*QCOMR(NODE)                                 QRV1320
      IF (Q.GT.RIVERQ(NODE)) Q=RIVERQ(NODE)                              QRV1330
      QRR(NODE)=Q                                                          JEC
      IF (NODE.GE.NRNODE)    GO TO 155                                   QRV1335*
C     RIVERQ(NODE+1)=RIVERQ(NODE)-Q                                      QRV1340
      RIVERQ(NODE+1)=RIVERQ(NODE+1)+RIVERQ(NODE)-Q                       QRV1340*
      IF (RIVERQ(NODE+1).GE.0.0)     GO TO 155                           QRV1341*
      WRITE (IO,6110) NODE,RIVERQ(NODE+1)                                QRV1342*
      RIVERQ(NODE+1) = 0.0                                               QRV1343*
  155 BUD(12+L) = BUD(12+L) + Q                                          QRV1344*
      Q=Q+QCOMR(NODE)*HAQ                                                QRV1350
      DO 160 I=1,NETYP                                                   QRV1360
      NI=NGL(I,NERN)                                                     QRV1370
  160 QZ(NI)=QZ(NI)+Q*RW(I,NODE)                                         QRV1380
  170 CONTINUE                                                           QRV1390
C     BUD(13)=RIVERQ(1)-RIVERQ(NEND(1))                                  QRV1400
C                                                                        QRV1410
C     IF (NREACH.LT.2) RETURN                                            QRV1420
C     NR1=NREACH-1                                                       QRV1430
C     DO 180 N=1,NR1                                                     QRV1440
C     L=N+13                                                             QRV1450
C 180 BUD(L)=RIVERQ(NEND(N))-RIVERQ(NEND(N+1))                           QRV1460
 6110 FORMAT (5X,'DIVERSION AFTER NODE',I3,'EXCEEDSFLOWBY'F10.2)         QRV1691*
      RETURN                                                             QRV1470


C



      END                                                                QRV1700-
```

```
C     ----------------------------------------------------------------
      SUBROUTINE PTFNDR (XP,YP,NE,W,NO,NT)
C     ----------------------------------------------------------------
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     C                                                              C
C     C                THIS SUBROUTINE CALCULATES THE LOCAL COORDI-  C
C     C   NATES OF A POINT WITHIN AN ELEMENT. IF THE POINT TURNS OUT C
C     C   NOT TO BE WITHIN THE ELEMENT SPECIFIED, A MESSAGE IS       C
C     C   PRINTED GIVING THE CALCULATED LOCAL COORDINATES WHICH CAN  C
C     C   BE USED TO HELP LOCATE THE CORRECT ELEMENT NUMBER          C
C     C                                                              C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C     ----------------------------------------------------------------
C     XP,YP - THE GLOBAL COORDINATES OF THE POINT
C     NE - THE ELEMENT THAT THE POINT IS LOCATED WITHIN
C     NO - THE WELL OR RIVER NODE NUMBER THAT THE POINT REPRESENTS
C     W1,W2,W3 - THE THREE LOCAL COORDINATES OF THE POINT WITHIN
C                      THE TRIANGULAR ELEMENT
C     ETA,ZETA - THE LOCAL X - Y COORDINATES OF THE POINT WITHIN
C                      THE QUADRALATERAL ELEMENT
C     W1,W2,W3,W4 - THE FOUR LOCAL COORDINATES OF THE POINT WITHIN
C                      THE QUADRILATERRAL ELEMENT
C     ----------------------------------------------------------------
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      DIMENSION W(1)
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT
C
      IP=(NO-1)*4
      IF (QUAD) GO TO 20
C
C     PTFNDR FOR TRIANGULAR ELEMENTS
C
```

```
      IERR=0
      DO 10 I=1,3
      I1=I+1
      IF (I1.EQ.4) I1=1
      I2=I+2
      IF (I2.GT.3) I2=I2-3
      NI1=NGL(I1,NE)
      NI2=NGL(I2,NE)
      IPI=IP+I
      W(IPI)=((X(NI1)*Y(NI2)-X(NI2)*Y(NI1))+(Y(NI1)-Y(NI2))*XP+(X(NI2)-X
     1(NI1))*YP)/(2.0*AREA(NE))
      IF (W(IPI).GT.1..OR.W(IPI).LT.0) IERR=1
   10 CONTINUE
C
C     IF W(I) IS GREATER THAN 1 OR NEGATIVE, IT MUST BE LOCATED IN
C     A DIFFERENT ELEMENT
C
      IF (IERR.EQ.0) RETURN
      IF (NT.EQ.1) WRITE (IO,6000) NO,NE,W(IP+1),W(IP+2),W(IP+3)
C
      IF (NT.EQ.2) WRITE (IO,6010) NO,NE,W(IP+1),W(IP+2),W(IP+3)
      RETURN
C
C     PTFNDR FOR QUAD. ELEMENTS
C
   20 X1=X(NGL(1,NE))
      Y1=Y(NGL(1,NE))
      X2=X(NGL(2,NE))
      Y2=Y(NGL(2,NE))
      X3=X(NGL(3,NE))
      Y3=Y(NGL(3,NE))
      X4=X(NGL(4,NE))
      Y4=Y(NGL(4,NE))
      A=X1+X2+X3+X4
      B=X2+X3-X1-X4
      C=X3+X4-X1-X2
      D=X1+X3-X2-X4
      E=Y1+Y2+Y3+Y4
      F=Y2+Y3-Y1-Y4
      G=Y3+Y4-Y1-Y2
      V=Y1+Y3-Y2-Y4
```

```
      XO=4.*XP-A
      YO=4.*YP-E
      IF (D) 100,30,100
   30 IF (V) 50,40,50
   40 ETA=(G*XO-C*YO)/(B*G-F*C)
      ZETA=(B*YO-F*XO)/(B*G-F*C)
      GO TO 230
   50 IF (C) 70,60,70
   60 ETA=XO/B
      ZETA=(YO-F*ETA)/(G+V*ETA)
      GO TO 230
   70 IF (B) 90,80,90
   80 ZETA=XO/C
      ETA=(YO-G*ZETA)/(F+V*ZETA)
      GO TO 230
   90 ABAR=-B*V/C
      BBAR=F+V*XO/C-B*G/C
      CBAR=G*XO/C-YO
      BBAR=BBAR/(2.*ABAR)
      CBAR=CBAR/ABAR
      YBB=BBAR*BBAR-CBAR
      CSTAR=DSQRT(YBB)
      ETA=-BBAR+CSTAR
      ZETA=(XO-B*ETA)/C
      R1=ETA*ETA+ZETA*ZETA
      IF (ETA*ETA.GT.1..OR.ZETA*ZETA.GT.1.) ETA=-BBAR-CSTAR
      ZETA=(XO-B*ETA)/C
      R2=ETA*ETA+ZETA*ZETA
      IF (R2.GT.R1) ETA=-BBAR+CSTAR
      ZETA=(XO-B*ETA)/C
      GO TO 230
  100 IF (V) 160,110,160
  110 IF (G) 130,120,130
  120 ETA=YO/F
      ZETA=(XO-B*ETA)/(C+D*ETA)
      GO TO 230
  130 IF (F) 150,140,150
  140 ZETA=YO/G
      ETA=(XO-C*ZETA)/(B+D*ZETA)
```

```
C
      GO TO 230
  150 ABAR=-D*F/G
      BBAR=B+D*YO/G-C*F/G
      CBAR=C*YO/G-XO
      BBAR=BBAR/(2.*ABAR)
      CBAR=CBAR/ABAR
      YBB=BBAR*BBAR-CBAR
      CSTAR=DSQRT(YBB)
      ETA=-BBAR+CSTAR
      ZETA=(YO-F*ETA)/G
      R1=ETA*ETA+ZETA*ZETA
      IF (ETA*ETA.GT.1..OR.ZETA*ZETA.GT.1.) ETA=-BBAR-CSTAR
      ZETA=(YO-F*ETA)/G
      R2=ETA*ETA+ZETA*ZETA
      IF (R2.GT.R1) ETA=-BBAR+CSTAR
      ZETA=(YO-F*ETA)/G
      GO TO 230
  160 ABAR=B*V-F*D
      BBAR=C*V-D*G
      CBAR=V*XO-D*YO
      IF (BBAR) 200,170,200
  170 IF (ABAR) 190,180,190
  180 GO TO 230
  190 ETA=CBAR/ABAR
      ZETA=(YO-F*ETA)/(V*ETA+G)
      GO TO 230
  200 IF (ABAR) 220,210,220
  210 ZETA=CBAR/BBAR
      ETA=(XO-C*ZETA)/(B+D*ZETA)
      GO TO 230
  220 XBAR=-ABAR*D/BBAR
      YBAR=B+CBAR*D/BBAR-ABAR*C/BBAR
      ZBAR=CBAR*C/BBAR-XO
      YBAR=YBAR/(2.*XBAR)
      ZBAR=ZBAR/XBAR
      YBB=(YBAR*YBAR-ZBAR)
```

```
      IF (YBB.LT.0.) YBB=0.0
      CSTAR=DSQRT(YBB)
      ETA=-YBAR+CSTAR
      ZETA=(CBAR-ABAR*ETA)/BBAR
      R1=ETA*ETA+ZETA*ZETA
      IF (ETA*ETA.GT.1..OR.ZETA*ZETA.GT.1.) ETA=-YBAR-CSTAR
      ZETA=(CBAR-ABAR*ETA)/BBAR
      R2=ETA*ETA+ZETA*ZETA
      IF (R2.GT.R1) ETA=-YBAR+CSTAR
      ZETA=(CBAR-ABAR*ETA)/BBAR
  230 CONTINUE
      W(IP+1)=(1.-ETA)*(1.-ZETA)*.25
      W(IP+2)=(1.+ETA)*(1.-ZETA)*.25
      W(IP+3)=(1.+ETA)*(1.+ZETA)*.25
      W(IP+4)=(1.-ETA)*(1.+ZETA)*.25
      IF (ETA*ETA.LE.1.0.AND.ZETA*ZETA.LE.1.0) RETURN
C
C     IF THE MAGNITUDE OF ETA OR ZETA IS > 1, IT MUST BE LOCATED IN
C     A DIFFERENT ELEMENT
C
      IF (NT.EQ.1) WRITE (IO,6020) NO,NE,ETA,ZETA
      IF (NT.EQ.2) WRITE (IO,6030) NO,NE,ETA,ZETA
      RETURN
C


C


 6000 FORMAT (1H ,5X,'** ERROR **   RIVER NODE',I4,' IS NOT IN ELEMENT',
     1I4,'   CALCULATED VALUES FOR W1-W3 ARE ',3F10.5)
 6010 FORMAT (1H ,5X,'** ERROR **   WELL NODE',I4,' IS NOT IN ELEMENT',I
     14,'   CALCULATED VALUES FOR W1-W3 ARE ',3F10.5)
 6020 FORMAT (1H ,5X,'** ERROR **   RIVER NODE',I4,' IS NOT IN ELEMENT',
     1I4,'   CALCULATED VALUES FOR ETA,ZETA ARE ',1P2E19.12)
 6030 FORMAT (1H ,5X,'** ERROR **   WELL NODE',I4,' IS NOT IN ELEMENT',I
     14,'   CALCULATED VALUES FOR ETA,ZETA ARE ',1P2E19.12)
      END
```

```
C     ------------------------------------------------------------------
      SUBROUTINE BNDCON (A,UV,NIJD,NBWD)                                BND  10
C     ------------------------------------------------------------------
C                                                                       BND  20
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCBND  30
C     C                                                                 BND  40
C     C               THIS ROUTINE APPLIES THE FIXED HEAD BOUNDARY      BND  50
C     C    CONDITION. FIRST, THE COEFFICIENTS IN THE ROW OF A FIXED     BND  60
C     C    HEAD NODE ARE STORED,THEN THE ROW IN THE 'A' MATRIX IS       BND  70
C     C    ZEROED OUT. FOR THE CONFINED CASE, ONLY THE SYMMETRIC HALF   BND  80
C     C    OF 'A' IS STORED, SO, THE COLUMN MUST BE ZEROED OUT, TOO     BND  90
C     C    A 1.0 IS PLACED ON THE DIAGONAL OF THE MATRIX, AND THE       BND 100
C     C    SPECIFIED HEAD IS PLACED ON THE R.H.S. IN THE MAIN PROGRAM   BND 110
C     C                                                                 BND 120
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCBND 130
C                                                                       BND 140
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               BND 150
      REAL BUDTTL
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN       BND 160
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),     BND 180
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                          BND 190
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)                         BND 200
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),      MAI   90
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),                      MAI  100
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),     QRV 120*
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD              BND 210
      COMMON/BNDRY/BQH(572),QB(572),PBH(12),PBF(12),BB(9,50),IBNODE(572)BND 220
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP           BND 230
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT ,NN                       BND 250
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN BND 260
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                BND 270
      COMMON/HEAD2/ HI(572),CLDH(572)                                   MAI  230
C                                                                       BND 280
      DIMENSION A(NIJD,NBWD),UV(1)                                      BND 290
C                                                                       BND 320
C     ------------------------------------------------------------------
C     BB - STORAGE MATRIX FOR BOUNDARY FLUX TERMS                       BND 330
C     ------------------------------------------------------------------
```

```
C
C     LOAD THE TERMS OF THE A MATRIX INTO THE BB MATRIX
C
      I=0
      DO 160 NB=1,NIJ
      IF (IBNODE(NB).LT.2) GO TO 160
      I=I+1
      BB(1,I)=A(NB,IDIAG)
      IF (NB.EQ.NIJ) GO TO 60
      BB(2,I)=A(NB,IDIAG+1)
      IF (NB+JT-1-NIJ) 20,50,60
C
   20 IF (NB+JT-NIJ) 30,40,50
   30 BB(3,I)=A(NB,JT+IDIAG+1)
   40 BB(4,I)=A(NB,JT+IDIAG)
   50 BB(5,I)=A(NB,JT+IDIAG-1)
   60 IF (NB.EQ.1) GO TO 160
C
C     FOR CONFINED CASE, THE TERMS THAT WOULD BE TO THE LEFT OF THE
C     DIAGONAL MUST BE EVALUTED THROUGH THEIR SYMMETRIC COUNTERPART.
C
      IF (WTABLE) GO TO 110
      BB(6,I)=A(NB-1,2)
      IF (NB-JT) 160,100,70
   70 IF (NB-JT-1) 160,90,80
   80 BB(7,I)=A(NB-JT-1,JT+2)
   90 BB(8,I)=A(NB-JT,JT+1)
  100 BB(9,I)=A(NB-JT+1,JT)
      GO TO 160
C
C     FOR WATER-TABLE CASE, ALL TERMS ARE ON THE SAME LINE OF MATRIX 'A'
C
  110 BB(6,I)=A(NB,IDIAG-1)
      IF (NB-JT) 160,150,120
  120 IF (NB-JT-1) 160,140,130
  130 BB(7,I)=A(NB,IDIAG-JT-1)
  140 BB(8,I)=A(NB,IDIAG-JT)
  150 BB(9,I)=A(NB,IDIAG-JT+1)
```

```
  160 CONTINUE
C
C     ZERO THE ROW (AND COLUMN) OF A SPECIFIED HEAD NODE IN THE A MATRIX
C
      DO 220 NB=1,NIJ
      IF (IBNODE(NB).LT.2) GO TO 220
      DO 170 J=1,NBW
  170 A(NB,J)=0.
C
C     SET 1.0 ON THE DIAGONAL
C
      A(NB,IDIAG)=1.
C
C     ZERO OUT COLUMN TERMS FOR THE CONFINED AQUIFER CASE. THE
C     VALUE OF THESE TERMS TIMES THE SPECIFIED HEADS WILL BE LOADED
C     ON THE R.H.S. IN THE 'QBOUND' ENTRY
C
      IF (WTABLE) GO TO 220
      IF (NB.EQ.1) GO TO 220
      A(NB-1,2)=0.
      IF (NB-JT) 220,210,180
  180 IF (NB-JT-1) 220,200,190
  190 A(NB-JT-1,JT+2)=0.
  200 A(NB-JT,JT+1)=0.
  210 A(NB-JT+1,JT)=0.
  220 CONTINUE
      RETURN
       END
C
C
C     ------------------------------------------------------------------
       SUBROUTINE QBOUND(A,UV,NIJD,NBWD)
C     ------------------------------------------------------------------
C
```

```
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC       BND1030
C     C                                                        CC       BND1040
C     C         THIS ENTRY TAKES  CARE OF SPECIFIED BOUNDARY   CC       BND1050
C     C     FLUXES. IT ALSO ADJUSTS FOR THE ZEROING OUT OF THE  CC      BND1060
C     C     COLUMN OF THE 'A' MATRIX AT A SPECIFIED HEAD NODE.  CC      BND1070
C     C                                                        CC       BND1080
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC       BND1090
C                                                                       BND1100
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               BND 150
      REAL BUDTTL
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN       BND 160
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),     BND 180
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                          BND 190
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)                         BND 200
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),      MAI   90
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),                      MAI  100
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),     QRV 120*
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD              BND 210
      COMMON/BNDRY/BQH(572),QB(572),PBH(12),PBF(12),BB(9,50),IBNODE(572)BND 220
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP           BND 230
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT ,NN                       BND 250
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN BND 260
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                BND 270
      COMMON/HEAD2/ HI(572),OLDH(572)                                   MAI  230
C                                                                       BND 280
      DIMENSION A(NIJD,NBWD),UV(1)                                      BND 290
C     ------------------------------------------------------------
C     QRE - RIGHT HAND SIDE OF THE FLOW EQUATION CONTAINING FLUX TERMS  BND1110
C     TQH - SPECIFIED HEAD OR FLUX ADJUSTED FOR MONTHLY VARIABILITY     BND1120
C     ------------------------------------------------------------
C                                                                       BND1130
C     ZERO THE NODAL RECHARGE ARRAY                                     BND1140
C                                                                       BND1150
      DO 230 N=1,NIJ                                                    BND1160
  230 QRE(N)=0.                                                         BND1170
      TBH=0.0                                                           BND1180
      TBF=0.0                                                           BND1181
```

```
      DO 235 IM=1,12                                              BND1182
      TBH=TBH+PBH(IM)*FMON(IM)                                    BND1183
  235 TBF=TBF+PBF(IM)*FMON(IM)                                    BND1184
      I=0                                                         BND1190
      DO 340 NB=1,NIJ                                             BND1200
      IF (IBNODE(NB).LT.2) GO TO 330                              BND1210
      TQH=TBH*BQH(NB)                                             BND1220
C                                                                 BND1230
C     ADJUSTMENT FOR THE ZEROING OUT OF THE COLUMN IN 'A'         BND1240
C                                                                 BND1250
      IF (WTABLE) GO TO 340                                       BND1260
      I=I+1                                                       BND1270
      IF (NB.EQ.NIJ) GO TO 280                                    BND1280
      QRE(NB+1)=QRE(NB+1)-BB(2,I)*TQH                             BND1290
      IF (NB+JT-1-NIJ) 240,270,280                                BND1300
  240 IF (NB+JT-NIJ) 250,260,270                                  BND1310
  250 QRE(NB+JT+1)=QRE(NB+JT+1)-BB(3,I)*TQH                       BND1320
  260 QRE(NB+JT)=QRE(NB+JT)-BB(4,I)*TQH                           BND1330
  270 QRE(NB+JT-1)=QRE(NB+JT-1)-BB(5,I)*TQH                       BND1340
  280 IF (NB.EQ.1) GO TO 340                                      BND1350
      QRE(NB-1)=QRE(NB-1)-BB(6,I)*TQH                             BND1360
C
      IF (NB-JT) 340,320,290                                      BND1370
  290 IF (NB-JT-1) 320,310,300                                    BND1380
  300 QRE(NB-JT-1)=QRE(NB-JT-1)-BB(7,I)*TQH                       BND1390
  310 QRE(NB-JT)=QRE(NB-JT)-BB(8,I)*TQH                           BND1400
  320 QRE(NB-JT+1)=QRE(NB-JT+1)-BB(9,I)*TQH                       BND1410
      GO TO 340                                                   BND1420
  330 IF (IBNODE(NB).LT.1) GO TO 340                              BND1430
      TQF=TBF*BQH(NB)                                             BND1431
      QRE(NB)=QRE(NB)+TQF                                         BND1440
      IF (TQF.GT.0.0)   BUD(3) = BUD(3) + TQF                     BND1450
      IF (TQF.LT.0.0)   BUD(4) = BUD(4) + TQF
  340 CONTINUE                                                    BND1460
      DO 350 NB=1,NIJ                                             BND1470
      IF (IBNODE(NB).LT.2) GO TO 350                              BND1480
      QRE(NB)=0.                                                  BND1490
  350 CONTINUE                                                    BND1500
      RETURN                                                      BND1510
       END
```

```
C                                                                       BND1520
C     ---------------------------------------------------------------
C                                                                       BND1530
       SUBROUTINE MASBAL (A,UV,NIJD,NBWD)
C     ---------------------------------------------------------------
C                                                                       BND1550
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC   BND1560
C     C                                                            CC   BND1570
C     C              THIS ENTRY PERFORMS THE ACCOUNTING NEEDED     CC   BND1580
C     C        FOR THE MASS BALANCE CHECK.                         CC   BND1590
C     C                                                            CC   BND1600
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC   BND1610
C                                                                       BND1620
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               BND 150
      REAL BUDTTL
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN       BND 160
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),     BND 180
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                          BND 190
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)                         BND 200
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),      MAI   90
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),                      MAI  100
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),     QRV 120*
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD              BND 210
      COMMON/BNDRY/BQH(572),QB(572),PBH(12),PBF(12),BB(9,50),IBNODE(572)BND 220
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP           BND 230
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT ,NN                       BND 250
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN BND 260
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                BND 270
      COMMON/HEAD2/ HI(572),OLDH(572)                                   MAI  230
C                                                                       BND 280
      DIMENSION A(NIJD,NBWD),UV(1)                                      BND 290
      IF (.NOT.WTABLE) GO TO 370                                        BND1630
      DO 360 I=1,NIJ                                                    BND1640
  360 H(I)=H(I)-HO(I)                                                   BND1650
  370 QSH=0.                                                            BND1660
      QSHM = 0.0                                                        BND1665
      I=0                                                               BND1670
      DO 480 NB=1,NIJ                                                   BND1680
      IF (IBNODE(NB).LT.2) GO TO 480                                    BND1690
      I=I+1                                                             BND1700
```

```
C
      QBQ=BB(1,I)*H(NB)                                                 BND1710
      IF (NB.EQ.NIJ) GO TO 420                                          BND1720
      QBQ=QBQ+BB(2,I)*H(NB+1)                                           BND1730
      IF (NB+JT-1-NIJ) 380,410,420                                      BND1740
  380 IF (NB+JT-NIJ) 390,400,410                                        BND1750
  390 QBQ=QBQ+BB(3,I)*H(NB+JT+1)                                        BND1760
  400 QBQ=QBQ+BB(4,I)*H(NB+JT)                                          BND1770
  410 QBQ=QBQ+BB(5,I)*H(NB+JT-1)                                        BND1780
  420 IF (NB.EQ.1) GO TO 470                                            BND1790
      QBQ=QBQ+BB(6,I)*H(NB-1)                                           BND1800
      IF (NB-JT) 470,460,430                                            BND1810
  430 IF (NB-JT-1) 470,450,440                                          BND1820
  440 QBQ=QBQ+BB(7,I)*H(NB-JT-1)                                        BND1830
  450 QBQ=QBQ+BB(8,I)*H(NB-JT)                                          BND1840
  460 QBQ=QBQ+BB(9,I)*H(NB-JT+1)                                        BND1850
  470 QB(NB)=QBQ-QB(NB)                                                 BND1860
      IF(NN .EQ. NSTEP) GO TO 472                                         JEC
      IF(MOD(NN,NPRNT).EQ.0) GO TO 472                                    JEC
      IF(NN .EQ. 1) GO TO 472                                             JEC
       MPRNT = NPRNT/2                                                    JEC
       IF(MOD(NN,MPRNT) .EQ. 0) GO TO 472                                 JEC
       GO TO 475                                                          JEC
 472   WRITE(IO,6050) NB, QB(NB)                                          JEC
6050   FORMAT(1H ,1X,'NODE=',I3,1X,'SPEC HEAD IN-OUT',F10.5)              JEC
 475  IF (QB(NB).GT.0.0)   QSH = QSH + QB(NB)                          BND1870
      IF (QB(NB).LT.0.0)   QSHM = QSHM + QB(NB)                        BND1875
  480 CONTINUE                                                          BND1880
      IF(.NOT. LRIVER)GO TO 488                                          JEC
      IF(NN.EQ.NSTEP)GO TO 485                                           JEC
      IF(MOD(NN,NPRNT).EQ.0) GO TO 485                                   JEC
      IF(NN.EQ.1)GO TO 485                                               JEC
      IF(MOD(NN,MPRNT).EQ.0)GO TO 485                                    JEC
      GO TO 488                                                          JEC
485   WRITE(IO,6068)                                                     JEC
6068  FORMAT(1H0,5X,'RIVER-NODE FLUXES'//)                               JEC
      DO 486 I=1,32                                                      JEC
      II=I+32                                                            JEC
486   WRITE(IO,6070) I,QRR(I),II,QRR(II)                                 JEC
```

```
6070  FORMAT(1X,I3,F12.5,1X,I3,F12.5)                                    JEC
      WRITE(IO,6073)                                                     JEC
6073  FORMAT(1H ,//)                                                     JEC
488   CONTINUE
C
      BUD(1)=QSH                                                         BND1890
      BUD(2)=QSHM                                                        BND1895
      IF (STEADY) GO TO 500                                              BND1900
      BUD5=0.0                                                           BND1910
      DO 490 I=1,NIJ                                                     BND1920
  490 BUD5=BUD5+3.0*UV(I)*H(I)                                           BND1930
      BUD(5)=BUD(5)-BUD5                                                 BND1940
 500   CONTINUE                                                          BND1950
      BALMAS=0.                                                          BND1960
      BALTOT=0.                                                          BND1970
      WRITE(IO,7000)
 7000 FORMAT(1H ,/,6X,'BUDGET BALANCE'/)
      WRITE(IO,8000)
 8000 FORMAT(1H ,28X,'FT**3/S  ',5X,'FT**3',/)                           JEC
      DO 510 L=1,NBUD                                                    BND1980
      BUDTOT(L)=BUDTOT(L)+BUD(L)*DELT                                    BND1990
      BALMAS=BALMAS+BUD(L)                                               BND2000

C

      BALTOT=BALTOT+BUDTOT(L)                                            BND2010
      WRITE (IO,6010) (BUDTTL(N,L),N=1,5),BUD(L),BUDTOT(L)               BND2020
  510 BUD(L)=0.                                                          BND2030
      WRITE (IO,6020)                                                    BND2040
      WRITE (IO,6030) BALMAS,BALTOT                                      BND2050
C     DO 600 I=1,IS                                                       OUT 220
C     K=(I-1)*JT                                                          OUT 230
C     DO 610 J=1,JT                                                       OUT 240
C     HI(K+J)=OLDH(K+J)-H(K+J)                                            OUT 250
C     SATTH = T(K+J)/.0015
C     IF (SATTH .GE. HI(K+J)) GO TO 610
C     WRITE (IO,6005) I,J
C 610 CONTINUE
C 600 CONTINUE
 6005 FORMAT(1H ,10X,'NODE',I3,',',I3,' GOES DRY')
      IF (.NOT.WTABLE) RETURN                                            BND2060
```

```
      DO 520 I=1,NIJ                                                    BND2070
  520 H(I)=H(I)+HO(I)                                                   BND2080
      DO 600 I=1,IS                                                      OUT 220
      K=(I-1)*JT                                                         OUT 230
      DO 610 J=1,JT                                                      OUT 240
      IF (H(K+J) .GT. BOTT(K+J)) GO TO 610
      WRITE (IO,6005) I,J
  610 CONTINUE
  600 CONTINUE
      RETURN                                                            BND2090
 6000 FORMAT(/5X,' STEP BEGINNING ',A3,I3,',',I5,/)
 6010 FORMAT (7X,5A4,F10.4,1P1E12.4)                                    BND2120
 6020 FORMAT(1H ,27X,22H --------  ---------- )
 6030 FORMAT(1H ,4X,16H  MASS RESIDUAL ,4X,1P2E12.4)
      END                                                               BND2150-
C     ----------------------------------------------------------------
      SUBROUTINE SDCOMP (A,NIJ,NBW)                                     SDC  10
C     ----------------------------------------------------------------
C                                                                       SDC  20
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SDC  30
C     C                                                              CC SDC  40
C     C                THIS ROUTINE DECOMPOSES THE SYMMETRIC MATRIX  CC SDC  50
C     C      'A' (CONFIED AQUIFER CASE).                             CC SDC  60
C     C                                                              CC SDC  70
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SDC  80
C                                                                       SDC  90
C                                                                       SDC 100
C     ----------------------------------------------------------------
C     NIJ - NUMBER OF NODES                                             SDC 110
C     NBW- IS THE FULL BANDWIDTH OF THE ASSYMMETRIC MATRIX A            SDC 120
C     ----------------------------------------------------------------
C                                                                       SDC 130
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               SDC 140
      DIMENSION A(NIJ,NBW),B(1),X(1)                                    SDC 150
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                SDC 160
C     DECOMPOSE SYM. MATRIX A                                           SDC 170
      DO 50 N=1,NIJ                                                     SDC 180
      IB=NIJ-N+1                                                        SDC 190
      IF (IB.GT.NBW) IB=NBW                                             SDC 200
      DO 50 L=1,IB                                                      SDC 210
      IACCUM=NBW-L                                                      SDC 220
      IF (IACCUM.GT.(N-1)) IACCUM=N-1                                   SDC 230
      SUM=A(N,L)                                                        SDC 240
      IF (IACCUM.LT.1) GO TO 20                                         SDC 250
```

```
C
      DO 10 K=1,IACCUM                                                   SDC 260
      I=N-K                                                              SDC 270
      J=L+K                                                              SDC 280
   10 SUM=SUM-A(I,K+1)*A(I,J)                                            SDC 290
   20 IF (L.GT.1) GO TO 40                                               SDC 300
      IF (SUM.LE.0) GO TO 30                                             SDC 310
      ADIAGN=1./DSQRT(SUM)                                               SDC 320
      A(N,L)=ADIAGN                                                      SDC 330
      GO TO 50                                                           SDC 340
   30 WRITE (IO,6000) N                                                  SDC 350
      STOP2                                                              SDC 360
   40 A(N,L)=SUM*ADIAGN                                                  SDC 370
   50 CONTINUE                                                           SDC 380
      RETURN                                                             SDC 390
 6000 FORMAT (1H1,5X,24HDECOMPOSITION FAILS ROW ,I3,16H HAS ZERO LENGTH)SDC 860
       END
C     ---------------------------------------------------------------
C                                                                        SDC 400
C                                                                        SDC 410
       SUBROUTINE SSOLVE(A,NIJ,NBW,B,X)
C     ---------------------------------------------------------------
C                                                                        SDC 430
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC            SDC 440
C     C                                                    CC            SDC 450
C     C         THIS ENTRY DOES THE FORWARD AND BACKWARD     CC            SDC 460
C     C     SUBSTITUTIONS NEEDED TO SOLVE THE SYSTEM OF      CC            SDC 470
C     C     EQUATIONS AND RETURNS THE NEW HEADS IN 'X'       CC            SDC 480
C     C                                                    CC            SDC 490
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC            SDC 500
C                                                                        SDC 510
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                                SDC 140
      DIMENSION A(NIJ,NBW),B(1),X(1)                                     SDC 150
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                 SDC 160
C                                                                        SDC 520
C     FORWARD SUBSTITUTE FOR LOWER TRIANGULAR SOLUTION                   SDC 530
C                                                                        SDC 540
```

```
C     ---------------------------------------------------------------
C     B - THE R.H.S. OF THE EQUATION
C     X - THE UNKNOWN VECTOR
C     ---------------------------------------------------------------
C
      DO 80 N=1,NIJ
      SUM=B(N)
      IB=N-NBW+1
      IF (IB.LT.1) IB=1
      IE=N-1
      IF (IB.GT.IE) GO TO 70
      DO 60 K=IB,IE
      I=N-K+1
   60 SUM=SUM-A(K,I)*X(K)
   70 X(N)=SUM*A(N,1)
   80 CONTINUE
C
C     BACKWARD SUBSTITUTE FOR UPPER TRIANGULAR SOLUTION
C
      DO 110 N=1,NIJ
      IJ=NIJ-N+1
      IE=IJ+NBW-1
      IF (IE.GT.NIJ) IE=NIJ
      SUM=X(IJ)
C
      IB=IJ+1
      IF (IB.GT.IE) GO TO 100
      DO 90 K=IB,IE
      I=K-IJ+1
   90 SUM=SUM-A(IJ,I)*X(K)
  100 X(IJ)=SUM*A(IJ,1)
  110 CONTINUE
      RETURN
C
      END
```

```
C     ------------------------------------------------------------------
      SUBROUTINE ADCOMP (A,NIJ,NBW)
C     ------------------------------------------------------------------
C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     C
C     C               THIS SUBROUTINE IS CALLED FOR A WATER-TABLE AQUIFER
C     C      DECOMPOSES THE ASYMMETRIC 'A' MARIX INTO A UPPER * LOWER FO
C     C      USING THE DOOLITTLE VARIANT OF GAUSS ELIMINATION. THE DECOM
C     C      SITION MULTIPLIERS ARE SAVED IN THE LOWER TRIANGLE.
C     C
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION  A(NIJ,NBW),  B(1),XX(1)
C
C     ------------------------------------------------------------------
C     NIJ - NUMBER OF NODES
C     NBW- IS THE FULL BANDWIDTH OF THE ASSYMMETRIC MATRIX A
C     IHALFB - IS THE HALF-BAND WIDTH OF MATRIX A NOT INCLUDING DIAGONA
C     IHBP - THE HALF-BAND WIDTH OF MATRIX A, INCLUDES DIAGONAL
C     PIVOT - THE DIAGONAL TERM OF EACH ROW
C     ------------------------------------------------------------------
C
      NRS=NIJ-1
      IHALFB=NBW/2
      IHBP=IHALFB+1
      NN=NIJ+1
      DO 30 K=1,NRS
      PIVOT=A(K,IHBP)
      KK=K+1
      KC=IHBP
      DO 20 I=KK,NIJ
      KC=KC-1
      IF (KC.LE.0) GO TO 30
      IF (DABS(A(I,KC)).LE.1.0D-10) GO TO 20
      C=-A(I,KC)/PIVOT
      A(I,KC)=C
      KI=KC+1
      LIM=KC+IHALFB
      DO 10 J=KI,LIM
      JC=IHBP+J-KC
```

```
   10 A(I,J)=A(I,J)+C*A(K,JC)                                          ADC 400
   20 CONTINUE                                                         ADC 410
   30 CONTINUE                                                         ADC 420
      RETURN                                                           ADC 430
      END
C                                                                      ADC 440
C     ------------------------------------------------------------
C                                                                      ADC 450

C


      SUBROUTINE ASOLVE(A,NIJ,NBW,B,XX)
C     ------------------------------------------------------------
C                                                                      ADC 470
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCADC 480
C     C                                                                ADC 490
C     C                THIS ENTRY PERFORMS THE BACKWARD SUBSTITUTION TO ADC 500
C     C     SOLVE FOR THE UNKNOWN 'X' USING THE RIGHT HAND SIDE 'B'    ADC 510
C     C                                                                ADC 520
C     CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCADC 530
C                                                                      ADC 540
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                              ADC 120
      DIMENSION  A(NIJ,NBW),  B(1),XX(1)                               ADC 140
      XX(1)=B(1)                                                       ADC 550
      IHALFB=NBW/2
      IHBP=IHALFB+1
       NN=NIJ+1
      DO 70 I=2,NIJ                                                    ADC 560
      JC=IHBP-I+1                                                      ADC 570
      JI=1                                                             ADC 580
      IF (JC.LE.0) GO TO 40                                            ADC 590
      GO TO 50                                                         ADC 600
   40 JC=1                                                             ADC 610
      JI=I-IHBP+1                                                      ADC 620
   50 SUM=0.0                                                          ADC 630
      DO 60 J=JC,IHALFB                                                ADC 640
      SUM=SUM+A(I,J)*XX(JI)                                            ADC 650
   60 JI=JI+1                                                          ADC 660
```

```
70 XX(I)=B(I)+SUM
   XX(NIJ)=XX(NIJ)/A(NIJ,IHBP)
   DO 90 IBACK=2,NIJ
   I=NN-IBACK
   JP=I
   KR=IHBP+1
   MR=MINO(NBW,IHALFB+IBACK)
   SUM=0.0
   DO 80 J=KR,MR
   JP=JP+1
80 SUM=SUM+A(I,J)*XX(JP)
9C XX(I)=(XX(I)-SUM)/A(I,IHBP)
   RETURN
   END
C  ----------------------------------------------------------------
   SUBROUTINE QZEE (UV)
C  ----------------------------------------------------------------
   IMPLICIT DOUBLE PRECISION (A-H,O-Z)
   REAL BUDTTL
   LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
   COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),
  1ALSD(572),X(572),Y(572),AREA(1020),SAREA
   COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)
   COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(2C),NBUD
   COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP
   COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)
   COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN
   COMMON/WELLS/ QW(200),AREAPP(200),QAPP(1020),REAPP(1020),
  1WW(4,200),PMPDMD(5,12),PMPAPP(5),NEW(200),NTW(200),NAPP(200),
  2NEAPP(30,200),NWELLS,NSEWER,NWTYP
   COMMON /WETHER/ PRECIP(12),U(12),SC,DEPTH,SF,ETFAC(8)
   COMMON /MPSCL/ XSCL,YSCL ,XO,YO
   COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT
```

```
C
      DIMENSION UV(1),LAT(3),LON(3)                                     QZE 180
C                                                                       QZE 190
C     ------------------------------------------------------------------
C     PRECIP - MONTHLY VALUES FOR PRECIPITATION                         QZE 200
C     U - MONTHLY VALUES FOR E.T. DEMAND                                QZE 210
C     SC - SOIL MOISTURE STORAGE TERM                                   QZE 220
C     DEPTH - EXTINCTION DEPTH FOR E.T.                                 QZE 230
C     SF1-SF4 - COEFFICIENTS USED TO CALCULATE SOIL MOISTURE E.T. FACTORQZE 240
C     ETFAC - SOIL MOISTURE E.T. FACTORS                                QZE 250
C     ------------------------------------------------------------------
C                                                                       QZE 260
      READ (IN,5010) (PRECIP(M),M=1,12)                                 QZE 270
      IF (IPRINT.GE.2) WRITE (IO,6010) (PRECIP(M),M=1,12)               QZE 280
      IF (.NOT.EVPTRN) RETURN                                           QZE 290
      READ (IN,5010) (U(M),M=1,12)                                      QZE 300
      IF (IPRINT.GE.2) WRITE (IO,6020) (U(M),M=1,12)                    QZE 310
      READ (IN,5010) SC,DEPTH                                           QZE 320
      IF (IPRINT.GE.2) WRITE (IO,6030) SC,DEPTH                         QZE 330
      SF=ETFAC(1)+SC*(ETFAC(2)+SC*(ETFAC(3)*SC-ETFAC(4)))               QZE 340
      RETURN                                                            QZE 350
 5010 FORMAT (12F6.0)                                                   QZE2240
 6010 FORMAT (1H1/1H ,30X,'PRECIPITATION AND EVAPOTRANSPIRATION DATA'/1HQZE2280
     10,10X,'MONTHLY PRECIPITATTION VALUES'/1H ,5X,12F8.3)              QZE2290
 6020 FORMAT (1H0,10X,'MONTHLY VALUES FOR E.T. DEMAND'/1H ,12F10.4)     QZE2300
 6030 FORMAT (1H0,5X,'SOIL MOISTURE STORAGE TERM = ',F10.4/1H ,5X,'EXTINQZE2310
     1CTION DEPTH FOR E.T. = ',F10.4)                                   QZE2320
      END
C                                                                       QZE 360
```

```
C     ----------------------------------------------------------------
       SUBROUTINE PUMPNU (UV)
C     ----------------------------------------------------------------
C                                                                       QZE 380
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                               QZE  20
      REAL BUDTTL
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN       QZE  30
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),     QZE  50
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                          QZE  60
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)                         QZE  70
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD              QZE  80
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP           QZE  90
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN QZE 110
      COMMON/WELLS/ QW(200),AREAPP(200),QAPP(1020),REAPP(1020),         QZE 120
     1WW(4,200),PMPDMD(5,12),PMPAPP(5),NEW(200),NTW(200),NAPP(200),     QZE 130
     2NEAPP(30,200),NWELLS,NSEWER,NWTYP                                 QZE 140
      COMMON /WETHER/ PRECIP(12),U(12),SC,DEPTH,SF,ETFAC(8)             QZE 150
      COMMON /MPSCL/ XSCL,YSCL ,XO,YO                                   QZE 160
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                QZE 170
      DIMENSION UV(1),LAT(3),LON(3)                                     QZE 180
C
C     ----------------------------------------------------------------
C     NWELLS - TOTAL NUMBER OF WELLS                                    QZE 390
C       NSEWER - NO. OF WELLS WHOSE OUTFLOW CONTRIBUTES DIRECTLY TO THE QZE 400
C       NWTYP - NO. OF WELL TYPES                                       QZE 410
C       PMPAPP - PERCENT OF PUMPAGE THAT IS APPLIED WATER BY PUMPAGE TYPQZE 420
C       PMPDMD - MONTHLY PUMPAGE DEMAND DISTRIBUTION BY PUMPAGE TYPES   QZE 430
C     ----------------------------------------------------------------
C                                                                       QZE 440
      READ (IN,5000) NWELLS,NSEWER,NWTYP                                QZE 450
      IF (IPRINT.GE.2) WRITE (IO,6040) NWELLS,NSEWER,NWTYP              QZE 460
C
      IF (NWELLS.LT.1) RETURN                                           QZE 470
C                                                                       QZE 480
      IF (IPRINT.GE.2) WRITE (IO,6050)                                  QZE 490
      DO 20 N=1,NWTYP                                                   QZE 500
      READ (IN,5011) (PMPDMD(N,M),M=1,12),PMPAPP(N)                     QZE 510
      IF (IPRINT.GE.2) WRITE (IO,6060) N,PMPAPP(N)                      QZE 520
   20 IF (IPRINT.GE.2) WRITE (IO,6070) (PMPDMD(N,M),M=1,12)             QZE 530
      IF (IPRINT.GE.4) WRITE (IO,6080)                                  QZE 540
```

```
C
C     ----------------------------------------------------------------
C          WELL INPUT DATA
C     XW,YW - WELL X,Y COORDINATES
C     LAT,LON - DEGS,MINS AND SECS OF WELL LAT-LONG COORDINATES
C     NEW - ELEMENT IN WHICH WELL IS LOCATED
C     NTW - TYPE OF WELL
C           NTW = 1  - WELL WATER IS APPLIED OVER A NUMBER OF ELEMENTS
C           NTW = 2  - WELL WATER IS RETURNED DIRECTLY TO RIVER
C     NAPP - ELEMENTS ON WHICH WELL WATER IS APPLIED
C     QW - FLOW RATE FROM THE WELL
C     ----------------------------------------------------------------
C
      DO 70 N=1,NWELLS
      IF (LATLON) GO TO 30
      READ (IN,5030) XW,YW,NEW(N),NTW(N),NAPP(N),QW(N)
C     XW=XW*XSCL
C     YW=YW*YSCL
      GO TO 40
   30 READ (IN,5020) LON,LAT,NEW(N),NTW(N),NAPP(N),QW(N)
      PLONG=LON(1)+(LON(3)/60.+LON(2))/60.
      PLAT=LAT(1)+(LAT(3)/60.+LAT(2))/60.
      CALL LAMBRT (PLONG,PLAT,XW,YW)
   40 XW = XSCL*(XW-XO)
      YW = YSCL*(YW-YO)
      IF (LPLOT) CALL PLTW (XW,YW,N)
      IF (IPRINT.GE.4) WRITE (IO,6000)N,XW,YW,NEW(N),NTW(N),NAPP(N),QW(N
     1)
C
C     SUM UP THE AREA OVER WHICH WELL WATER IS APPLIED
C
      NAPPLY=NAPP(N)
      AR=0.
      IF (NAPPLY.LE.0) GO TO 60
      READ (IN,5000) (NEAPP(NN,N),NN=1,NAPPLY)
      IF (IPRINT.GE.4) WRITE (IO,6090) (NEAPP(NN,N),NN=1,NAPPLY)
      DO 50 L=1,NAPPLY
   50 AR=AR+AREA(NEAPP(L,N))
   60 AREAPP(N)=AR
C
```

```
C     CALCULATE LOCAL WELL COORDINATES WITHIN THE ELEMENT                  QZE 930
C                                                                          QZE 940
      CALL PTFNDR (XW,YW,NEW(N),WW,N,2)                                    QZE 950
   70 CONTINUE                                                             QZE 960
      WRITE(IO,7000)
 7000 FORMAT(1H ,120('-') )
C                                                                          QZE 970
      RETURN                                                               QZE 980
 5000 FORMAT (20I4)                                                        QZE2230
 5011 FORMAT (13F5.0)                                                      QZE2241
 5020 FORMAT (9I4,4X,F10.0)                                                QZE2250
 5030 FORMAT (2F12.0,3I4,4X,F10.0)                                         QZE2260


C


 6000 FORMAT (1H ,5X,I4,2F12.3,2X,I5,2X,I5,2X,I5,2X,F12.4)                QZE2270
 6040 FORMAT (1H1/1H ,30X,'WELL DATA'/1H0,5X,'NUMBER OF WELLS (NWELLS)',QZE2330
     1' = ',I4/1H ,5X,'NUMBER OF SEWERED WELLS (NSEWER) = ',I4/1H ,5X,'NQZE2340
     2UMBER OF WELL TYPES (NWTYP) = ',I2)                                  QZE2350
 6050 FORMAT (1H0,30X,'WELL TYPE PARAMETERS')                              QZE2360
 6060 FORMAT (1H0,10X,'TYPE ',I4/1H ,5X,'% OF PUMPAGE APPLIED =',F6.3)  QZE2370
 6070 FORMAT (1H ,10X,'MONTHLY PUMPAGE DEMAND VALUES'/1H ,5X,12F10.3)   QZE2380
 6080 FORMAT (1H0,30X,'WELL DATA'/1H0,5X,'WELL',3X,'X-COORD.',5X,'Y-COORQZE2390
     1D.',3X,'ELEM.',2X,'TYPE',2X,'# APPLIED',3X,'WITHDRAWL'/)         QZE2400
 6090 FORMAT (1H ,30X,'WATER IS APPLIED ON ELEMENTS',2X,10I5,/
     $ (11X,20I5))
      END
C                                                                          QZE 990
```

```
C     ------------------------------------------------------------
       SUBROUTINE LOADQR (UV)
C     ------------------------------------------------------------
C                                                                        QZE1010
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                                QZE  20
      REAL BUDTTL
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN        QZE  30
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),      QZE  50
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                           QZE  60
      COMMON/WTBLE/ QBAR(572),BOTT(572),HO(572)                          QZE  70
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD               QZE  80
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP            QZE  90
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)MAI 140
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN QZE 110
      COMMON/WELLS/ QW(200),AREAPP(200),QAPP(1020),REAPP(1020),          QZE 120
     1WW(4,200),PMPDMD(5,12),PMPAPP(5),NEW(200),NTW(200),NAPP(200),      QZE 130
     2NEAPP(30,200),NWELLS,NSEWER,NWTYP                                  QZE 140
      COMMON /WETHER/ PRECIP(12),U(12),SC,DEPTH,SF,ETFAC(8)              QZE 150
      COMMON /MPSCL/ XSCL,YSCL ,XO,YO                                    QZE 160
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                 QZE 170
      DIMENSION UV(1),LAT(3),LON(3)                                      QZE 180
C     ZERO THE ELEMENT APPLICATICN AND RECHARGE ARRAYS                   QZE1020
C                                                                        QZE1030
      DO 80 NE=1,NEL                                                     QZE1040
      QAPP(NE)=0.                                                        QZE1050
   80 REAPP(NE)=0.                                                       QZE1060
C                                                                        QZE1070
C     LOAD THE SEWERED PUMPAGE  (RETURN FLOW DIRECTLY TO RIVER)          QZE1080
C                                                                        QZE1090
      ASEWR=0.                                                           QZE1100
      QSEWR=0.                                                           QZE1110
      EXCESS=0.                                                          QZE1120
      IF (NWELLS.LT.1) GO TO 170                                         QZE1130
      IF (NSEWER.LT.1) GO TO 130                                         QZE1140
      DO 100 NS=1,NSEWER                                                 QZE1150
      ASEWR=ASEWR+AREAPP(NS)                                             QZE1160
      Q=PMPDMD(NTW(NS),KMN)*QW(NS)                                       QZE1170
       IF (Q.GT.0.0)   BUD(7) = BUD(7) - Q                               QZE1180
      IF (Q.LT.0.0)   BUD(6) = BUD(6) - Q                                QZE1185
      QSEWR=QSEWR+Q                                                      QZE1190
```

```
      EXCESS=EXCESS+Q-PMPAPP(1)*QW(NS)                                   QZE1200
      NER=NEW(NS)                                                        QZE1210
      DO 90 I=1,NETYP                                                    QZE1220
      NI=NGL(I,NER)                                                      QZE1230
   90 QRE(NI)=QRE(NI)-Q*WW(I,NS)                                         QZE1240
  100 CONTINUE                                                           QZE1250
      SEWAGE=QSEWR                                                       QZE1260
C
      IF (EXCESS.LT.0.) GO TO 130                                        QZE1270
      SEWAGE=SEWAGE-EXCESS                                               QZE1280
C     LOAD THE APPLIED SPRINKLER WATER INTO THE APPLIED ELEMENTS         QZE1290
      BUD(8)=BUD(8)+EXCESS                                               QZE1300
      IF(ASEWR .EQ. 0.) GO TO 106
      QA=EXCESS/ASEWR                                                    QZE1310
106   QA = 0.0
      DO 120 NS=1,NSEWER                                                 QZE1320
      NAPPLY=NAPP(NS)                                                    QZE1330
      IF (NAPPLY.EQ.0) GO TO 120                                         QZE1340
      DO 110 L=1,NAPPLY                                                  QZE1350
      NL=NEAPP(L,NS)                                                     QZE1360
  110 QAPP(NL)=QAPP(NL)+QA                                               QZE1370
  120 CONTINUE                                                           QZE1380
  130 CONTINUE                                                           QZE1390
C     LOAD OTHER PUMPAGE TYPES                                           QZE1400
      NSEWR1=NSEWER+1                                                    QZE1410
      IF (NSEWR1.GE.NWELLS) GO TO 170                                    QZE1420
      DO 160 NS=NSEWR1,NWELLS                                            QZE1430
      Q=PMPDMD(NTW(NS),KMN)*QW(NS)                                       QZE1440
      IF (Q.GT.0.0)   BUD(7) = BUD(7) - Q                                QZE1450
      IF (Q.LT.0.0)   BUD(6) = BUD(6) - Q                                QZE1455
      NER=NEW(NS)                                                        QZE1460
      DO 140 I=1,NETYP                                                   QZE1470
      NI=NGL(I,NER)                                                      QZE1480
  140 QRE(NI)=QRE(NI)-Q*WW(I,NS)                                         QZE1490
C                                                                        QZE1500*
      IF (NAPP(NS).LT.1) GO TO 160                                       QZE1510
```

```
C     LOAD THE APPLIED AND RECHARGED WATER INTO THE ELEMENTS             QZE1520
      QA=Q*PMPAPP(NTW(NS))                                               QZE1530
      QR=Q-QA                                                            QZE1540
      BUD(8)=BUD(8)+QA                                                   QZE1550
      BUD(9)=BUD(9)+QR                                                   QZE1560
      QA=QA/AREAPP(NS)                                                   QZE1570
      QR=QR/AREAPP(NS)                                                   QZE1580
      NAPPLY=NAPP(NS)                                                    QZE1590
      DO 150 L=1,NAPPLY                                                  QZE1600
      NL=NEAPP(L,NS)                                                     QZE1610
      REAPP(NL)=REAPP(NL)+QR                                             QZE1620
  150 QAPP(NL)=QAPP(NL)+QA                                               QZE1630
  160 CONTINUE                                                           QZE1640
C                                                                        QZE1650
C     APPLY RAIN AND CALCULATE ET FOR EACH ELEMENT                       QZE1660
C                                                                        QZE1670
C     ---------------------------------------------------------------
C     RAIN - MONTLY PRECIP VALUE IN FT/SEC                               QZE1680
C     UET - MONTHLY VALUE FOR E.T. DEMAND                                QZE1690
C     ---------------------------------------------------------------
C     CALCULATED E.T.                                                    QZE1700
C                                                                        QZE1710
  170 RDT=1./(IDMON(KMN)*86400.)                                         QZE1720
      RAIN=PRECIP(KMN)*RDT/12.                                           QZE1730
      IF (EVPTRN) UET=U(KMN)*RDT/12.                                     QZE1740
      IF (EVPTRN) ETFACT=SF*(10.**(ETFAC(5)*U(KMN)))*RDT/12.             QZE1750
      DO 220 NE=1,NEL                                                    QZE1760
      APPLY=QAPP(NE)+RAIN                                                QZE1770
      BUD(10)=BUD(10)+RAIN*AREA(NE)                                      QZE1780
      IF (.NOT.EVPTRN) GO TO 200                                         QZE1790
      ET=ETFACT*(ETFAC(6)*(12.*APPLY/RDT)**ETFAC(7)-ETFAC(8))            QZE1800
      IF(ET.LT.0.0) ET=0.0                                               QZE1805
C

      IF (ET.GT.UET) ET=UET                                              QZE1810
      IF (ET.GT.APPLY) ET=APPLY                                          QZE1820
      APPLY=APPLY-ET                                                     QZE1830
      BUD(11)=BUD(11)-ET*AREA(NE)                                        QZE1840
      IF (ET.GE.UET) GO TO 200                                           QZE1850
```

```
C     COMPUTE SURFACE INDUCED ET FOR EACH ELEMENT                      QZE1860
      DET=UET-ET                                                       QZE1870
      AR=-DEPTH                                                        QZE1880
      DEPSAT=0.0                                                       QZE1890
      DO 180 I=1,NETYP                                                 QZE1900
      NI=NGL(I,NE)                                                     QZE1910
  180 DEPSAT=DEPSAT+DMAX1((H(NI)-ALSD(NI)),AR)                         QZE1920
      DEPSAT=DEPSAT/(1.*NETYP)                                         QZE1930
      IF (DEPTH+DEPSAT) 200,200,190                                    QZE1940
  190 ADET=DET*(DEPTH+DEPSAT)/DEPTH                                    QZE1950
      IF (ADET.GT.DET) ADET=DET                                        QZE1960
      APPLY=APPLY-ADET                                                 QZE1970
      BUD(12)=BUD(12)-ADET*AREA(NE)                                    QZE1980
C     LOAD THE ELEMENT RECHARGE INTO THE NODAL RECHARGE ARRAY          QZE1990
  200 QR=(APPLY+REAPP(NE))*AREA(NE)/(1.*NETYP)                         QZE2000
      DO 210 I=1,NETYP                                                 QZE2010
      NI=NGL(I,NE)                                                     QZE2020
  210 QRE(NI)=QRE(NI)+QR                                               QZE2030
  220 CONTINUE                                                         QZE2040
      IF (STEADY) RETURN                                               QZE2050
      BUD5=0.0                                                         QZE2060
      DO 230 I=1,NIJ                                                   QZE2070
C                                                                      QZE2080
C     CALCULATE TIME DERIVATIVE BASED ON PAST HEAD VALUES              QZE2090
C          AND UPDATE THE PAST HEADS                                   QZE2100
C                                                                      QZE2110
      STOR=UV(I)*(4.*H(I)-HP(I))                                       QZE2120
C                                                                      QZE2130
C     CORRECT TIME DERIVATIVE TERM FOR WATER-TABLE                     QZE2140
C                                                                      QZE2150
      IF (WTABLE) STOR=STOR-UV(I)*3.0*HO(I)                            QZE2160
      HP(I)=H(I)                                                       QZE2170
      BUD5=BUD5+STOR                                                   QZE2180
  230 QRE(I)=QRE(I)+STOR                                               QZE2190
      BUD(5)=BUD5                                                      QZE2200
      RETURN                                                           QZE2210
      END                                                              QZE2420-
```

```
C     ----------------------------------------------------------------
      SUBROUTINE OUTPUT (IPR)                                             OUT  10
C     ----------------------------------------------------------------
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                                 OUT  20
       REAL XSCLP,YSCLP
      LOGICAL STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN         OUT  30
      COMMON/AQUIFR/ H(572),HP(572),QRE(572),QZ(572),T(572),S(572),       OUT  50
     1ALSD(572),X(572),Y(572),AREA(1020),SAREA                            OUT  60
      COMMON/RIVERB/ HPOOL(2),STAGE(20,2),DSCHRG(20,2),QCOMR(118),        OUT  70
     1ELVR(118),XFACTR(118),RW(4,118),RIVERH(118),                        OUT  80
     2RIVERQ(118),FLOWIN(366,7),QCOR(5),SEWAGE,NODEIN(7),NSTAGE(2),       QRV 120*
     3NRN(118),NER(118),NRTYP(118),NREACH,NRNODE,NTRIB,QRR(64)
      COMMON /SIZE/ IS,JT,NIJ,NEL,NBW,IDIAG,NGL(4,1020),NETYP             OUT 110
      COMMON /LOGIC/STEADY,WTABLE,QUAD,LATLON,LRIVER,DRAWD,LPLOT,EVPTRN OUT 120
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                                  OUT 130
      COMMON /PLT/ XSCLP,YSCLP,IPLOT                                      MAI  200
      COMMON/HEAD2/ HI(572),OLDH(572)                                     OUT 140
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT,NN
C
      WRITE (IO,6020)                                                     OUT 150
      WRITE(IO,6035)
      DO 10 I=1,IS                                                        OUT 160
      K=(I-1)*JT                                                          OUT 170
      IKK = K + 1
      WRITE(IO,6000) I,IKK,(H(K+J),J=1,JT)
   10 CONTINUE                                                            OUT 190
      IF (.NOT.DRAWD) GO TO 40                                            OUT 200
      WRITE (IO,6030)                                                     OUT 210
      WRITE(IO,6035)
      DO 30 I=1,IS                                                        OUT 220
      K=(I-1)*JT                                                          OUT 230
      DO 20 J=1,JT                                                        OUT 240
   20 HI(K+J)=OLDH(K+J)-H(K+J)                                            OUT 250
      IKK = K + 1
   25  WRITE(IO,6000) I,IKK,(HI(K+J),J=1,JT)
   30 CONTINUE                                                            OUT 270
   40 CONTINUE                                                            OUT 280
```

```
      IF (LRIVER) WRITE (IO,6040)                                      OUT 290
      IF (LRIVER) WRITE (IO,6010) (N,RIVERH(N),ELVR(N),RIVERQ(N),N=1,  OUT 300
     1NRNODE)                                                          OUT 310
C     IF(LPLOT.AND.IPLT2.EQ.9) CALL GPCP(H,NIJ,' HEAD ','VALUES')       OUT 320
C     IF(LPLOT.AND.IPLT2.EQ.10) CALL VPLOT                              OUT 330
      RETURN                                                           OUT 340
 6000 FORMAT(1H ,2X,I4,2X,I4,2X,(10F10.2))
 6010 FORMAT (5X,I4,3F10.2)                                            OUT 360
 6020 FORMAT (1HO,30X,'HEAD VALUES'/)                                  OUT 370
 6030 FORMAT (1HO,30X,'DRAWDOWNS FROM INITIAL HEAD VALUES'/)           OUT 380
 6035  FORMAT(1H ,2X,' ROW',2X,'NODE')
 6040 FORMAT (1HO,30X,'RIVER-STAGE AND DISCHARGE VALUES'/,1H ,5X,'NODE',OUT 390
     13X,'STAGE',4X,'BOTTOM ELV',4X,'DISCHARGE'/)                      OUT 400
6111  FORMAT(5F8.2)
      END                                                              OUT 410-
C     ---------------------------------------------------------------
      BLOCK DATA                                                       BLK  10
C     ---------------------------------------------------------------
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)                              BLK  20
      REAL BUDTTL,TITLE1,TITLE2,XSCLP,YSCLP
      COMMON/BNDRY/BQH(572),QB(572),PBH(12),PBF(12),BB(9,50),IBNODE(572)BLK  22
      COMMON /BUDGET/ BUDTTL(5,20),BUD(20),BUDTOT(20),NBUD             BLK  30
      COMMON /IOUNIT/ IN,IO,IPRINT,NPRNT                               BLK  40
      COMMON /MPSCL/ XSCL,YSCL ,XO,YO                                  BLK  50
      COMMON /PLT/ XSCLP,YSCLP,IPLOT                                   BLK  60
      COMMON /TIME/FMON(12),IDMON(12),KYR,KMN,KDY,IDAY,KDYS,IDYR,MON(12)BLK  70
      COMMON/TIME2/ DELT,BETA,EPS,NSTEP,MAXIT                          BLK  80
      COMMON /WETHER/ PRECIP(12),U(12),SC,DEPTH,SF,ETFAC(8)            BLK  90
       DIMENSION TITLE1(5,12),TITLE2(5,6)
      EQUIVALENCE (BUDTTL(1,1),TITLE1(1,1)),(BUDTTL(1,13),TITLE2(1,1))
      DATA IN/15/,IO/16/
      DATA XSCLP/1.0/,YSCLP/1.C/,IPLOT/0/                              BLK 110
      DATA XSCL/1.0/,YSCL/1.0/,XO/1.E30/,YO/1.E30/                     BLK 120
      DATA U/12*0.0/,SC/0.0/,DEPTH/0.0/                                BLK 130
      DATA BETA/1.0/,EPS/0.0/,MAXIT/1/                                 BLK 140
      DATA NBUD/12/                                                    BLK 150
      DATA ETFAC/0.531747,0.295164,0.003804,0.057697,                  BLK 160
     1   0.02426,0.70917,0.82416,0.11556/                              BLK 170
      DATA BB/450*0.0/                                                 BLK 171
      DATA TITLE1/240H  SPEC. HEAD INFLOW   SPEC. HEAD OUTFLOW  SPEC. BDBLK 180
     1RY INFLOW   SPEC. BDRY OUTFLOW  STORAGE CHANGE      PUMP INJECTN WBLK 190
     2ELLS  PUMP DISCHRG WELLS   APPLIED WATER      DIRECT RECHARGE    BLK 200
```

```
C
      3PRECIPITATION       EVAPOTRNSPIRATION   GROUND-WATER E.T. /      BLK 205
       DATA TITLE2/120H   1ST REACH LOSS      2ND REACH LOSS      3RD REABLK 210
      1CH LOSS      4TH REACH LOSS      5TH REACH LOSS      6TH REACH LOSBLK 220
      2S   /                                                            BLK 230
       DATA BUD/20*0./,BUDTOT/20*0./                                    BLK 270
       DATA FMON/12*0.0/
       DATA IDMON/ 31,28,31,30,31,30,31,31,30,31,30,31/                 BLK 280
       DATA MON/'JAN','FEB','MAR','APR','MAY','JUN',                    BLK 290
      1   'JUL','AUG','SEP','OCT','NOV','DEC' /                         BLK 300
       END                                                              BLK 310-
```

Model Input for Example Problem

```
EXAMPLE SETUP PROBLEM: ONE RIVER,ONE INJECTION WELL,ONE PUMPING WELL,
         ET AND PRECIPITATION OPTION, AND CONFINED AQUIFER
   F     F     F     F     T     T     T     T
   6   1
1983  01  01   1   5
  20       1.0      .0001
         1.00       1.00
   6    4000.0    4000.0
  20  20
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   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                                                                           0
   0                                                                           0
   0                                                                           0
   0                                                                           0
   0                                                                           0
   0                                                                           0
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
      HEAD     0     ( 9F6.0)      200.0       1
      HP       0     ( 9F6.0)      200.0       1
      STOR     0     ( 9F6.0)      1.000E-2    1
      TRAN     0     ( 9F6.0)    1.15740E-1    1
      ALSD     0     ( 9F6.0)      200.0       1
       BQH    15     (20F4.0)        1.00      1
 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200
 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01
   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0
   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0
       0.0        0.0        0.0    19000.0
    1000.0        0.0     1000.0    19000.0
```

```
00060:    2000.0        0.0    2000.0   19000.0
00061:    3000.0        0.0    3000.0   19000.0
00062:    4000.0        0.0    4000.0   19000.0
00063:    5000.0        0.0    5000.0   19000.0
00064:    6000.0        0.0    6000.0   19000.0
00065:    7000.0        0.0    7000.0   19000.0
00066:    8000.0        0.0    8000.0   19000.0
00067:    9000.0        0.0    9000.0   19000.0
00068:   10000.0        0.0   10000.0   19000.0
00069:   11000.0        0.0   11000.0   19000.0
00070:   12000.0        0.0   12000.0   19000.0
00071:   13000.0        0.0   13000.0   19000.0
00072:   14000.0        0.0   14000.0   19000.0
00073:   15000.0        0.0   15000.0   19000.0
00074:   16000.0        0.0   16000.0   19000.0
00075:   17000.0        0.0   17000.0   19000.0
00076:   18000.0        0.0   18000.0   19000.0
00077:   19000.0        0.0   19000.0   19000.0
00078:   1  18    1    1
00079:1.736E-6
00080:   3
00081:   0.0    1.0   2.0
00082:   0.0    1.0  100.
00083:       9999.        1001.   1    1 345   0   1000.00     40.00     199.00   0.
00084:       9999.        2001.   1    1 347   0   1000.00     40.00     199.00   0.
00085:       9999.        3001.   1    1 349   0   1000.00     40.00     199.00   0.
00086:       9999.        4001.   1    1 351   0   1000.00     40.00     199.00   0.
00087:       9999.        5001.   1    1 353   0   1000.00     40.00     199.00   0.
00088:       9999.        6001.   1    1 355   0   1000.00     40.00     199.00   0.
00089:       9999.        7001.   1    1 357   0   1000.00     40.00     199.00   0.
00090:       9999.        8001.   1    1 359   0   1000.00     40.00     199.00   0.
00091:       9999.        9001.   1    1 361   0   1000.00     40.00     199.00   0.
00092:       9999.       10001.   1    1 363   0   1000.00     40.00     199.00   0.
00093:       9999.       11001.   1    1 365   0   1000.00     40.00     199.00   0.
00094:       9999.       12001.   1    1 367   0   1000.00     40.00     199.00   0.
00095:       9999.       13001.   1    1 369   0   1000.00     40.00     199.00   0.
00096:       9999.       14001.   1    1 371   0   1000.00     40.00     199.00   0.
00097:       9999.       15001.   1    1 373   0   1000.00     40.00     199.00   0.
00098:       9999.       16001.   1    1 375   0   1000.00     40.00     199.00   0.
00099:       9999.       17001.   1    1 377   0   1000.00     40.00     199.00   0.
00100:       9999.       18001.   1    1 379   0    999.00     40.00     199.00   0.
00101:   1
00102:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00103:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00104:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00105:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00106:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00107:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00108:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00109:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00110:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00111:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00112:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00113:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00114:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00115:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00116:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00117:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00118:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00119:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
```

```
00120:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00121:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00122:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00123:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00124:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00125:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00126:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00127:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00128:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00129:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00130:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00131:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00132:      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0      50.0
00133:   .43  1.88   .81  1.88  3.43  1.24   .53  1.35  2.89  1.49   .20  0.00
00134:   .49   .63  1.10  2.25  3.49  5.30  7.15  6.74  4.24  3.01  1.16   .61
00135:  6.0  10.0
00136:   2   0   2
00137:   1    1    1    1    1    1    1    1    1    1    1    1 1.0
00138:   1    1    1    1    1    1    1    1    1    1    1    1 1.0
00139:     3999.0       8001.0 131   1   0     -1.0000
00140:    11999.0       8001.0 435   2   0      1.5474
```

Model Output for Example Problem

(partial listing)

```
1
 ---------------------------------------------------------------------------------------------------------
0                             EXAMPLE SETUP PROBLEM: ONE RIVER,ONE INJECTION WELL,ONE PUMPING WELL,
                                   ET AND PRECIPITATION OPTION,-AND CONFINED AQUIFER
0*********************************************************************************************************
                                         MODEL RUN DATE:    WED, OCT 26 1983
                                         MODEL RUN TIME:    13:32:37
**********************************************************************************************************

 ---------------------------------------------------------------------------------------------------------
0                                  LOGICAL CONTROL VARIABLES
      STEADY   WTABLE     QUAD   LATLON   LRIVER    DRAWD    LPLOT   EVPTRN
         F        F         F        F        T        T        T        T
0     THE PRINTOUT CONTROL PARAMETER (IPRINT) =     6
      NUMBER OF TIME STEPS BETWEEN EXTENDED PRINTOUTS (NPRNT) =     1
0     THE STARTING DATE FOR THE SIMULATION IS : JAN  1, 1983
      NUMBER OF DAYS PER TIME STEP (IDAY) =  1
      NUMBER OF TIME STEPS TO BE TAKEN (NSTEP) =     5
0                                  ITERATION PARAMETERS FOR STREAMFLOW SOLUTION ROUTINE
      MAXIMUM NUMBER OF ITERATIONS (MAXIT) =  20
      CONVERGENCE ACCELERATION PARAMETER (BETA) =   1.00000
      CONVERGENCE CRITERION (EPS) = 0.000100
0     SCALING FACTOR FOR X - COORDINATES (XSCL) =        1.000
      SCALING FACTOR FOR Y - COORDINATES (YSCL) =        1.000
0     PLOT CONTROL PARAMETER (IPLOT) =  6
      PLOT SCALING FACTOR IN X DIRECTION (XSCLP) =    4000.000
      PLOT SCALING FACTOR IN Y DIRECTION (YSCLP) =    4000.000
0     NUMBER OF NODES IN ROW =   20
      NUMBER OF NODES IN COLUMN =   20
0     NUMBER OF NODES (NIJ) =   400
      NUMBER OF ELEMENTS (NEL) =   722
      HALF BANDWIDTH (NBW) =  22

1                                  BOUNDARY-CONDITION TYPE MAP
                                        0 - INTERIOR NODE
                                        1 - SPECIFIED-FLUX BOUNDARY NODE
                                        2 - SPECIFIED-HEAD BOUNDARY NODE

     ROW  NODE
      1     1       2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
      2    21       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
      3    41       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0


     18   341       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
     19   361       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
     20   381       1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1

1                                  INPUT DATA FOR ARRAY   HEAD
0     HEAD WAS NOT READ, ENTIRE MATRIX SET EQUAL TO     2.000E+02
1                                  INPUT DATA FOR ARRAY   HP
0     HP   WAS NOT READ, ENTIRE MATRIX SET EQUAL TO     2.000E+02
1                                  INPUT DATA FOR ARRAY   STOR
0     STOR WAS NOT READ, ENTIRE MATRIX SET EQUAL TO     1.000E-02
1                                  INPUT DATA FOR ARRAY   TRAN
0     TRAN WAS NOT READ, ENTIRE MATRIX SET EQUAL TO     1.157E-01
1                                  INPUT DATA FOR ARRAY   ALSD
0     ALSD WAS NOT READ, ENTIRE MATRIX SET EQUAL TO     2.000E+02
1                                  INPUT DATA FOR ARRAY   BQH
```

```
1

0     BQH WAS READ FROM UNIT 15,ON FORMAT    (20F4.0) , AND SCALED BY     1.000E+00

    ROW  NODE
     1     1   2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02
 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02 2.000E+02
     2    21   0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01
 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01


    19   361   0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01
 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01 0.000E-01
    20   381   1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02
 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02 1.000E-02

0                            MONTHLY MULTIPLIERS OF SPECIFIED HEAD VALUES
         1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00

0                            MONTHLY MULTIPLIERS OF SPECIFIED FLUX VALUES
         1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00

1         THE X AND Y OFFSETS FOR THE GRID ORIGIN ARE          0.0000          0.0000

0                            NODAL X - Y COORDINATES

         1       0.0000       0.0000
         2       0.0000    1000.0000
         3       0.0000    2000.0000
         4       0.0000    3000.0000


       397   19000.0000   16000.0000
       398   19000.0000   17000.0000
       399   19000.0000   18000.0000
       400   19000.0000   19000.0000

1                            GLOBAL INDICES AND ELEMENT AREAS

         1    1   21    2    500000.0000
         2    2   21   22    500000.0000
         3    2   22    3    500000.0000
         4    3   22   23    500000.0000


       719  378  398  379    500000.0000
       720  379  398  399    500000.0000
       721  379  399  380    500000.0000
       722  380  399  400    500000.0000
0         TOTAL MODEL AREA =      3.61000E+08
1
                             RIVER PARAMETERS
0    NUMBER OF RIVER REACHES =    1
     NUMBER OF RIVER NODES =    18
     NUMBER OF RIVER-LEAKANCE ZONES =    1

0                            RIVER-LEAKANCE VALUES BY ZONE (QCOR(N))
     ZONE  1    1.73600E-06

0                            RIVER-REACH PARAMETERS
          REACH NUMBER  1
        3 POINTS USED IN STAGE - DISCHARGE RELATIONSHIP
```

```
          POOL ELEVATION =        0.000
            STAGE        0.000    1.000     2.000
          DISCHARGE      0.000    1.000   100.000

0                             RIVER-NODE DATA

0         NODE     X-COORD     Y-COORD    REACH  ZONE  ELEM.  TYPE     LENGTH      WIDTH     ELEVATION     XFACTOR
            1     9999.000    1001.000     1      1     345     0      1000.000    40.000    199.000     0.000
            2     9999.000    2001.000     1      1     347     0      1000.000    40.000    199.000     0.000
            3     9999.000    3001.000     1      1     349     0      1000.000    40.000    199.000     0.000


           16     9999.000   16001.000     1      1     375     0      1000.000    40.000    199.000     0.000
           17     9999.000   17001.000     1      1     377     0      1000.000    40.000    199.000     0.000
           18     9999.000   18001.000     1      1     379     0       999.000    40.000    199.000     0.000

0         RIVER-NODE LOCATION OF TRIBUTARIES      1

0                             DAILY INFLOW VALUES (FLOWIN(N))     1

          50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00
          50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00


          50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00     50.00
          50.00     50.00     50.00     50.00     50.00     50.00
1
                              PRECIPITATION AND EVAPOTRANSPIRATION DATA

0              MONTHLY PRECIPITATTION VALUES
            0.430   1.880   0.810   1.880   3.430   1.240   0.530   1.350   2.890   1.490   0.200   0.000

0              MONTHLY VALUES FOR E.T. DEMAND
         0.4900    0.6300    1.1000    2.2500    3.4900    5.3000    7.1500    6.7400    4.2400    3.0100    1.1600    0.6100

0         SOIL MOISTURE STORAGE TERM =      6.0000
          EXTINCTION DEPTH FOR E.T. =     10.0000
1
                              WELL DATA
0         NUMBER OF WELLS (NWELLS) =     2
          NUMBER OF SEWERED WELLS (NSEWER) =     0
          NUMBER OF WELL TYPES (NWTYP) =  2

0                             WELL TYPE PARAMETERS
0              TYPE     1
          % OF PUMPAGE APPLIED = 1.000
               MONTHLY PUMPAGE DEMAND VALUES
               1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000

0              TYPE     2
          % OF PUMPAGE APPLIED = 1.000
               MONTHLY PUMPAGE DEMAND VALUES
               1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000     1.000

0                             WELL DATA
0         WELL    X-COORD.      Y-COORD.    ELEM.   TYPE   # APPLIED    WITHDRAWL

             1     3999.000     8001.000     131      1       0        -1.0000
             2    11999.000     8001.000     435      2       0         1.5474
        ---------------------------------------------------------------------------------------------------------------------
```

1

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0 TIME STEP NUMBER 5

TIME STEP BEGINNING JAN 5, 1983

HMAX = -0.245137
HMAX = -0.000079

NODE=	1	SPEC	HEAD	IN-OUT	0.00187
NODE=	2	SPEC	HEAD	IN-OUT	0.00375
NODE=	3	SPEC	HEAD	IN-OUT	0.00302
NODE=	4	SPEC	HEAD	IN-OUT	0.00144
NODE=	5	SPEC	HEAD	IN-OUT	-0.00164
NODE=	6	SPEC	HEAD	IN-OUT	-0.00704
NODE=	7	SPEC	HEAD	IN-OUT	-0.01519
NODE=	8	SPEC	HEAD	IN-OUT	-0.02471
NODE=	9	SPEC	HEAD	IN-OUT	-0.03035
NODE=	10	SPEC	HEAD	IN-OUT	-0.02473
NODE=	11	SPEC	HEAD	IN-OUT	-0.01521
NODE=	12	SPEC	HEAD	IN-OUT	-0.00705
NODE=	13	SPEC	HEAD	IN-OUT	-0.00164
NODE=	14	SPEC	HEAD	IN-OUT	0.00145
NODE=	15	SPEC	HEAD	IN-OUT	0.00305
NODE=	16	SPEC	HEAD	IN-OUT	0.00382
NODE=	17	SPEC	HEAD	IN-OUT	0.00417
NODE=	18	SPEC	HEAD	IN-OUT	0.00431
NODE=	19	SPEC	HEAD	IN-OUT	0.00435
NODE=	20	SPEC	HEAD	IN-OUT	0.00229

0 RIVER-NODE FLUXES

1	0.02524	33	0.00000
2	0.02482	34	0.00000
3	0.02620	35	0.00000
4	0.02990	36	0.00000
5	0.03732	37	0.00000
6	0.05011	38	0.00000
7	0.06797	39	0.00000
8	0.08227	40	0.00000
9	0.06789	41	0.00000
10	0.04996	42	0.00000
11	0.03709	43	0.00000
12	0.02955	44	0.00000
13	0.02562	45	0.00000
14	0.02374	46	0.00000
15	0.02295	47	0.00000
16	0.02278	48	0.00000
17	0.02309	49	0.00000
18	0.02420	50	0.00000
19	0.00000	51	0.00000

BUDGET BALANCE

	FT**3/S	FT**3
SPEC. HEAD INFLOW	0.0335	1.3646E+04

```
1

     SPEC. HEAD OUTFLOW      -0.1276  -2.4455E+04
     SPEC. BDRY INFLOW        0.2000   8.6400E+04
     SPEC. BDRY OUTFLOW       0.0000   0.0000E-01
     STORAGE CHANGE           0.4144   1.8902E+05
     PUMP INJECTN WELLS       1.0000   4.3200E+05
     PUMP DISCHRG WELLS      -1.5474  -6.6843E+05
      APPLIED WATER           0.0000   0.0000E-01
     DIRECT RECHARGE          0.0000   0.0000E-01
     PRECIPITATION            4.8297   2.0864E+06
     EVAPOTRNSPIRATION       -2.8793  -1.2439E+06
     GROUND-WATER E.T.       -2.5940  -1.1271E+06
      1ST REACH LOSS          0.6707   2.5646E+05
                             --------  ----------
   MASS RESIDUAL          -5.4130E-05 -8.9200E+00

0                      HEAD VALUES
 ROW  NODE
  1     1     200.00    200.00    200.00    200.00    200.00    200.00    200.00    200.00    200.00      200.00
 200.00   200.00    200.00    200.00    200.00    200.00    200.00    200.00    200.00    200.00
  2    21     199.97    199.98    199.98    200.00    200.02    200.07    200.14    200.22    200.27      200.22
 200.14   200.07    200.02    200.00    199.98    199.98    199.97    199.97    199.97    199.97
  3    41     199.96    199.96    199.98    200.00    200.06    200.16    200.33    200.55    200.71      200.55
 200.33   200.16    200.06    200.00    199.97    199.96    199.96    199.95    199.95    199.95
  4    61     199.95    199.96    199.98    200.01    200.10    200.26    200.56    201.04    201.60      201.04
 200.56   200.26    200.10    200.01    199.97    199.96    199.95    199.94    199.94    199.94
  5    81     199.95    199.96    199.98    200.02    200.12    200.32    200.73    201.60    203.72      201.60
 200.73   200.32    200.12    200.02    199.98    199.96    199.95    199.94    199.94    199.94
  6   101     199.95    199.96    199.98    200.02    200.10    200.26    200.56    201.04    201.59      201.04
 200.56   200.26    200.10    200.02    199.98    199.96    199.95    199.95    199.94    199.94
  7   121     199.96    199.97    199.98    200.01    200.06    200.16    200.33    200.55    200.71      200.55
 200.33   200.16    200.06    200.01    199.98    199.97    199.96    199.96    199.95    199.95
  8   141     199.98    199.98    199.99    200.00    200.03    200.08    200.14    200.22    200.27      200.22
 200.14   200.08    200.03    200.01    199.99    199.99    199.98    199.98    199.97    199.97
  9   161     200.01    200.01    200.01    200.02    200.02    200.01    200.01    200.00    200.00      200.00
 200.01   200.01    200.02    200.02    200.02    200.02    200.02    200.01    200.01    200.00
 10   181     200.05    200.06    200.06    200.05    200.03    199.98    199.89    199.79    199.73      199.79
 199.89   199.98    200.03    200.06    200.07    200.08    200.08    200.07    200.06    200.05
 11   201     200.08    200.13    200.14    200.12    200.06    199.96    199.77    199.51    199.31      199.51
 199.77   199.96    200.06    200.12    200.15    200.16    200.16    200.16    200.14    200.09
 12   221     200.04    200.04    200.03    199.99    199.88    199.66    199.23    198.52    197.68      198.52
 199.23   199.66    199.88    199.99    200.04    200.07    200.07    200.07    200.06    200.05
 13   241     199.99    199.99    199.97    199.90    199.77    199.47    198.86    197.53    194.25      197.52
 198.85   199.47    199.77    199.91    199.97    200.00    200.01    200.01    200.01    200.01
 14   261     199.96    199.95    199.93    199.87    199.75    199.50    199.05    198.31    197.45      198.30
 199.04   199.50    199.75    199.88    199.94    199.96    199.97    199.98    199.98    199.98
 15   281     199.95    199.94    199.92    199.88    199.79    199.62    199.36    199.01    198.76      199.01
 199.36   199.62    199.79    199.88    199.93    199.95    199.96    199.96    199.96    199.96
 16   301     199.95    199.95    199.93    199.90    199.85    199.75    199.62    199.47    199.38      199.47
 199.62   199.75    199.85    199.90    199.94    199.95    199.96    199.96    199.96    199.97
 17   321     199.98    199.97    199.96    199.94    199.91    199.86    199.79    199.73    199.70      199.73
 199.79   199.86    199.91    199.94    199.96    199.97    199.97    199.98    199.98    199.98
 18   341     200.01    200.01    200.00    199.99    199.97    199.94    199.91    199.89    199.87      199.89
 199.91   199.94    199.97    199.99    200.00    200.00    200.01    200.01    200.02    200.02
 19   361     200.09    200.07    200.06    200.05    200.04    200.02    200.01    200.00    199.99      200.00
 200.01   200.02    200.04    200.05    200.05    200.06    200.06    200.07    200.08    200.09
 20   381     200.20    200.16    200.14    200.13    200.12    200.11    200.10    200.09    200.08      200.09
 200.09   200.11    200.11    200.12    200.13    200.13    200.14    200.15    200.17    200.21

0                      DRAWDOWNS FROM INITIAL HEAD VALUES
 ROW  NODE
```

1

1	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	21	0.03	0.02	0.02	0.00	-0.02	-0.07	-0.14	-0.22	-0.27	-0.22	-0.14	-0.07	-0.02	0.00	0.02	0.02	0.03	0.03	0.03	0.03
3	41	0.04	0.04	0.02	-0.00	-0.06	-0.16	-0.33	-0.55	-0.71	-0.55	-0.33	-0.16	-0.06	-0.00	0.03	0.04	0.04	0.05	0.05	0.05
4	61	0.05	0.04	0.02	-0.01	-0.10	-0.26	-0.56	-1.04	-1.60	-1.04	-0.56	-0.26	-0.10	-0.01	0.03	0.04	0.05	0.06	0.06	0.06
5	81	0.05	0.04	0.02	-0.02	-0.12	-0.32	-0.73	-1.60	-3.72	-1.60	-0.73	-0.32	-0.12	-0.02	0.02	0.04	0.05	0.06	0.06	0.06
6	101	0.05	0.04	0.02	-0.02	-0.10	-0.26	-0.56	-1.04	-1.59	-1.04	-0.56	-0.26	-0.10	-0.02	0.02	0.04	0.05	0.05	0.06	0.06
7	121	0.04	0.03	0.02	-0.01	-0.06	-0.16	-0.33	-0.55	-0.71	-0.55	-0.33	-0.16	-0.06	-0.01	0.02	0.03	0.04	0.04	0.05	0.05
8	141	0.02	0.02	0.01	-0.00	-0.03	-0.08	-0.14	-0.22	-0.27	-0.22	-0.14	-0.08	-0.03	-0.01	0.01	0.01	0.02	0.02	0.03	0.03
9	161	-0.01	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00
10	181	-0.05	-0.06	-0.06	-0.05	-0.03	0.02	0.11	0.21	0.27	0.21	0.11	0.02	-0.03	-0.06	-0.07	-0.08	-0.08	-0.07	-0.06	-0.05
11	201	-0.08	-0.13	-0.14	-0.12	-0.06	0.04	0.23	0.49	0.69	0.49	0.23	0.04	-0.06	-0.12	-0.15	-0.16	-0.16	-0.16	-0.14	-0.09
12	221	-0.04	-0.04	-0.03	0.01	0.12	0.34	0.77	1.48	2.32	1.48	0.77	0.34	0.12	0.01	-0.04	-0.07	-0.07	-0.07	-0.06	-0.05
13	241	0.01	0.01	0.03	0.10	0.23	0.53	1.14	2.47	5.75	2.48	1.15	0.53	0.23	0.09	0.03	-0.00	-0.01	-0.01	-0.01	-0.01
14	261	0.04	0.05	0.07	0.13	0.25	0.50	0.95	1.69	2.55	1.70	0.96	0.50	0.25	0.12	0.06	0.04	0.03	0.02	0.02	0.02
15	281	0.05	0.06	0.08	0.12	0.21	0.38	0.64	0.99	1.24	0.99	0.64	0.38	0.21	0.12	0.07	0.05	0.04	0.04	0.04	0.04
16	301	0.05	0.05	0.07	0.10	0.15	0.25	0.38	0.53	0.62	0.53	0.38	0.25	0.15	0.10	0.06	0.05	0.04	0.04	0.04	0.03
17	321	0.02	0.03	0.04	0.06	0.09	0.14	0.21	0.27	0.30	0.27	0.21	0.14	0.09	0.06	0.04	0.03	0.03	0.02	0.02	0.02
18	341	-0.01	-0.01	-0.00	0.01	0.03	0.06	0.09	0.11	0.13	0.11	0.09	0.06	0.03	0.01	0.00	-0.00	-0.01	-0.01	-0.02	-0.02
19	361	-0.09	-0.07	-0.06	-0.05	-0.04	-0.02	-0.01	0.00	0.01	0.00	-0.01	-0.02	-0.04	-0.05	-0.05	-0.06	-0.06	-0.07	-0.08	-0.09
20	381	-0.20	-0.16	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09	-0.08	-0.09	-0.09	-0.11	-0.11	-0.12	-0.13	-0.13	-0.14	-0.15	-0.17	-0.21

0

RIVER-STAGE AND DISCHARGE VALUES

NODE	STAGE	BOTTOM ELV	DISCHARGE
1	200.49	199.00	50.00
2	200.49	199.00	49.97
3	200.49	199.00	49.95
4	200.49	199.00	49.92
5	200.49	199.00	49.89
6	200.49	199.00	49.86
7	200.49	199.00	49.81
8	200.49	199.00	49.74
9	200.49	199.00	49.66
10	200.49	199.00	49.59
11	200.49	199.00	49.54
12	200.49	199.00	49.50
13	200.49	199.00	49.47
14	200.49	199.00	49.45
15	200.49	199.00	49.42
16	200.49	199.00	49.40
17	200.49	199.00	49.38
18	200.49	199.00	49.35