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Data management program for groundwater and surface water models

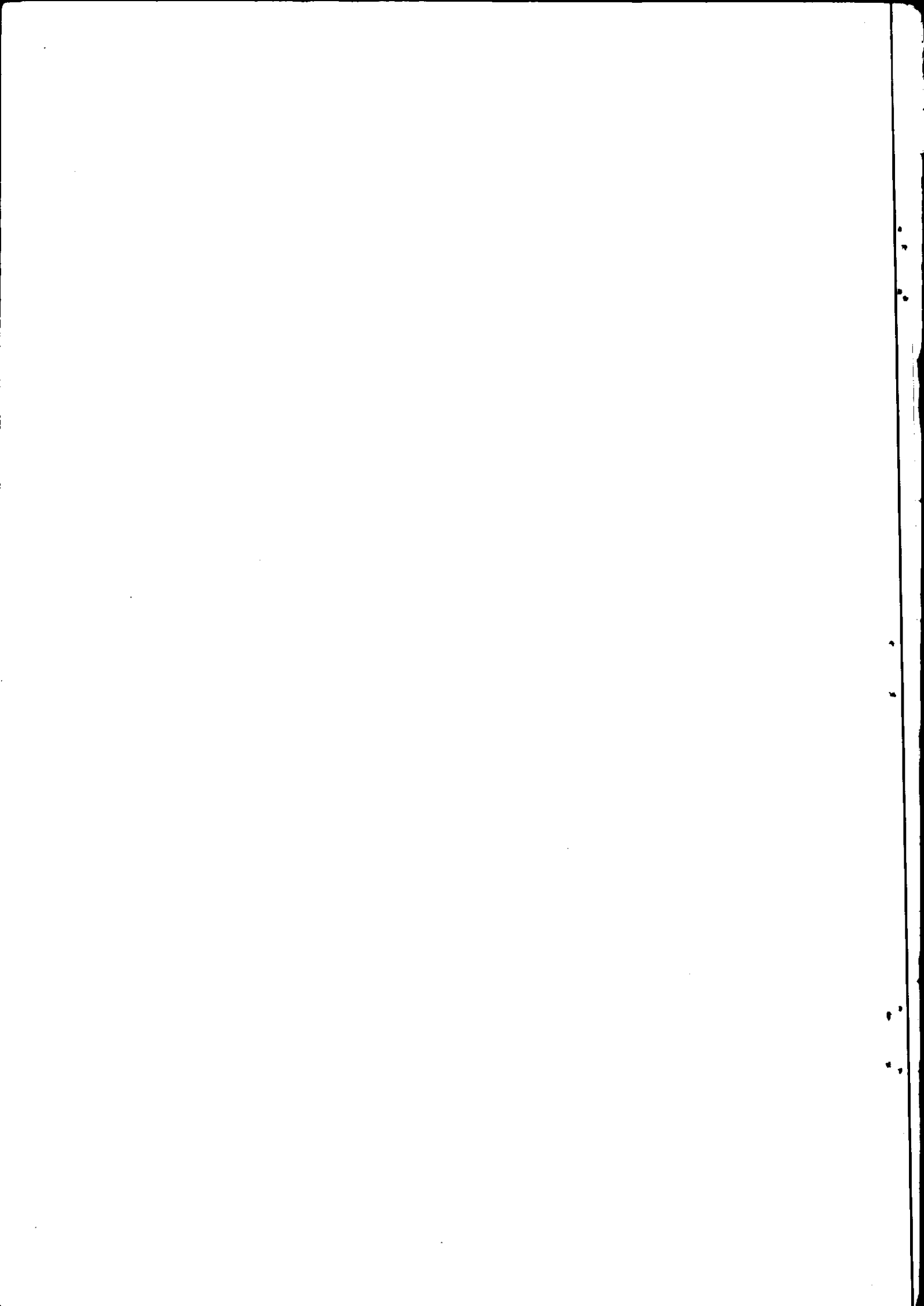
E.P. Querner

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Table of Contents

	page
1. INTRODUCTION	1
2. NETWORK GENERATION AND INPUT OF DATA FOR GROUNDWATER MODELS	2
2.1. Network generation and geo-hydrological data	2
2.2. Compilation of basic input data	6
2.3. Contact points	7
3. UNSATURATED ZONE	8
3.1. Meteorological data	8
3.2. Crop evapotranspiration factors	9
3.3. Soil physical properties	12
4. SURFACE WATER SYSTEM	13
5. GRAPHICAL PRESENTATION OF RESULTS	14
6. EXAMPLE	17
6.1. Network generation and basic input of data	17
6.2. File with contact points	29
6.3. Rainfall and evapotranspiration	31
6.4. Crop evapotranspiration factors	34
6.5. Command file for calculation characteristics unsaturated zone	36
6.6. Equilibrium moisture content	41
6.7. Calculation with program CAPSEV	45
6.8. Characteristics surface water system	52
6.9. Graphical presentation of results	56

1. INTRODUCTION

The program FEMSIN contains various data management routines. These routines are support software for data collection and for presentation of results.

It enables you to generate a simple network for the groundwater flow models of either triangular or rectangular elements. All relevant data can be given interactively.

For the unsteady groundwater flow model SIMGRO or SIMPRO various data is required to simulate the flow of water in the unsaturated zone. The calculation of these characteristics is simplified by generating command procedures and output in the form as required by the groundwater models.

For the surface water system one requires information of the storage capacity and a stage-discharge relation. From the density of the ditches per subregion and information on channel sizes, this information is calculated.

One can select information from output files of the models and make a plot file. The necessary graphical software packages are SIMPLOT and DI3000.

Nov 1988

2. NETWORK GENERATION AND INPUT OF DATA FOR GROUNDWATER MODELS

With this part of the program FEMSIN one can generate a finite element network and compile the input data for running the steady state groundwater flow model FEMSATS or the unsteady groundwater flow model SIMGRO. One can either do the network generation or the compilation of input data or both. Keep in mind that the information output from one module is not automatically used in the other module when doing the network generation and compilation of input data in two separate steps (see also table 1). In paragraph 2.1 and 2.2 a detailed description of the network generation and basic input of data is given. An example is given in paragraph 6.1.

Table 1 - Data obtained with network generation and compilation of basic input data

Network	***.DAT	- nodes per subregion flux per node on boundary
	***.NDE	- node numbers and coordinates geo-hydrological data per node and layer elemental configuration
Input data	***.DAT	- other input data
	***.NDE	- for channel system data per node

*** - FEMSATS or SIMGRO

2.1. Network generation and geo-hydrological input

Type of network

The program can generate triangular or rectangular elements as shown in figure 1. The nodes and elements are numbered as shown. From the number of rows and columns and the spacing, the network can be constructed. Spatially the network is fixed by specifying the coordinates of the first nodal point (see figure 1).

Input per subregion

The input of certain information for the nodes must be given as input data per subregion. The definition of subregions is only necessary if certain parameters vary within the region to be modelled. This is often the case.

For the model SIMGRO the unsaturated zone is considered on a

subregional level. For these situations various subregions characterized by soil physical properties, hydrological conditions and the surface water characteristics must be distinguished.

Rectangular subregions or polygons

The schematisation of the region in subregions is performed by given coordinates of the boundaries of each subregions. The nodes within a subregions can then be determined. Ordinary rectangular subregions can be used by specifying two sets of coordinates as shown in figure 2. Complex shaped subregions can be distinguished by a polygon as shown in figure 3. By specifying a number of bounds the extend of a subregion is fixed. For instance condition 1 means that all nodes left of the x-value given are inside the subregion. All nodes on the boundary will be placed in one subregion. This procedure is necessary for the model SIMGRO. The last subregion contains the nodes on the boundary.

Table 2 - Conditions for definition of subregions, where the index n stands for node and i for input coordinate value (LE - less or equal; GE - greater or equal; LT - less; GT - greater)

1	-	Xn	.LE.	Xi				
2	-	Yn	.LE.	Yi				
3	-	Xn	.GE.	Xi				
4	-	Yn	.GE.	Yi				
5	-	Xn	.LT.	Xi	and	Yn	.LT.	Yi
6	-	Xn	.LT.	Xi	and	Yn	.GT.	Yi
7	-	Xn	.GT.	Xi	and	Yn	.GT.	Yi
8	-	Xn	.GT.	Xi	and	Yn	.LT.	Yi
9	-	Xn	.GT.	Xi1	and	Xn	.LT.	Xi2 and
		Yn	.GT.	Yi1	and	Yn	.LT.	Yi2

Type of layer

From each layer the type is required, which can be either an aquifer or aquitard. The first layer may be either of the two, but two the same layers after each other is not possible. The last layer must be always an aquifer (see figure 4).

Flux on boundary

For all nodes on the boundary and only for the aquifers, a head or a flux must be specified. Per layer and for the four sides of the network a flux must be given. One takes the average or most frequent occurring flux at this stage. Subsequent in the data file one can change the values for specific nodes. If a head must be specified, then the records containing the fluxes on the boundary must be removed from the file FEMSATS.DAT or SIMGRO.DAT.

Nov 1988

Geo-hydrological data

Per subregion and per layer certain information is required. For an aquifer one must give a transmissivity (kD), layer thickness (D) and specific storage (S). For an aquitard one must give a vertical resistance (C), layer thickness and specific storage. The specific storage is not required for the first layer and for steady state calculations (FEMSATS).

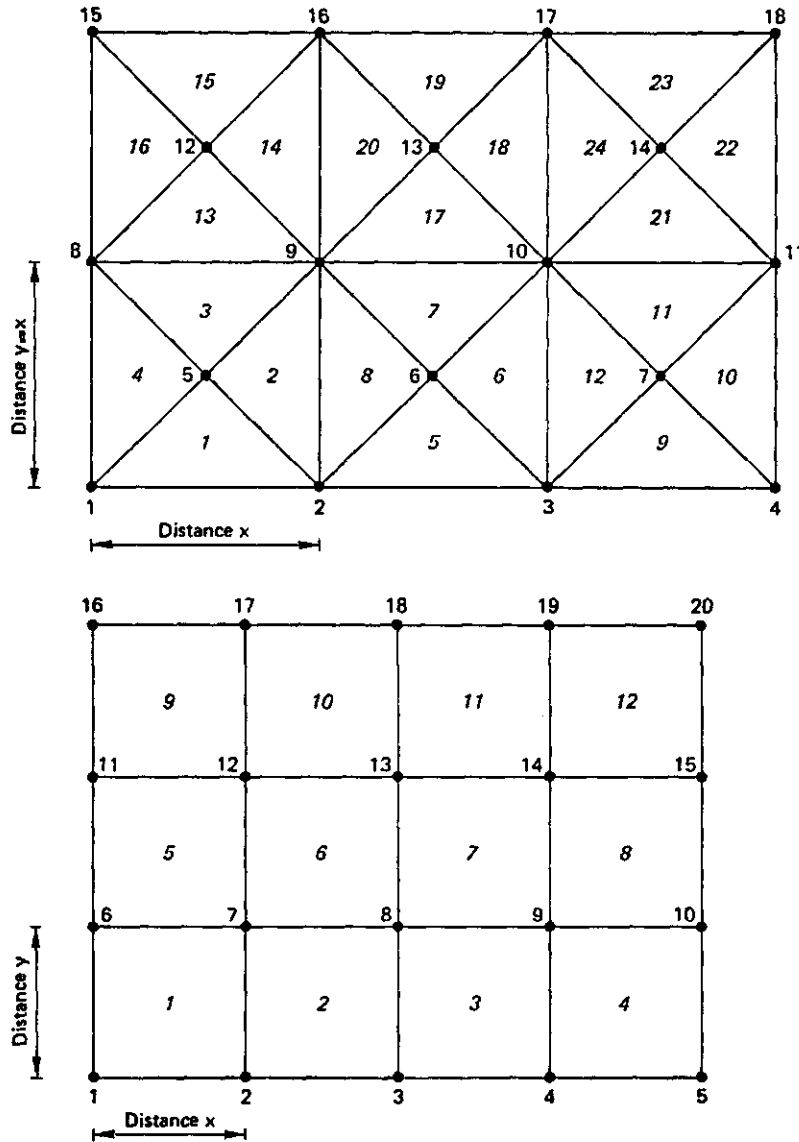


Figure 1 - Example of triangular (a) and rectangular elements (b) generated by network generator

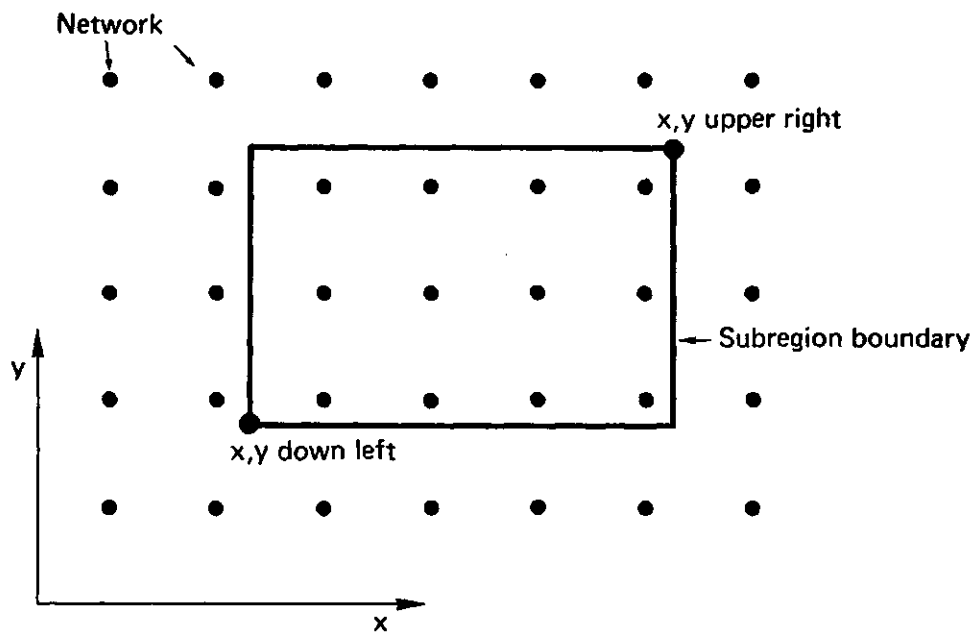


Figure 2 - Example of how to define rectangular subregions

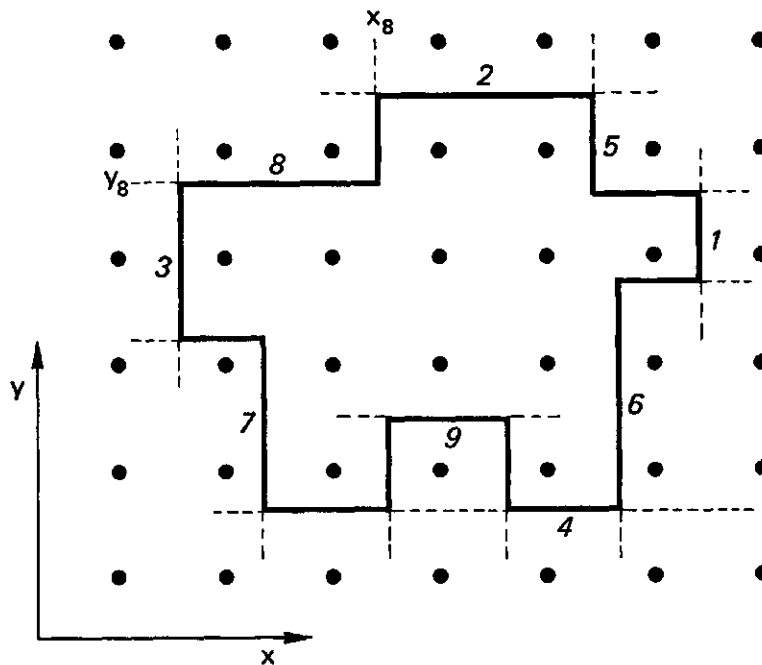


Figure 3 - Method how to define irregular subregion by means of polygons

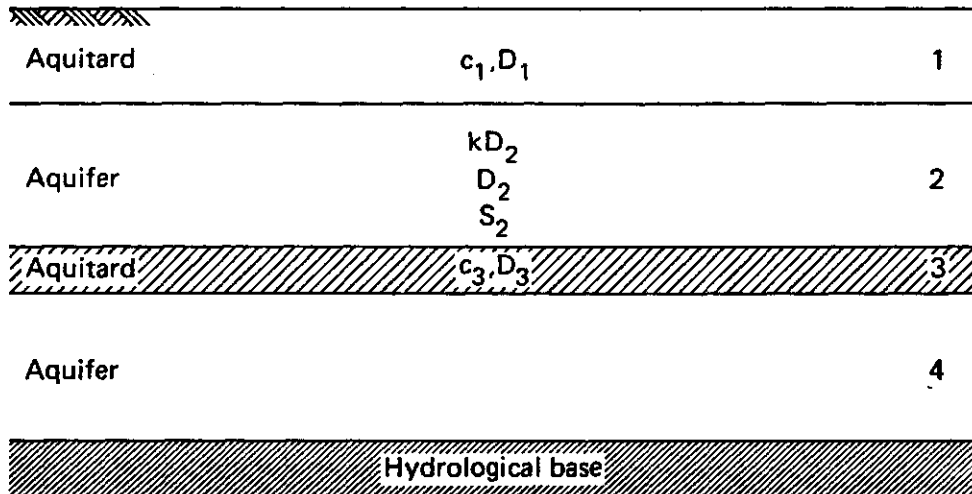


Figure 4 - Typical schematization of groundwater system. The top layer may be an aquifer as well.

2.2. Compilation of basic input data

All information as given in the user manual must be given here. Except the information already given in the previous paragraph. It is advised to take the manual as well in order to read more information concerning certain input data (read the remarks given by each record carefully).

FEMSATS

SIMGRO

The characteristics of the unsaturated zone must be calculated with the program CAPSEV. The way this can be done is described in paragraph 3.3. A file with the data must be available or otherwise use the data given in file STANDARD.DAT.

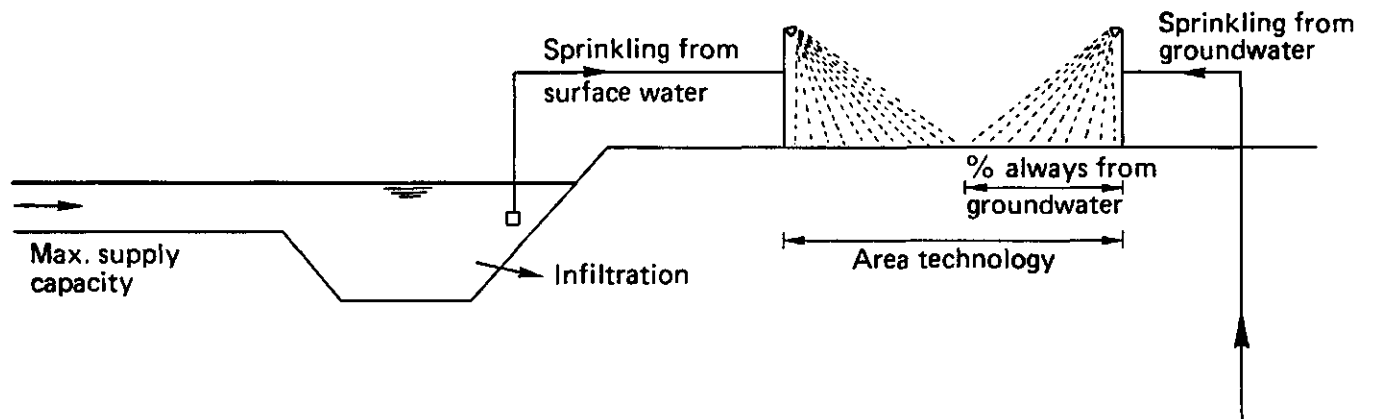


Figure 5 - Definition of sprinkling from groundwater and or surface water

2.3. Contact points

The contact points are the adjacent nodes j of node i . The contact points can be derived from the node numbers per element. With the aid of the program FEMSIN this information can be collected. The file with geo-hydrological data (***.NDE file) is required. Information not relevant for the compilation of contact points is skipped in this file. See paragraph 6.2 for an example.

Nov 1988

3. UNSATURATED ZONE

Meteorological data is required to calculate evapotranspiration. From the specific data the potential evapotranspiration for grassland and forest is calculated (see paragraph 3.1). For fallow tilled soil in winter a factor is calculated to derive at the evaporation from the evapotranspiration rate for grassland.

Necessary for the model SIMGRO and SIMPRO are crop evapotranspiration factors. The potential evapotranspiration of a certain crop is related to the evapotranspiration of grass, which is part of the input. The way to obtain this data is given in paragraph 3.2.

3.1. Meteorological data

The file with meteorological data must contain per day the precipitation, temperature, relative humidity and radiation flux (incoming global radiation and if available nett radiation). From this data the potential evapotranspiration rates for grass and forest are calculated. The potential evapotranspiration for grass is calculated with the Makkink equation. For pine and deciduous forest the MUST-concept has been taken as the sum of transpiration and interception. For the interception of pine forest a reservoir of 1.5 mm in winter and 2.0 mm in summer has been taken, for deciduous forest 0.5 mm in winter and 1.5 mm in summer (WORKING GROUP EVAPORATION, 1984). The surface resistance R_c is a function of solar radiation (STEWART and DE BRUIN, 1985). The solar radiation required for this relation are daily values and therefore the short wave radiation (24 hour value) is multiplied with a factor three to use the relation. The evapotranspiration for a deciduous forest is the sum of evapotranspiration from fallow soil and the trees. The percentage soil cover is 20 % in winter and 100 % in summer (june-august).

The evaporation factor for fallow tilled soil in winter is calculated as well in this part of the program. The calculation method for fallow soil is described in paragraph 3.2. An example of the necessary steps to obtain the input file is shown in paragraph 6.3.

Input data for FEMSIN

Day	Mth	Yr	Prec [mm]	Temp [oC]	Rhum [-]	Rsrad [W/m2]	Rnrad [W/m2]
22	6	1975	5.0	17.8	0.82	136.	77.
23	6	1975	32.7	20.7	0.82	232.	139.
24	6	1975	1.0	18.4	0.82	229.	135.
25	6	1975	0.0	13.7	0.72	159.	90.
26	6	1975	0.0	15.4	0.73	331.	169.
27	6	1975	0.0	13.6	0.68	112.	66.
28	6	1975	0.4	12.2	0.71	134.	74.
29	6	1975	4.1	12.7	0.80	226.	125.
30	6	1975	0.0	13.9	0.74	308.	161.
1	7	1975	0.0	14.4	0.75	318.	167.
2	7	1975	0.0	16.8	0.72	271.	144.

Results for file SIMGRO.EVP

Day	Year	Rainfall [mm]	ETp gras [mm]	ETp pine [mm]	ETp deci [mm]	evap. fac. bare soil
173	1975	5.00	2.05	3.56	3.18	1.00
174	1975	32.70	3.68	4.38	4.06	1.00
175	1975	1.00	3.49	3.54	3.60	1.00
176	1975	0.00	2.20	2.44	2.47	0.84
177	1975	0.00	4.75	2.86	2.93	0.38
178	1975	0.00	1.55	2.20	2.22	0.31
179	1975	0.40	1.79	2.39	2.42	0.45
180	1975	4.10	3.05	3.84	3.49	1.00
181	1975	0.00	4.28	2.80	2.86	0.30
182	1975	0.00	4.47	2.85	2.92	0.25
183	1975	0.00	4.00	2.75	2.80	0.23

Note : The column headings must be deleted before using the file.
The format for the data is : 1X,I4,1X,I4,5F10.0

3.2. Crop evapotranspiration factors

For the calculation of potential evapotranspiration for each technology the models use the value for grassland as a reference. From the potential rate for grassland the rates for other crops are derived by multiplication with crop dependable factors. For the summer period these figures are given by FEDDES (1987). Therefore the potential evapotranspiration for a technology j is:

$$E_p^j = f_j^c E_{grass}$$

The factors for the summer period must be placed in file `***.FAC` with format : `5X,6F5.0`. Per timestep TRDP (see factor-record) one value (record) must be given. With a timestep for rainfall and evapotranspiration of one day there must be at least 183 records for the summer period (depending on timestep and calculation times the summer period can be a bit more and has a maximum length of : $183 + \text{timestep} - 1$). As an example the most frequent used technologies and conversion factors are shown in Table 3 and 4. A file `CROPF.FAC` contains the data shown in Table 4, this information is read by `FEMSIN`. One must select six crops or technologies. The evapotranspiration factors will be placed in the file for use by the program `SIMGRO` or `SIMPRO`. If the crop factor is `-0.01`, then the model uses the factor for fallow soil from the `***.EVP` file.

For fallow soil the method as described by Boesten and Stroosnijder is considered. They suggested a simple parametric model to estimate daily evaporation from fallow tilled soil. Cumulative actual evaporation is proportionally to the square root of cumulative potential evaporation. Therefore:

$$\begin{aligned} \sum E_p < \beta^2 & \quad - \quad \sum E - \sum E_p \\ \sum E_p > \beta^2 & \quad - \quad \sum E - \beta \sqrt{\sum E_p} \\ \beta & = 1.6 - 2.0 \quad (\text{FEMSIN } \beta = 2.0) \end{aligned}$$

The way to use this module is shown in paragraph 6.4.

Table 3 - Crops and technologies with available crop evapotranspiration factors

1	grassland	gras
2	cereals	granen
3	maize	mais
4	potatoes	aardappelen
5	sugarbeets	suikerbieten
6	pulse	peulvruchten
7	unions (planting)	plantui
8	unions (sowing)	zaaiui
9	chicory	witlof
10	bulbous/tuberous plant	bol/knolgewassen
11	fruit trees	pit/steenvruchten (volgroeid)
12	large scale horticulture	akkerbouwmatigetuinbouw
13	small scale horticulture	vollegrondstuinbouw
14	arable farming	akkerbouw (algemeen)

Table 4 - Evapotranspiration factors per decade

	decade	1	2	3	4	5	6	7	8	9	10
april	9	1.0	0.7					0.5			
	10	1.0	0.8				0.5	0.7	0.4		
	11	1.0	0.9				0.7	0.7	0.5		
mai	12	1.0	1.0	0.5		0.5	0.8	0.8	0.5		
	13	1.0	1.0	0.7	0.7	0.5	0.9	0.8	0.7		0.5
june	14	1.0	1.0	0.8	0.9	0.5	1.0	0.9	0.7		0.7
	15	1.0	1.2	0.9	1.0	0.8	1.2	1.0	0.8	0.5	0.7
	16	1.0	1.2	1.0	1.2	1.0	1.2	1.0	0.8	0.5	0.9
july	17	1.0	1.2	1.2	1.2	1.0	1.2	1.0	0.9	0.5	1.2
	18	1.0	1.0	1.3	1.2	1.2	1.0	1.0	1.0	0.8	1.2
	19	1.0	0.9	1.3	1.1	1.1	0.8	1.0	1.0	1.0	1.2
aug	20	1.0	0.8	1.2	1.1	1.1		1.0	1.0	1.1	1.2
	21	1.0	0.6	1.2	1.1	1.1		1.0	1.0	1.1	1.2
	22	1.0		1.2	1.1	1.2			1.0	1.1	1.2
sept	23	0.9		1.2	1.1	1.2			0.9	1.1	1.2
	24	0.9		1.2	0.7	1.2			0.7	1.1	1.2
	25	0.9		1.2		1.1				1.1	1.2
	26	0.9		1.2		1.1				1.1	1.2

	decade	11	12	13	14
april	9	1.0			
	10	1.0	0.5		0.5
mai	11	1.0	0.7	0.7	0.6
	12	1.4	0.8	0.8	0.7
	13	1.4	0.9	0.9	0.8
june	14	1.4	1.0	1.0	0.9
	15	1.6	1.2	1.0	1.0
	16	1.6	1.2	1.2	1.0
july	17	1.6	1.2	1.2	1.1
	18	1.7	1.0	1.2	1.1
	19	1.7	0.9	1.1	1.2
aug	20	1.7	0.8	1.1	1.1
	21	1.3	0.7	1.1	1.0
	22	1.3		1.0	1.0
sept	23	1.2		0.9	0.9
	24	1.2		0.7	
	25	1.2			
	26	1.2			

Nov 1988

3.3. Soil physical properties

For each soil physical unit the equilibrium moisture content, capillary rise and storage coefficient must be calculated. The equilibrium moisture content is calculated from "h-teta" curves with the program FEMSIN. The groundwater models require information per soil physical unit and for three root zone depths. A command procedure is generated with FEMSIN to reduce the efforts to compile all this information and the calculated results are tabulated in a form as required by the models. The capillary rise and storage coefficient can be calculated with the program CAPSEV (WESSELING, BLOEMEN and KROONEN, 1984). Here as well a command procedure is firstly generated with FEMSIN and subsequent this file is executed. In paragraph 6.5 - 6.7 the calculation of the three parameters is shown.

4. SURFACE WATER SYSTEM

From the surface water system the information required is the density of the ditches and their sizes. One has to characterize the ditches in a number of classes. Per class the density per unit of hectare and the depth, bottom width and side slope must be given. From this information the stage-storage relation is calculated.

An imaginary weir at the outlet on the boundary is situated. It only serves as an outlet for the drainage water from that particular subregion. The discharge is calculated for a particular level. With the weir width given, the stage-discharge rate is calculated. Also considered is the flow resistance within the subregion.

The information calculated in this module is also saved in the file OPENW.DAT. An example of the necessary steps is shown in paragraph 6.8.

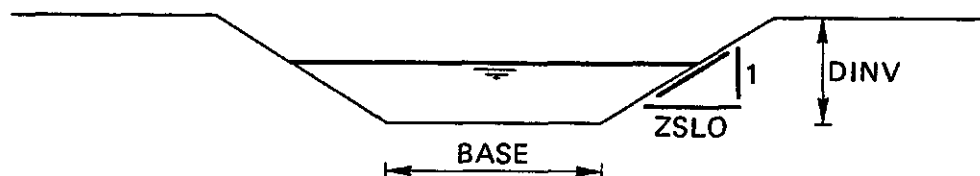


Figure 6 - Typical cross-section of ditch per class. A number of classes represent the surface water system

Nov 1988

5. GRAPHICAL PRESENTATION OF RESULTS

In the groundwater and surface water models results can be written to files. Subsequent certain parameters can be selected and plotted or made visible on a graphical display unit. The data management is done in FEMSIN and the graphical output is done by special graphics programmes.

Time-hydraulic head graphs

Program FEMSIN has an option with which you can select results from certain nodes or subregions from file `***.PRS` and plot these. One can as well merge these results with measured data. One graph is obtained with calculated results and measured data. In this way one can easily verify the model results. The way these routines work is shown in paragraph 6.9.

Isolines

A program PLOT2D is available to produce isolines with the package DI3000. For plotting results we have to use a routine from the program FEMSIN to select the coordinates from one file and add the results from another file. This program allows you to enter specific options used in order to produce the graph in a certain way. The results from the example are shown in figure 7 and 8.

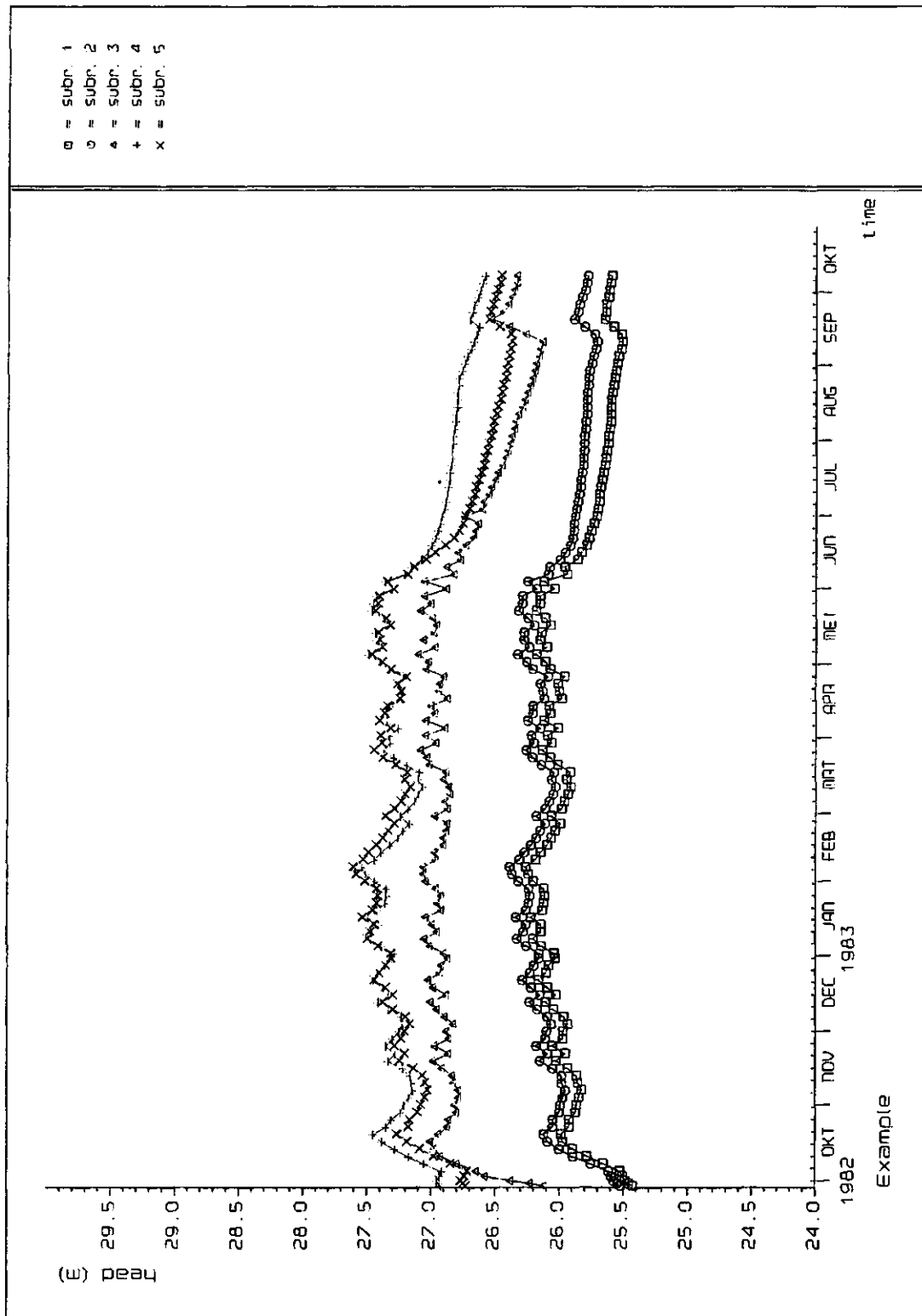


Figure 7 - Time-hydraulic head graph

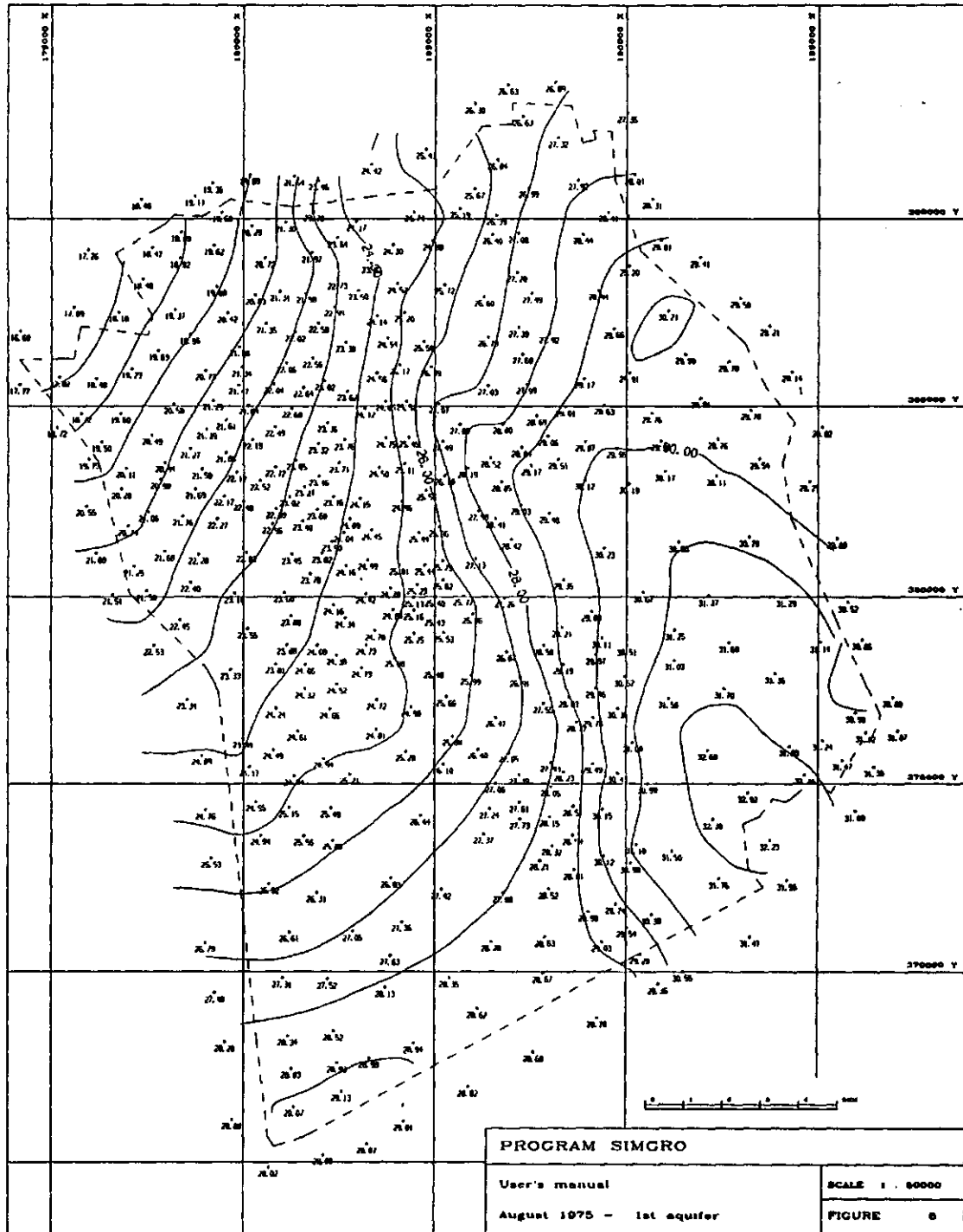


Figure 8 - Isoline

6. EXAMPLE

6.1. Network generation and basic input of data

\$ RUN FEMSIN

```

          PROGRAM  F E M S I N
    *****  DATA MANAGEMENT PROGRAM  *****
    
```

WHICH MODULE ?

- 0 = end of program FEMSIN
- 1 = compile file with contact points
- 2 = data management for time-head graphs
- 3 = data management for plotting isolines
- 4 = network generator and set up basic data files
- 5 = calculation of parameters unsaturated zone
- 6 = calculate absolute deviation

MODULE ----- ? 4

DATA COMPILATION FOR PROGRAM FEMSATS AND SIMGRO

WHICH MODULE ?

- 0 = end of module data compilation
- 1 = generate network and compile data
- 2 = compile evapotranspiration factors (SIMGRO.FAC)
- 3 = data for surface water system (SIMGRO)
- 4 =

MODULE ----- ? 1

```

Module to generate finite element network
and to compile data deck
    *****
    
```

Which subprogram

- 1 - Network generation
- 2 - Network generation and compile data deck
- 3 - Compile data deck

Give number ----- ? 2

Network and/or data deck for groundwater model
 (FEMSATS = 1 , SIMGRO = 2) ----- ? 2

Type of network (tri. = 1 , rect. = 2) ----- ? 2

Nov 1988

```
Number of columns ----- ? 10
Number of rows ----- ? 10
Distance between nodes of rectangle ( m )
    X-direction ----- ? 1000
    Y-direction ----- ? 1000
Give node number to begin with ----- ? 1
Give element number to begin with ----- ? 101
Give coordinates for node 1 ( m )
    X-direction ----- ? 180000.
    Y-direction ----- ? 368000.
Number of layers for groundwater system ----- ? 2
Input per subregion = 1, not = 2 ----- ? 1
Rectangular subr. (-1) or polygons (-2) ----- ? 2
Give number of subregions (incl on boundary) --- ? 6

Subregion : 1
conditions - true then inside region
1 - ( node .LE. X ) value ----- ? 183500
2 - ( node .LE. Y ) value ----- ? 380000
3 - ( node .GE. X ) value ----- ? 179000
4 - ( node .GE. Y ) value ----- ? 373500

Conditions - true then inside region , code :
0 - end of input conditions
5 - ( node .LT. X AND .LT. Y )
6 - ( node .LT. X AND .GT. Y )
7 - ( node .GT. X AND .GT. Y )
8 - ( node .GT. X AND .LT. Y )
9 - ( node .GT. X1 AND .LT. X1 AND
    node .GT. Y2 AND .LT. Y2 )

code ----- ? 6
values ( X and Y ) ----- ? 181500,374500

Conditions - true then inside region , code :
0 - end of input conditions
5 - ( node .LT. X AND .LT. Y )
6 - ( node .LT. X AND .GT. Y )
7 - ( node .GT. X AND .GT. Y )
8 - ( node .GT. X AND .LT. Y )
9 - ( node .GT. X1 AND .LT. X1 AND
    node .GT. Y2 AND .LT. Y2 )

code ----- ? 0
```

Most frequent groundlevel (above MSL) ----- ? 26.80

Subregion : 2

conditions - true then inside region
 1 - (node .LE. X) value ----- ? 187500
 2 - (node .LE. Y) value ----- ? 380000
 3 - (node .GE. X) value ----- ? 183500
 4 - (node .GE. Y) value ----- ? 374500

Conditions - true then inside region , code :

0 - end of input conditions
 5 - (node .LT. X AND .LT. Y)
 6 - (node .LT. X AND .GT. Y)
 7 - (node .GT. X AND .GT. Y)
 8 - (node .GT. X AND .LT. Y)
 9 - (node .GT. X1 AND .LT. X1 AND
 node .GT. Y2 AND .LT. Y2)
 code ----- ? 5
 values (X and Y) ----- ? 186500,375500

Conditions - true then inside region , code :

0 - end of input conditions
 5 - (node .LT. X AND .LT. Y)
 6 - (node .LT. X AND .GT. Y)
 7 - (node .GT. X AND .GT. Y)
 8 - (node .GT. X AND .LT. Y)
 9 - (node .GT. X1 AND .LT. X1 AND
 node .GT. Y2 AND .LT. Y2)

code ----- ? 0

Most frequent groundlevel (above MSL) ----- ? 26.90

Subregion : 3

conditions - true then inside region
 1 - (node .LE. X) value ----- ? 187500
 2 - (node .LE. Y) value ----- ? 374500
 3 - (node .GE. X) value ----- ? 182500
 4 - (node .GE. Y) value ----- ? 370500

Conditions - true then inside region , code :

0 - end of input conditions
 5 - (node .LT. X AND .LT. Y)
 6 - (node .LT. X AND .GT. Y)
 7 - (node .GT. X AND .GT. Y)
 8 - (node .GT. X AND .LT. Y)
 9 - (node .GT. X1 AND .LT. X1 AND
 node .GT. Y2 AND .LT. Y2)

code ----- ? 6
 values (X and Y) ----- ? 186500,372500

Conditions - true then inside region , code :

0 - end of input conditions

Nov 1988

5 - (node .LT. X AND .LT. Y)
6 - (node .LT. X AND .GT. Y)
7 - (node .GT. X AND .GT. Y)
8 - (node .GT. X AND .LT. Y)
9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ----- ? 6
values (X and Y) ----- ? 185500,371500

Conditions - true then inside region , code :

0 - end of input conditions
5 - (node .LT. X AND .LT. Y)
6 - (node .LT. X AND .GT. Y)
7 - (node .GT. X AND .GT. Y)
8 - (node .GT. X AND .LT. Y)
9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ----- ? 7
values (X and Y) ----- ? 183500,371500

Conditions - true then inside region , code :

0 - end of input conditions
5 - (node .LT. X AND .LT. Y)
6 - (node .LT. X AND .GT. Y)
7 - (node .GT. X AND .GT. Y)
8 - (node .GT. X AND .LT. Y)
9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ----- ? 8
values (X and Y) ----- ? 183500,372500

Conditions - true then inside region , code :

0 - end of input conditions
5 - (node .LT. X AND .LT. Y)
6 - (node .LT. X AND .GT. Y)
7 - (node .GT. X AND .GT. Y)
8 - (node .GT. X AND .LT. Y)
9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ----- ? 0

Most frequent groundlevel (above MSL) ----- ? 27.40

Subregion : 4

conditions - true then inside region

1 - (node .LE. X) value ----- ? 190000
2 - (node .LE. Y) value ----- ? 380000
3 - (node .GE. X) value ----- ? 186500
4 - (node .GE. Y) value ----- ? 371500

Conditions - true then inside region , code :

- 0 - end of input conditions
- 5 - (node .LT. X AND .LT. Y)
- 6 - (node .LT. X AND .GT. Y)
- 7 - (node .GT. X AND .GT. Y)
- 8 - (node .GT. X AND .LT. Y)
- 9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ? 7
values (X and Y) ? 187500,375500

Conditions - true then inside region , code :

- 0 - end of input conditions
- 5 - (node .LT. X AND .LT. Y)
- 6 - (node .LT. X AND .GT. Y)
- 7 - (node .GT. X AND .GT. Y)
- 8 - (node .GT. X AND .LT. Y)
- 9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ? 0

Most frequent groundlevel (above MSL) ? 28.30

Subregion : 5

conditions - true then inside region

- 1 - (node .LE. X) value ? 190000
- 2 - (node .LE. Y) value ? 380000
- 3 - (node .GE. X) value ? 170000
- 4 - (node .GE. Y) value ? 360000

Conditions - true then inside region , code :

- 0 - end of input conditions
- 5 - (node .LT. X AND .LT. Y)
- 6 - (node .LT. X AND .GT. Y)
- 7 - (node .GT. X AND .GT. Y)
- 8 - (node .GT. X AND .LT. Y)
- 9 - (node .GT. X1 AND .LT. X1 AND
node .GT. Y2 AND .LT. Y2)

code ? 0

Most frequent groundlevel (above MSL) ? 28.10

GEO-HYDROLOGICAL DATA

Layer no : 1 give type

(aquifer = 1, C-layer = 2) ? 2

Layer no : 2 give type

(aquifer = 1, C-layer = 2) ? 1

Nov 1988

FLUX ON BOUNDARY

For layer : 2 give flux per node (in = pos)
for right, upper, left and lower boundary ----- ? 0, -80, 30, -20

Input for subregion 1

Layer no : 1

Give vertical resistance (d) ----- ? 100

Give thickness of layer (m) ----- ? 25

Layer no : 2

Give KD value (m²/d) ----- ? 3500

Give thickness of layer (m) ----- ? 45

Give the specific storage ----- ? .0006

Input for subregion 2

Layer no : 1

Give vertical resistance (d) ----- ? 100

Give thickness of layer (m) ----- ? 25

Layer no : 2

Give KD value (m²/d) ----- ? 3500

Give thickness of layer (m) ----- ? 45

Give the specific storage ----- ? .0006

Input for subregion 3

Layer no : 1

Give vertical resistance (d) ----- ? 5000

Give thickness of layer (m) ----- ? 25

Layer no : 2

Give KD value (m²/d) ----- ? 3500

Give thickness of layer (m) ----- ? 45

Give the specific storage ----- ? .0006

Input for subregion 4

Layer no : 1

Give vertical resistance (d) ----- ? 1000

Give thickness of layer (m) ----- ? 25

Layer no : 2

Give KD value (m²/d) ----- ? 3500

Give thickness of layer (m) ----- ? 45

Give the specific storage ----- ? .0006

Input for subregion 5

Layer no : 1

Give vertical resistance (d) ----- ? 500

Give thickness of layer (m) ----- ? 25

Layer no : 2

Give KD value (m²/d) ----- ? 3500

Give thickness of layer (m) ----- ? 45

Give the specific storage ----- ? .0006

Input for subregion 6

Layer no : 1

Give vertical resistance (d) ----- ? 200

Give thickness of layer (m) ----- ? 25

Layer no : 2

Give KD value (m²/d) ----- ? 3500

Give thickness of layer (m) ----- ? 45

Give the specific storage ----- ? .0006

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Complete data deck - use manual as well

Give heading-records (max 70 char)

rec 1 - Cursus planvorming in het waterbeheer

rec 2 - Simulaties met het model SIMGRO - ICW

Number-record

Number of technologies	----- ?	6
Number of agricultural technologies	----- ?	4
Pointer index for urban area	----- ?	0
Pointer index for pine forest	----- ?	5
Pointer index for deciduous forest	----- ?	0

Criteria-record

Day number to start calculations	----- ?	271
Year to start	----- ?	1981
Day number to stop calculations	----- ?	280
Year to stop	----- ?	1982
Time interval for results (m**3 table)	----- ?	182

Option-record

ICON , IPLR , IPRI , IPRQ , IRES , IANS , ISURF , ISEC
default: 1 , 0 , 1 , 0 , 2 , 5 , 1 , 0
codes : 1,2,1,0,2,5,2,0

Save results for time-hydr. head graphs

Give number of subr. (1-subr+one layer)	----- ?	10
1 - give node/subr. and layer	----- ?	1,1
2 - give node/subr. and layer	----- ?	1,2
3 - give node/subr. and layer	----- ?	2,1
4 - give node/subr. and layer	----- ?	2,2
5 - give node/subr. and layer	----- ?	3,1
6 - give node/subr. and layer	----- ?	3,2
7 - give node/subr. and layer	----- ?	4,1
8 - give node/subr. and layer	----- ?	4,2
9 - give node/subr. and layer	----- ?	5,1
10 - give node/subr. and layer	----- ?	5,2

Techn 1	give name (max 15 char)	----- ?	Bouwland - ber
Techn 2	give name (max 15 char)	----- ?	Bouwland - onb
Techn 3	give name (max 15 char)	----- ?	Grasland - ber
Techn 4	give name (max 15 char)	----- ?	Grasland - onb
Techn 5	give name (max 15 char)	----- ?	Bos
Techn 6	give name (max 15 char)	----- ?	Natuurterrein

Techn 1	give root zone depth	----- ?	0.35
Techn 2	give root zone depth	----- ?	0.35
Techn 3	give root zone depth	----- ?	0.25
Techn 4	give root zone depth	----- ?	0.25
Techn 5	give root zone depth	----- ?	1.00

Techn 6 give root zone depth ----- ? 0.25

Max surface water supply region (m3/s) ----- ? 0.50

Pointer index - for grass and natural vegetation add
negative sign (no fallow soil in winter)

Techn 1 give pointer index evap. ----- ? 1
 Techn 2 give pointer index evap. ----- ? 2
 Techn 3 give pointer index evap. ----- ? -3
 Techn 4 give pointer index evap. ----- ? -4
 Techn 5 give pointer index evap. ----- ? 0
 Techn 6 give pointer index evap. ----- ? -6

Techn 1 give interception (%) ----- ? 10
 Techn 2 give interception (%) ----- ? 10
 Techn 3 give interception (%) ----- ? 0
 Techn 4 give interception (%) ----- ? 0
 Techn 5 give interception (%) ----- ? 0
 Techn 6 give interception (%) ----- ? 5

Techn 1 give sprinkling rotation scheme ----- ? 7
 Techn 2 give sprinkling rotation scheme ----- ? 0
 Techn 3 give sprinkling rotation scheme ----- ? 7
 Techn 4 give sprinkling rotation scheme ----- ? 0
 Techn 5 give sprinkling rotation scheme ----- ? 0
 Techn 6 give sprinkling rotation scheme ----- ? 0

Techn 1 give period sprinkling (beg,end) ----- ? 130,240
 Techn 2 give period sprinkling (beg,end) ----- ? 0,0
 Techn 3 give period sprinkling (beg,end) ----- ? 90,275
 Techn 4 give period sprinkling (beg,end) ----- ? 0,0
 Techn 5 give period sprinkling (beg,end) ----- ? 0,0
 Techn 6 give period sprinkling (beg,end) ----- ? 0,0

Level control-record

Lowering of summer target level as function of groundwater depth

1 =	no lowering				
2 =	0.80	0.90	1.00	1.10	1.20 (h*)
	0.20	0.15	0.10	0.05	0.0 lowering
3 =	0.80	0.90	1.00	1.10	1.20 (h*)
	0.30	0.25	0.20	0.10	0.0 lowering
4 =	0.90	1.00	1.20	1.30	1.50 (h*)
	0.20	0.15	0.10	0.05	0.0 lowering
5 =	0.90	1.00	1.20	1.30	1.50 (h*)
	0.30	0.25	0.20	0.10	0.0 lowering

Record 1 - give number (1-5) ----- ? 1
 Record 2 - give number (1-5) ----- ? 2
 Record 3 - give number (1-5) ----- ? 3

Nov 1988

Characteristics unsaturated zone must be calculated with
CAPSEV or use standard figures

Give file name to read data (STANDARD.DAT) --- ? standard.dat

Area-record

Subr.	1	techn.	1	give area (%)	----- ?	10
Subr.	1	techn.	2	give area (%)	----- ?	35
Subr.	1	techn.	3	give area (%)	----- ?	15
Subr.	1	techn.	4	give area (%)	----- ?	30
Subr.	1	techn.	5	give area (%)	----- ?	10
Subr.	1	techn.	6	give area (%)	----- ?	0
Subr.	2	techn.	1	give area (%)	----- ?	5
Subr.	2	techn.	2	give area (%)	----- ?	15
Subr.	2	techn.	3	give area (%)	----- ?	20
Subr.	2	techn.	4	give area (%)	----- ?	55
Subr.	2	techn.	5	give area (%)	----- ?	5
Subr.	2	techn.	6	give area (%)	----- ?	0
Subr.	3	techn.	1	give area (%)	----- ?	0
Subr.	3	techn.	2	give area (%)	----- ?	0
Subr.	3	techn.	3	give area (%)	----- ?	0
Subr.	3	techn.	4	give area (%)	----- ?	0
Subr.	3	techn.	5	give area (%)	----- ?	40
Subr.	3	techn.	6	give area (%)	----- ?	60
Subr.	4	techn.	1	give area (%)	----- ?	5
Subr.	4	techn.	2	give area (%)	----- ?	30
Subr.	4	techn.	3	give area (%)	----- ?	5
Subr.	4	techn.	4	give area (%)	----- ?	35
Subr.	4	techn.	5	give area (%)	----- ?	25
Subr.	4	techn.	6	give area (%)	----- ?	0
Subr.	5	techn.	1	give area (%)	----- ?	5
Subr.	5	techn.	2	give area (%)	----- ?	30
Subr.	5	techn.	3	give area (%)	----- ?	5
Subr.	5	techn.	4	give area (%)	----- ?	60
Subr.	5	techn.	5	give area (%)	----- ?	0
Subr.	5	techn.	6	give area (%)	----- ?	0

Drainage-record

Subr	1	depth 2nd and depth 3rd	----- ?	2.00, 1.10
Subr	2	depth 2nd and depth 3rd	----- ?	2.00, 1.10
Subr	3	depth 2nd and depth 3rd	----- ?	1.35, 0.90
Subr	4	depth 2nd and depth 3rd	----- ?	2.00, 1.10
Subr	5	depth 2nd and depth 3rd	----- ?	1.75, 1.10
Subr	1	drainage res. 2nd and 3rd	----- ?	1000, 400
Subr	2	drainage res. 2nd and 3rd	----- ?	1000, 500
Subr	3	drainage res. 2nd and 3rd	----- ?	200, 100
Subr	4	drainage res. 2nd and 3rd	----- ?	800, 400
Subr	5	drainage res. 2nd and 3rd	----- ?	1200, 500

Management-record

Subr	1	soil physical unit (1-6)	----- ?	3
Target level summer and winter weir level			----- ?	1.10, 1.40
Water level control - regime number (1-3)			----- ?	2

Max supply cap. surface water (m3/d) ----- ? 15000.
 Max extraction sprinkling from surf. water ----- ? 0.
 Max extraction sprinkling from groundwater ----- ? 7000.
 % of sprinkling always from groundw. ----- ? 50.
 Layer number extraction sprinkling ----- ? 2

Subr 2 soil physical unit (1-6) ----- ? 3
 Target level summer and winter weir level ----- ? 1.10,1.40
 Water level control - regime number (1-3) ----- ? 2
 Max supply cap. surface water (m3/d) ----- ? 30000.
 Max extraction sprinkling from surf. water ----- ? 3500.
 Max extraction sprinkling from groundwater ----- ? 3500.
 % of sprinkling always from groundw. ----- ? 5.
 Layer number extraction sprinkling ----- ? 2

Subr 3 soil physical unit (1-6) ----- ? 2
 Target level summer and winter weir level ----- ? 0.30,0.30
 Water level control - regime number (1-3) ----- ? 1
 Max supply cap. surface water (m3/d) ----- ? 0.
 Max extraction sprinkling from surf. water ----- ? 0.
 Max extraction sprinkling from groundwater ----- ? 0.
 % of sprinkling always from groundw. ----- ? 0.
 Layer number extraction sprinkling ----- ? 2

Subr 4 soil physical unit (1-6) ----- ? 4
 Target level summer and winter weir level ----- ? 1.10,1.40
 Water level control - regime number (1-3) ----- ? 2
 Max supply cap. surface water (m3/d) ----- ? 7000.
 Max extraction sprinkling from surf. water ----- ? 7000.
 Max extraction sprinkling from groundwater ----- ? 1500.
 % of sprinkling always from groundw. ----- ? 30.
 Layer number extraction sprinkling ----- ? 2

Subr 5 soil physical unit (1-6) ----- ? 5
 Target level summer and winter weir level ----- ? 1.10,1.30
 Water level control - regime number (1-3) ----- ? 2
 Max supply cap. surface water (m3/d) ----- ? 0.
 Max extraction sprinkling from surf. water ----- ? 0.
 Max extraction sprinkling from groundwater ----- ? 8000.
 % of sprinkling always from groundw. ----- ? 100.
 Layer number extraction sprinkling ----- ? 2

Discharge-record

Calculate characteristics of surface water system (1)
 or read calculated data from file OPENW.DAT (2)

Give number 1 or 2 ----- ? 2

Nov 1988

Time-record

timestep increase is automatically generated

Give day and year (end is 0,0) ----- ? 271. , 1981
Give code, layer, node/subr and new value ----- ? 2, 2, 16, -500.
Give day and year (end is 0,0) ----- ? 225. , 1982
Give code, layer, node/subr and new value ----- ? 6, 2, 0, 3.
Give day and year (end is 0,0) ----- ? 0,0

Give initial groundwater depth for all nodes --- ? 1.40

DATA COMPILATION FOR PROGRAM FEMSATS AND SIMGRO

WHICH MODULE ?

- 0 - end of module data compilation
- 1 - generate network and compile data
- 2 - compile evapotranspiration factors (SIMGRO.FAC)
- 3 - data for surface water system (SIMGRO)
- 4 -

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0

\$ set noverify

6.2. File with contact points

\$ RUN FEMSIN

PROGRAM F E M S I N
 ***** DATA MANAGEMENT PROGRAM *****

WHICH MODULE ?

- 0 = end of program FEMSIN
- 1 = compile file with contact points
- 2 = data management for time-head graphs
- 3 = data management for plotting isolines
- 4 = network generator and set up basic data files
- 5 = calculation of parameters unsaturated zone
- 6 = calculate absolute deviation

MODULE ----- ? 1

COMPILE FILE WITH CONTACT POINTS FOR GROUNDWATER MODEL

from which file has to be read ----- ? SIMGRO.NDE

to which file has to be written ----- ? SIMGRO.CON

triangular elements only (y or n) ----- ? N

no. of records skipped before reading node no. ----- ? 0

how many node numbers are present ----- ? 100

give for node numbers the format (5X,I5) ----- ? 5X,I5

how many elements must be read ----- ? 81

format for element no. and node (5X,5I5) ----- ? 5X,5I5

THE BANDWIDTH IS = 7
 FOR NODE = 62

the contact points are written on file : SIMGRO.CON

Nov 1988

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ? 0

6.3. Rainfall and evapotranspiration

Input data for FEMSIN

Day	Mth	Yr	Prec [mm]	Temp [oC]	Rhum [-]	Rsrad [W/m2]	Rnrad [W/m2]
22	6	1975	5.0	17.8	0.82	136.	77.
23	6	1975	32.7	20.7	0.82	232.	139.
24	6	1975	1.0	18.4	0.82	229.	135.
25	6	1975	0.0	13.7	0.72	159.	90.
26	6	1975	0.0	15.4	0.73	331.	169.
27	6	1975	0.0	13.6	0.68	112.	66.
28	6	1975	0.4	12.2	0.71	134.	74.
29	6	1975	4.1	12.7	0.80	226.	125.
30	6	1975	0.0	13.9	0.74	308.	161.
1	7	1975	0.0	14.4	0.75	318.	167.
2	7	1975	0.0	16.8	0.72	271.	144.

\$ RUN FEMSIN

```

                PROGRAM F E M S I N
          ***** DATA MANAGEMENT PROGRAM *****

```

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 5

DATA COMPILATION FOR UNSATURATED ZONE

WHICH MODULE ?

- 0 - end of module unsaturated zone
- 1 - equilibrium moisture content for root zone
- 2 - rainfall, potential evapotr. for grass and forest
- 3 - average rainfall and evapotr. from *.EVP file
- 4 - compile command files for characteristics unsat. zone

Nov 1988

MODULE ----- ? 2

CALCULATION OF EVAPOTRANSPIRATION DATA

Give filename with meteo data ----- ? DEBILT8185.DAT

Give filename for results ----- ? SIMGRO.EVP

How many records must be skipped with text ----- ? 0

Which parameters must be read

1 - IDAG,MND,IJAAR,PREC,TEM,RH,WIND,SHH,HNT (mm)

2 - IDAG,PREC,TEM,RH,SHH (from 1981 - mm)

3 - IDAG,IJAAR,PREC,TEM,RH,SHH (from 1981 - mm)

4 - unknown, show first record and start again

ENTER CHOICE ----- ? 3

Accumulated half year results to screen

(Y or N) ----- ? Y

Shown on screen :

Day	Year	Rainfall [mm]	ETp gras [mm]	ETp pine [mm]	ETp deci [mm]	evap. fac. fallow soil
90	1981	287.20	44.35	98.10	44.71	0.50
273	1981	357.90	416.59	440.18	395.41	0.34
90	1982	471.30	105.27	193.03	107.15	0.35
273	1982	238.40	508.48	473.86	429.10	1.00
90	1983	458.10	95.76	187.87	93.95	1.00
273	1983	411.00	447.26	448.54	411.62	0.25
90	1984	456.30	101.09	180.94	93.58	1.00
273	1984	365.50	396.36	397.60	359.41	1.00
90	1985	278.30	97.29	157.91	94.24	1.00
273	1985	414.90	411.72	424.55	383.62	0.28

READY

The accumulated results per half year are also written to file :
METEO.SUM

DATA COMPILATION FOR UNSATURATED ZONE

WHICH MODULE ?

0 - end of module unsaturated zone

1 - equilibrium moisture content for root zone

2 - rainfall, potential evapotr. for grass and forest

- 3 - average rainfall and evapotr. from *.EVP file
- 4 - compile command files for characteristics unsat. zone

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0

\$ set noverify

Results in file SIMGRO.EVP

Day	Year	Rainfall [mm]	ETp gras [mm]	ETp pine [mm]	ETp deci [mm]	evap. fac. fallow soil
173	1975	5.00	2.05	3.56	3.18	1.00
174	1975	32.70	3.68	4.38	4.06	1.00
175	1975	1.00	3.49	3.54	3.60	1.00
176	1975	0.00	2.20	2.44	2.47	0.84
177	1975	0.00	4.75	2.86	2.93	0.38
178	1975	0.00	1.55	2.20	2.22	0.31
179	1975	0.40	1.79	2.39	2.42	0.45
180	1975	4.10	3.05	3.84	3.49	1.00
181	1975	0.00	4.28	2.80	2.86	0.30
182	1975	0.00	4.47	2.85	2.92	0.25
183	1975	0.00	4.00	2.75	2.80	0.23

Note : The column headings must be deleted before using the file.
The format for the data is : 1X,I4,1X,I4,5F10.0

Nov 1988

6.4. Crop evapotranspiration factors

\$ RUN FEMSIN

```
          PROGRAM  F E M S I N
*****      DATA MANAGEMENT PROGRAM      *****
```

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 4

DATA COMPILATION FOR PROGRAM FEMSATS AND SIMGRO

WHICH MODULE ?

- 0 - end of module data compilation
- 1 - generate network and compile data
- 2 - compile evapotranspiration factors (SIMGRO.FAC)
- 3 - data for surface water system (SIMGRO)
- 4 -

MODULE ----- ? 2

SET UP OF FILE WITH CROP EVAPOTRANSPIRATION FACTORS

filename (incl extension .fac) - SIMGRO.FAC

Names of crops or technologies with evapotr. factors .

- 1 - gras
- 2 - granen
- 3 - mais
- 4 - aardappelen
- 5 - suikerbieten
- 6 - peulvruchten
- 7 - plantui
- 8 - zaaiui
- 9 - witlof
- 10 - bol/knolgewassen
- 11 - pit/steenvruchten (volgroeid)
- 12 - akkerbouwmatigetuinbouw
- 13 - vollegrondstuinbouw
- 14 - akkerbouw (algemeen)

Give six crop numbers (zero if not used) ----- ? 14,14,0,1,0,0

Evapotranspiration facors written to file : SIMGRO.FAC

DATA COMPILATION FOR PROGRAM FEMSATS AND SIMGRO

WHICH MODULE ?

- 0 - end of module data compilation
- 1 - generate network and compile data
- 2 - compile evapotranspiration factors (SIMGRO.FAC)
- 3 - data for surface water system (SIMGRO)
- 4 -

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0

If crop factor is -0.01, then the model uses the factor for fallow soil from the ****.EVP file.

Nov 1988

6.5. Command file for calculation characteristics unsaturated zone

The command procedure for the calculation of the characteristics unsaturated zone is obtained with FEMSIN as given below in an interactive way.

```
$ RUN FEMSIN
```

```
                PROGRAM  F E M S I N
*****          DATA  MANAGEMENT PROGRAM          *****
```

```
WHICH MODULE ?
```

- 0 = end of program FEMSIN
- 1 = compile file with contact points
- 2 = data management for time-head graphs
- 3 = data management for plotting isolines
- 4 = network generator and set up basic data files
- 5 = calculation of parameters unsaturated zone
- 6 = calculate absolute deviation

```
MODULE ----- ? 5
```

```
DATA COMPILATION FOR UNSATURATED ZONE
```

```
WHICH MODULE ?
```

- 0 = end of module unsaturated zone
- 1 = equilibrium moisture content for root zone
- 2 = rainfall, potential evapotr. for grass and forest
- 3 = average rainfall and evapotr. from *.EVP file
- 4 = compile command files for characteristics unsat. zone

```
MODULE ----- ? 4
```

```
Compilation of command file for CAPSEV and for
equilibrium moisture content root zone
```

```
Give filename with K(h) data as 5 characters
( e.g. KH ), the files are then KH1-X.DAT ----- ? KH
```

```
Give filename with Pf data as 5 characters
( e.g. PF ), the files are then PF1-X.DAT ----- ? PF
```

```
Number of soil physical units ----- ? 3
```

```
Number of rootzones for calculations ( MAX 3 ) ----- ? 3
```

```

Depth of rootzone ( 1 ) in cm ----- ? 25
Depth of rootzone ( 2 ) in cm ----- ? 50
Depth of rootzone ( 3 ) in cm ----- ? 100
Do you want output for model SIMGRO ( 0 , 1 ) ----- ? 1
    
```

```

The command procedure is written to file CAPSEV.COM and FEMSIN.COM
The groundwater depths are written to file DEPTH1-3.DAT
The pressure head is      :   -500
The root zone depths are :    25    50    100
    
```

DATA COMPILATION FOR UNSATURATED ZONE

WHICH MODULE ?

- 0 - end of module unsaturated zone
- 1 - equilibrium moisture content for root zone
- 2 - rainfall, potential evapotr. for grass and forest
- 3 - average rainfall and evapotr. from *.EVP file
- 4 - compile command files for characteristics unsat. zone

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0

\$ SET NOVERIFY

This part gives two output command files. After running these command files a number of data files are the result. The content of the files is:

```

Equilibrium moisture content:
FEMSIN.COM   -   VEQ.RES   -   results
              CAP1.RES   -   input data for file SIMGRO.DAT
    
```

Capillary rise and storage coefficient:

Nov 1988

CAPSEV.COM - CAPSEV.RES - all results of program CAPSEV
CAP2.RES - capillary rise for file SIMGRO.DAT
CAP3.RES - storage coefficient ,,

Both parts require the soil characteristics in the form of a K(h) and h(teta) relationship. The description of this input data is given in paragraph 6.7.

File FEMSIN.COM

```
$ SET VERIFY
$ RUN FEMSIN
5
1
pf 1.DAT
kh 1.DAT
FEMSIN.RES
25
1
1
0
0
$ COPY FEMSIN.RES VEQ.RES
$ RUN FEMSIN
5
1
pf 2.DAT
kh 2.DAT
FEMSIN.RES
25
2
1
0
0
$ APPEND FEMSIN.RES VEQ.RES
$ RUN FEMSIN
5
1
pf 3.DAT
kh 3.DAT
FEMSIN.RES
25
3
1
0
0
$ APPEND FEMSIN.RES VEQ.RES
$ SET NOVERIFY
```

Command procedure is repeated for root zone of 50 and 100 cm.

File CAPSEV.COM

```
$ SET VERIFY
$ RUN CAPSEV
C
5
1
kh    1.DAT
1
2
18
Y
DEPTH 1.DAT
1
    -500
    25
3
Y
pf    1.DAT
    25
    200
E
$ COPY MOIST.OUT CAPSEV.RES
$ RUN CAPSEV
C
5
1
kh    2.DAT
1
2
18
Y
DEPTH 1.DAT
1
    -500
    25
3
Y
pf    2.DAT
    25
    200
E
$ APPEND MOIST.OUT CAPSEV.RES
$ RUN CAPSEV
C
5
1
kh    3.DAT
1
```

Nov 1988

```
2
18
Y
DEPTH 1.DAT
1
  -500
  25
3
Y
pf    3.DAT
  25
  200
E
$ APPEND MOIST.OUT CAPSEV.RES
$ SET NOVERIFY
```

Command procedure is repeated for root zone of 50 and 100 cm. Three files DEPTH*.DAT are also generated automatically together with CAPSEV.COM. It contains the groundwater levels for which the capillary rise and the storage coefficient must be calculated (see also paragraph 6.7).

6.6. Equilibrium moisture content

As an example the calculation of equilibrium moisture content for one soil physical unit and for one root zone is given here (command procedure FEMSIN.COM as given in paragraph 6.5).

\$ RUN FEMSIN

```

                PROGRAM  F E M S I N
          *****  DATA MANAGEMENT PROGRAM  *****
    
```

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 5

DATA COMPILATION FOR UNSATURATED ZONE

WHICH MODULE ?

- 0 - end of module unsaturated zone
- 1 - equilibrium moisture content for root zone
- 2 - rainfall, potential evapotr. for grass and forest
- 3 - average rainfall and evapotr. from *.EVP file
- 4 - compile command files for characteristics unsat. zone

MODULE ----- ? 1

CALCULATION OF EQUILIBRIUM MOISTURE CONTENT

Give filename with h(teta) values (pf) ----- ? pf 1.DAT

Give filename with k(h) values ----- ? kh 1.DAT

Give filename for results ----- ? FEMSIN.RES

Give root zone in cm ----- ? 25

Give actual soil physical unit ----- ? 1

Nov 1988

Results for file SIMGRO.DAT (1 = yes) ----- ? 1

DATA COMPILATION FOR UNSATURATED ZONE

WHICH MODULE ?

- 0 - end of module unsaturated zone
- 1 - equilibrium moisture content for root zone
- 2 - rainfall, potential evapotr. for grass and forest
- 3 - average rainfall and evapotr. from *.EVP file
- 4 - compile command files for characteristics unsat. zone

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0

The calculated results of the equilibrium moisture content for root zone of 0.25, 0.50 and 1.00 m is given in file VEQ.RES. The data is also saved in file CAP!.RES for use by the groundwater models. Column 1 of this file shows the root zone depth, column 2 the groundwater depth from zero to 2.0 m and after that six columns with the equilibrium moisture content of the root zone in mm. This data is part of SIMGRO.DAT or SIMPRO.DAT.

File CAP!.RES

*V25	0.0	121.3	125.3	119.6	0.0	0.0	0.0
*V25	0.1	117.3	121.3	117.3	0.0	0.0	0.0
*V25	0.2	108.6	112.9	112.8	0.0	0.0	0.0
*V25	0.3	99.1	104.6	108.0	0.0	0.0	0.0
*V25	0.4	92.0	99.0	105.3	0.0	0.0	0.0
*V25	0.5	85.0	93.9	102.7	0.0	0.0	0.0
*V25	0.6	77.9	89.0	99.2	0.0	0.0	0.0

*V25	0.7	72.2	84.6	94.7	0.0	0.0	0.0
*V25	0.8	67.8	80.8	90.1	0.0	0.0	0.0
*V25	0.9	64.2	77.5	86.2	0.0	0.0	0.0
*V25	1.0	60.9	74.6	82.8	0.0	0.0	0.0
*V25	1.1	58.4	72.2	79.8	0.0	0.0	0.0
*V25	1.2	56.8	70.5	77.5	0.0	0.0	0.0
*V25	1.3	55.7	69.2	75.5	0.0	0.0	0.0
*V25	1.4	54.7	67.9	73.8	0.0	0.0	0.0
*V25	1.5	53.7	66.7	72.1	0.0	0.0	0.0
*V25	1.6	52.8	65.7	70.5	0.0	0.0	0.0
*V25	1.7	52.0	64.7	69.1	0.0	0.0	0.0
*V25	1.8	51.2	63.7	67.8	0.0	0.0	0.0
*V25	1.9	50.5	62.8	66.6	0.0	0.0	0.0
*V25	2.0	49.9	62.0	65.4	0.0	0.0	0.0
*V50	0.0	280.8	304.9	215.3	0.0	0.0	0.0
*V50	0.1	276.8	300.9	213.0	0.0	0.0	0.0
*V50	0.2	268.1	292.5	208.5	0.0	0.0	0.0
*V50	0.3	257.8	283.6	203.0	0.0	0.0	0.0
*V50	0.4	245.6	273.9	197.0	0.0	0.0	0.0
*V50	0.5	230.3	262.0	189.1	0.0	0.0	0.0
*V50	0.6	215.5	250.7	179.9	0.0	0.0	0.0
*V50	0.7	203.3	241.6	169.2	0.0	0.0	0.0
*V50	0.8	192.8	233.7	156.6	0.0	0.0	0.0
*V50	0.9	183.9	226.8	144.6	0.0	0.0	0.0
*V50	1.0	177.0	220.7	135.9	0.0	0.0	0.0
*V50	1.1	171.8	215.6	129.1	0.0	0.0	0.0
*V50	1.2	167.8	211.6	123.5	0.0	0.0	0.0
*V50	1.3	164.6	208.1	118.6	0.0	0.0	0.0
*V50	1.4	161.8	205.0	114.4	0.0	0.0	0.0
*V50	1.5	159.1	202.2	110.9	0.0	0.0	0.0
*V50	1.6	156.7	199.5	107.7	0.0	0.0	0.0
*V50	1.7	154.4	197.1	104.8	0.0	0.0	0.0
*V50	1.8	152.3	194.8	102.1	0.0	0.0	0.0
*V50	1.9	150.4	192.7	99.6	0.0	0.0	0.0
*V50	2.0	148.6	190.7	97.2	0.0	0.0	0.0
*V100	0.0	572.8	578.8	399.6	0.0	0.0	0.0
*V100	0.1	568.8	574.8	397.3	0.0	0.0	0.0
*V100	0.2	560.1	566.4	392.8	0.0	0.0	0.0
*V100	0.3	549.8	557.5	387.4	0.0	0.0	0.0
*V100	0.4	537.7	547.8	381.4	0.0	0.0	0.0
*V100	0.5	522.3	535.9	373.5	0.0	0.0	0.0
*V100	0.6	504.7	521.2	362.6	0.0	0.0	0.0
*V100	0.7	485.7	504.2	347.3	0.0	0.0	0.0
*V100	0.8	465.6	486.5	327.8	0.0	0.0	0.0
*V100	0.9	446.6	467.3	306.2	0.0	0.0	0.0
*V100	1.0	426.7	445.9	283.5	0.0	0.0	0.0
*V100	1.1	408.5	426.0	261.7	0.0	0.0	0.0
*V100	1.2	392.7	409.6	242.1	0.0	0.0	0.0
*V100	1.3	377.3	395.8	224.1	0.0	0.0	0.0
*V100	1.4	365.2	384.2	208.4	0.0	0.0	0.0
*V100	1.5	356.6	375.3	196.4	0.0	0.0	0.0
*V100	1.6	349.2	368.1	186.8	0.0	0.0	0.0
*V100	1.7	342.5	361.9	178.6	0.0	0.0	0.0
*V100	1.8	336.5	356.5	171.3	0.0	0.0	0.0

Nov 1988

*V100	1.9	331.0	351.7	165.0	0.0	0.0	0.0
*V100	2.0	326.2	347.5	159.4	0.0	0.0	0.0

6.7. Calculation with program CAPSEV

Files with soil physical properties

The files for the $K(h)$ and $h(\theta)$ relationship must be placed in a set of files given a number from one to the number of soil physical units.

$K(h)$ -relationship in file KH**.DAT

- Record 1 - A70 - text, e.g. profile name
- Record 2a - A70 - text, description of layer
- Record 2b - free - thickness of layer (cm)
- Record 2c - free - number of points in $K(h)$ -table
- Record 3a - free - absolute h -values in cm (from high to low)
- Record 3b - free - corresponding K -values (cm/day)

Remarks

- 1 - Repeat record 2 and 3 for each layer (max 10 layers).
- 2 - The maximum number of points to describe $K(h)$ -relation is 100.

$h(\theta)$ -relationship in file PF**.DAT

- Record 1 - free - minimum and maximum θ range for h -values
- Record 2 - free - absolute h -values (cm) for the range from min. θ to max. θ (h -values from high to low)

Remarks

- 1 - Repeat record 1 and 2 for each layer (max 10 layers).
- 2 - The maximum number of points to describe h - θ relation is 90.

With the program FEMSIN a command file can be made to run the program CAPSEV for various soil physical units and different root zones (see paragraph 6.5).

Nov 1988

File Khl.DAT

Z.P.P. Bodemfysische eenheid 2

Laag 1

20.0

42

0.158E+07	0.858E+04	0.464E+04	0.251E+04	0.158E+04	0.100E+04	0.708E+03	0.501E+03
0.398E+03	0.316E+03	0.251E+03	0.200E+03	0.158E+03	0.126E+03	0.100E+03	0.917E+02
0.841E+02	0.772E+02	0.708E+02	0.649E+02	0.596E+02	0.546E+02	0.501E+02	0.464E+02
0.430E+02	0.398E+02	0.369E+02	0.341E+02	0.316E+02	0.261E+02	0.215E+02	0.178E+02
0.147E+02	0.121E+02	0.100E+02	0.720E+01	0.518E+01	0.373E+01	0.268E+01	0.193E+01
0.139E+01	0.001E-10						
0.201E-04	0.669E-04	0.223E-03	0.743E-03	0.183E-02	0.452E-02	0.889E-02	0.175E-01
0.275E-01	0.431E-01	0.677E-01	0.106E+00	0.167E+00	0.262E+00	0.412E+00	0.488E+00
0.578E+00	0.684E+00	0.811E+00	0.960E+00	0.114E+01	0.135E+01	0.160E+01	0.185E+01
0.216E+01	0.250E+01	0.291E+01	0.338E+01	0.393E+01	0.573E+01	0.835E+01	0.122E+02
0.177E+02	0.258E+02	0.376E+02	0.716E+02	0.136E+03	0.260E+03	0.327E+03	0.328E+03
0.329E+03	0.330E+03						

Laag 2

60.0

54

0.158E+05	0.126E+05	0.100E+05	0.794E+04	0.631E+04	0.501E+04	0.398E+04	0.316E+04
0.251E+04	0.209E+04	0.174E+04	0.145E+04	0.120E+04	0.100E+04	0.926E+03	0.858E+03
0.794E+03	0.736E+03	0.681E+03	0.631E+03	0.584E+03	0.541E+03	0.501E+03	0.417E+03

0.184E-01	0.261E-01	0.371E-01	0.527E-01	0.656E-01	0.817E-01	0.102E+00	0.127E+00
0.158E+00	0.196E+00	0.245E+00	0.305E+00	0.370E+00	0.450E+00	0.547E+00	0.664E+00
0.807E+00	0.981E+00	0.149E+01	0.226E+01	0.343E+01	0.522E+01	0.792E+01	0.120E+02
0.183E+02	0.484E+02	0.128E+03	0.327E+03	0.328E+03	0.329E+03	0.330E+03	

Laag 5

190.0

36

0.158E+05	0.631E+04	0.251E+04	0.100E+04	0.708E+03	0.501E+03	0.369E+03	0.271E+03
0.200E+03	0.174E+03	0.151E+03	0.132E+03	0.115E+03	0.100E+03	0.891E+02	0.794E+02
0.708E+02	0.631E+02	0.562E+02	0.501E+02	0.464E+02	0.430E+02	0.398E+02	0.369E+02
0.341E+02	0.316E+02	0.237E+02	0.178E+02	0.133E+02	0.100E+02	0.681E+01	0.464E+01
0.316E+01	0.215E+01	0.147E+01	0.001E-10				
0.270E-07	0.334E-06	0.413E-05	0.510E-04	0.131E-03	0.336E-03	0.777E-03	0.180E-02
0.416E-02	0.606E-02	0.883E-02	0.129E-01	0.188E-01	0.274E-01	0.375E-01	0.514E-01
0.703E-01	0.963E-01	0.132E+00	0.181E+00	0.223E+00	0.275E+00	0.339E+00	0.417E+00
0.515E+00	0.635E+00	0.139E+01	0.306E+01	0.670E+01	0.147E+02	0.419E+02	0.120E+03
0.327E+03	0.328E+03	0.329E+03	0.330E+03				

File PF1.DAT

4 45

0.158E+07 0.858E+04 0.464E+04 0.251E+04 0.158E+04 0.100E+04 0.708E+03 0.501E+03
 0.398E+03 0.316E+03 0.251E+03 0.200E+03 0.158E+03 0.126E+03 0.100E+03 0.917E+02
 0.841E+02 0.772E+02 0.708E+02 0.649E+02 0.596E+02 0.546E+02 0.501E+02 0.464E+02
 0.430E+02 0.398E+02 0.369E+02 0.341E+02 0.316E+02 0.261E+02 0.215E+02 0.178E+02
 0.147E+02 0.121E+02 0.100E+02 0.720E+01 0.518E+01 0.373E+01 0.268E+01 0.193E+01
 0.139E+01 0.000E+00

11 64

0.158E+05 0.126E+05 0.100E+05 0.794E+04 0.631E+04 0.501E+04 0.398E+04 0.316E+04
 0.251E+04 0.209E+04 0.174E+04 0.145E+04 0.120E+04 0.100E+04 0.926E+03 0.858E+03
 0.794E+03 0.736E+03 0.681E+03 0.631E+03 0.584E+03 0.541E+03 0.501E+03 0.417E+03

0.341E+02 0.316E+02 0.268E+02 0.228E+02 0.193E+02 0.164E+02 0.139E+02 0.118E+02
 0.100E+02 0.681E+01 0.464E+01 0.316E+01 0.215E+01 0.147E+01 0.000E+00

2 37

0.158E+05 0.631E+04 0.251E+04 0.100E+04 0.708E+03 0.501E+03 0.369E+03 0.271E+03
 0.200E+03 0.174E+03 0.151E+03 0.132E+03 0.115E+03 0.100E+03 0.891E+02 0.794E+02
 0.708E+02 0.631E+02 0.562E+02 0.501E+02 0.464E+02 0.430E+02 0.398E+02 0.369E+02
 0.341E+02 0.316E+02 0.237E+02 0.178E+02 0.133E+02 0.100E+02 0.681E+01 0.464E+01
 0.316E+01 0.215E+01 0.147E+01 0.000E+00

File DEPTH1.DAT used by CAPSEV

30
 40
 50
 60
 70
 80
 90
 100
 110
 120
 130
 140
 150
 160
 170
 180
 190
 200

Nov 1988

File DEPTH2.DAT

50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

File DEPTH3.DAT

100
110
120
130
140
150
160
170
180
190
200

The files DEPTH*.DAT are automatically generated together with the command procedure. It contains the levels for which calculations are performed by CAPSEV. Standard an interval of 10 cm is selected. The first level should be equal or lower than the root zone depth.

Shown below are the results of the calculations with CAPSEV. All results are given in file CAPSEV.RES and the specific data for the groundwater models is given in file CAP2.RES and CAP3.RES. The capillary rise is required for root zone of 0.25, 0.50 and 1.00 m. Column 1 of file CAP2.RES shows the root zone depth, column 2 the groundwater depth from zero to 2.0 m and after that six columns with the capillary rise in mm/d. This data is part of SIMGRO.DAT or SIMPRO.DAT.

File CAP2.RES

*C25	0.0	5.00	5.00	5.00	0.00	0.00	0.00
*C25	0.1	5.00	5.00	5.00	0.00	0.00	0.00
*C25	0.2	5.00	5.00	5.00	0.00	0.00	0.00
*C25	0.3	5.00	5.00	5.00	0.00	0.00	0.00
*C25	0.4	5.00	5.00	5.00	0.00	0.00	0.00
*C25	0.5	5.00	5.00	5.00	0.00	0.00	0.00
*C25	0.6	4.27	5.00	5.00	0.00	0.00	0.00
*C25	0.7	2.28	3.48	5.00	0.00	0.00	0.00
*C25	0.8	1.38	2.21	4.17	0.00	0.00	0.00
*C25	0.9	0.90	1.47	1.23	0.00	0.00	0.00
*C25	1.0	0.64	1.03	0.41	0.00	0.00	0.00
*C25	1.1	0.45	0.72	0.18	0.00	0.00	0.00
*C25	1.2	0.35	0.53	0.10	0.00	0.00	0.00
*C25	1.3	0.26	0.39	0.07	0.00	0.00	0.00
*C25	1.4	0.20	0.30	0.05	0.00	0.00	0.00
*C25	1.5	0.16	0.24	0.04	0.00	0.00	0.00
*C25	1.6	0.15	0.18	0.03	0.00	0.00	0.00
*C25	1.7	0.13	0.14	0.01	0.00	0.00	0.00
*C25	1.8	0.11	0.12	0.01	0.00	0.00	0.00
*C25	1.9	0.09	0.10	0.02	0.00	0.00	0.00
*C25	2.0	0.06	0.08	0.02	0.00	0.00	0.00
*C50	0.0	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.1	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.2	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.3	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.4	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.5	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.6	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.7	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.8	5.00	5.00	5.00	0.00	0.00	0.00
*C50	0.9	3.00	3.67	5.00	0.00	0.00	0.00
*C50	1.0	1.73	2.00	4.18	0.00	0.00	0.00
*C50	1.1	1.11	1.21	1.21	0.00	0.00	0.00
*C50	1.2	0.77	0.80	0.41	0.00	0.00	0.00
*C50	1.3	0.56	0.55	0.18	0.00	0.00	0.00
*C50	1.4	0.44	0.39	0.10	0.00	0.00	0.00
*C50	1.5	0.34	0.30	0.07	0.00	0.00	0.00
*C50	1.6	0.27	0.22	0.05	0.00	0.00	0.00
*C50	1.7	0.23	0.18	0.02	0.00	0.00	0.00
*C50	1.8	0.19	0.14	0.03	0.00	0.00	0.00
*C50	1.9	0.15	0.12	0.01	0.00	0.00	0.00

Nov 1988

*C50	2.0	0.13	0.10	0.01	0.00	0.00	0.00
*C100	0.0	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.1	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.2	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.3	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.4	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.5	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.6	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.7	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.8	5.00	5.00	5.00	0.00	0.00	0.00
*C100	0.9	5.00	5.00	5.00	0.00	0.00	0.00
*C100	1.0	5.00	5.00	5.00	0.00	0.00	0.00
*C100	1.1	5.00	5.00	5.00	0.00	0.00	0.00
*C100	1.2	5.00	5.00	5.00	0.00	0.00	0.00
*C100	1.3	5.00	5.00	5.00	0.00	0.00	0.00
*C100	1.4	5.00	2.86	5.00	0.00	0.00	0.00
*C100	1.5	4.62	1.57	4.18	0.00	0.00	0.00
*C100	1.6	2.69	0.98	1.21	0.00	0.00	0.00
*C100	1.7	1.71	0.65	0.41	0.00	0.00	0.00
*C100	1.8	1.17	0.46	0.18	0.00	0.00	0.00
*C100	1.9	0.82	0.34	0.10	0.00	0.00	0.00
*C100	2.0	0.61	0.25	0.07	0.00	0.00	0.00

At present the storage coefficient for root zone of 0.25 m is required as input data. The coefficients for groundwater depth in the root zone must be inserted in the way as shown in Report ??.

File CAP3.RES

*U25	0.0	0.00	0.00	0.00	0.00	0.00	0.00
*U25	0.1	0.00	0.00	0.00	0.00	0.00	0.00
*U25	0.2	0.00	0.00	0.00	0.00	0.00	0.00
*U25	0.3	0.06	0.05	0.03	0.00	0.00	0.00
*U25	0.4	0.10	0.08	0.05	0.00	0.00	0.00
*U25	0.5	0.18	0.14	0.08	0.00	0.00	0.00
*U25	0.6	0.16	0.18	0.12	0.00	0.00	0.00
*U25	0.7	0.18	0.17	0.26	0.00	0.00	0.00
*U25	0.8	0.17	0.20	0.17	0.00	0.00	0.00
*U25	0.9	0.19	0.23	0.19	0.00	0.00	0.00
*U25	1.0	0.20	0.23	0.23	0.00	0.00	0.00
*U25	1.1	0.25	0.25	0.24	0.00	0.00	0.00
*U25	1.2	0.24	0.24	0.28	0.00	0.00	0.00
*U25	1.3	0.22	0.26	0.26	0.00	0.00	0.00
*U25	1.4	0.22	0.30	0.28	0.00	0.00	0.00
*U25	1.5	0.27	0.21	0.25	0.00	0.00	0.00
*U25	1.6	0.26	0.26	0.11	0.00	0.00	0.00
*U25	1.7	0.25	0.33	0.29	0.00	0.00	0.00
*U25	1.8	0.25	0.30	0.46	0.00	0.00	0.00
*U25	1.9	0.21	0.22	0.34	0.00	0.00	0.00
*U25	2.0	0.00	0.00	0.00	0.00	0.00	0.00

*U50	0.0	0.00	0.00	0.00	0.00	0.00	0.00
*U50	0.1	0.00	0.00	0.00	0.00	0.00	0.00
*U50	0.2	0.00	0.00	0.00	0.00	0.00	0.00
*U50	0.3	0.00	0.00	0.00	0.00	0.00	0.00
*U50	0.4	0.00	0.00	0.00	0.00	0.00	0.00
*U50	0.5	0.00	0.00	0.00	0.00	0.00	0.00
*U50	0.6	0.08	0.08	0.05	0.00	0.00	0.00
*U50	0.7	0.14	0.13	0.07	0.00	0.00	0.00
*U50	0.8	0.16	0.19	0.11	0.00	0.00	0.00
*U50	0.9	0.15	0.18	0.16	0.00	0.00	0.00
*U50	1.0	0.18	0.20	0.17	0.00	0.00	0.00
*U50	1.1	0.22	0.21	0.20	0.00	0.00	0.00
*U50	1.2	0.22	0.22	0.22	0.00	0.00	0.00
*U50	1.3	0.21	0.22	0.24	0.00	0.00	0.00
*U50	1.4	0.21	0.25	0.27	0.00	0.00	0.00
*U50	1.5	0.22	0.23	0.26	0.00	0.00	0.00
*U50	1.6	0.25	0.29	0.19	0.00	0.00	0.00
*U50	1.7	0.24	0.25	0.35	0.00	0.00	0.00
*U50	1.8	0.24	0.30	0.15	0.00	0.00	0.00
*U50	1.9	0.26	0.28	0.29	0.00	0.00	0.00
*U50	2.0	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.0	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.1	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.2	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.3	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.4	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.5	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.6	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.7	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.8	0.00	0.00	0.00	0.00	0.00	0.00
*U100	0.9	0.00	0.00	0.00	0.00	0.00	0.00
*U100	1.0	0.00	0.00	0.00	0.00	0.00	0.00
*U100	1.1	0.09	0.08	0.05	0.00	0.00	0.00
*U100	1.2	0.11	0.15	0.07	0.00	0.00	0.00
*U100	1.3	0.16	0.18	0.11	0.00	0.00	0.00
*U100	1.4	0.27	0.18	0.16	0.00	0.00	0.00
*U100	1.5	0.19	0.21	0.17	0.00	0.00	0.00
*U100	1.6	0.19	0.22	0.20	0.00	0.00	0.00
*U100	1.7	0.21	0.23	0.22	0.00	0.00	0.00
*U100	1.8	0.21	0.23	0.24	0.00	0.00	0.00
*U100	1.9	0.23	0.23	0.27	0.00	0.00	0.00
*U100	2.0	0.00	0.00	0.00	0.00	0.00	0.00

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6.8. Characteristics surface water system

\$ RUN FEMSIN

***** PROGRAM F E M S I N *****
DATA MANAGEMENT PROGRAM

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ? 4

DATA COMPILATION FOR PROGRAM FEMSATS AND SIMGRO

.....

WHICH MODULE ?

- 0 - end of module data compilation
- 1 - generate network and compile data
- 2 - compile evapotranspiration factors (SIMGRO.FAC)
- 3 - data for surface water system (SIMGRO)
- 4 -

MODULE ? 3

Module to calculate characteristics of the
surface water system

- Give total number of subregions ? 6
- Give number of subregions with boundary nodes ---- ? 1
- Subr 1 give winter weir level minus groundl. ---- ? 1.40
- Subr 2 give winter weir level minus groundl. ---- ? 1.40
- Subr 3 give winter weir level minus groundl. ---- ? 0.30
- Subr 4 give winter weir level minus groundl. ---- ? 1.40
- Subr 5 give winter weir level minus groundl. ---- ? 1.50

Give data per ditch class (from small to large) :

- CINT - Intensity per class (ml/ha)
- DINV - Invert level as depth minus ground level (m)
- ZSLO - Side slope of ditch (1:ZSLO)
- BASE - Width at invert (m)

Channel sizes of 0. means use values from first subregion

Number of ditch classes per subregion ----- ? 3

Subregion 1

Class 1 give CINT,DINV,ZSLO,BASE ----- ? 85, 0.90, 1.0,
0.70

Class 2 give CINT,DINV,ZSLO,BASE ----- ? 10, 1.35, 1.5,
1.10

Class 3 give CINT,DINV,ZSLO,BASE ----- ? 4, 2.00, 1.5,
1.75

Subregion 2

Class 1 give CINT,DINV,ZSLO,BASE ----- ? 60, 0.90, 1.0,
0.70

Class 2 give CINT,DINV,ZSLO,BASE ----- ? 10, 1.35, 1.5,
1.10

Class 3 give CINT,DINV,ZSLO,BASE ----- ? 4, 2.00, 1.5,
1.75

Subregion 3

Class 1 give CINT,DINV,ZSLO,BASE ----- ? 1500, 0.90, 1.0,
0.70

Class 2 give CINT,DINV,ZSLO,BASE ----- ? 5, 1.35, 1.5,
1.10

Class 3 give CINT,DINV,ZSLO,BASE ----- ? 0, 2.00, 1.5,
1.75

Subregion 4

Class 1 give CINT,DINV,ZSLO,BASE ----- ? 50, 0.90, 1.0,
0.70

Class 2 give CINT,DINV,ZSLO,BASE ----- ? 40, 1.35, 1.5,
1.10

Class 3 give CINT,DINV,ZSLO,BASE ----- ? 4, 2.00, 1.5,
1.75

Subregion 5

Class 1 give CINT,DINV,ZSLO,BASE ----- ? 120, 0.90, 1.0,
0.70

Class 2 give CINT,DINV,ZSLO,BASE ----- ? 25, 1.35, 1.5,
1.10

Class 3 give CINT,DINV,ZSLO,BASE ----- ? 10, 1.75, 1.5,
1.50

Subregion 1

Give width of imaginary weir at boundary ----- ? 1.10

Give area of subregion in (ha) ----- ? 700

Nov 1988

Subregion 2

Give width of imaginary weir at boundary ----- ? 0.90
Give area of subregion in (ha) ----- ? 700

Subregion 3

Give width of imaginary weir at boundary ----- ? 1.25
Give area of subregion in (ha) ----- ? 1400
nr,n,q,dely 3 1 0.051 -0.110 correction, prog. continues
nr,n,q,dely 3 1 0.079 -0.155 correction, prog. continues
nr,n,q,dely 3 1 0.115 -0.211 correction, prog. continues

Subregion 4

Give width of imaginary weir at boundary ----- ? 0.60
Give area of subregion in (ha) ----- ? 600

Subregion 5

Give width of imaginary weir at boundary ----- ? 1.50
Give area of subregion in (ha) ----- ? 3000

Results are saved in file OPENW.DAT

DATA COMPILATION FOR PROGRAM FEMSATS AND SIMGRO

WHICH MODULE ?

- 0 - end of module data compilation
- 1 - generate network and compile data
- 2 - compile evapotranspiration factors (SIMGRO.FAC)
- 3 - data for surface water system (SIMGRO)
- 4 -

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0

\$ set noverify

The file OPENW.DAT contains the discharge-records. Column 2 is the subregion number, column 3 is the distance below ground level and thereafter the storage and discharge capacity.

File OPENW.DAT

*DISH	1	0.10	234.	0.086
*DISH	1	-0.50	83.	0.068
*DISH	1	-0.80	36.	0.051
*DISH	1	-1.00	19.	0.036
*DISH	1	-1.20	12.	0.022
*DISH	1	-1.40	7.	0.000
*DISH	1	-1.60	4.	0.000
*DISH	1	-1.80	2.	0.000
*DISH	1	-2.30	0.	0.000
*DISH	1	-3.00	0.	0.000
*DISH	2	0.10	192.	0.075
*DISH	2	-0.50	71.	0.060
*DISH	2	-0.80	33.	0.045
*DISH	2	-1.00	19.	0.031
*DISH	2	-1.20	12.	0.018
*DISH	2	-1.40	7.	0.000
*DISH	2	-1.60	4.	0.000
-	-	-	-	-
*DISH	5	-1.00	33.	0.002
*DISH	5	-1.30	11.	0.000
*DISH	5	-1.40	6.	0.000
*DISH	5	-1.60	2.	0.000
*DISH	5	-1.80	0.	0.000
*DISH	5	-2.30	0.	0.000
*DISH	5	-3.00	0.	0.000
*DISH	6	0.10	0.	0.000
*DISH	6	0.00	0.	0.000
*DISH	6	-0.10	0.	0.000
*DISH	6	-0.20	0.	0.000
*DISH	6	-0.30	0.	0.000
*DISH	6	-0.50	0.	0.000
*DISH	6	-0.70	0.	0.000
*DISH	6	-1.00	0.	0.000
*DISH	6	-1.40	0.	0.000
*DISH	6	-1.80	0.	0.000

Nov 1988

6.9. Graphical presentation of results

For time-hydraulic head graphs, first extract results you want to plot from file SIMGRO.PRS as shown below.

\$ RUN FEMSIN

```
                PROGRAM  F E M S I N
          *****  DATA  MANAGEMENT  PROGRAM  *****
```

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 2

TIME-HEAD GRAPHS

WHICH MODULE ?

- 0 - end of module time-head graphs
- 1 - graphs for groundwater system
- 2 - graphs for surface water system
- 3 - create option file for program GRAFIEK
- 4 - create plot with program PLOTWAT

MODULE ----- ? 1

GROUNDWATER SYSTEM

- 0 - end of sub-program
- 1 - create data file to plot from the results (.PRS)
- 2 =

MODULE ----- ? 1

give filename with calculated data ----- ? SIMGRO.PRS

write results to file ----- ? SIMGRO.PRO

GROUNDWATER LEVELS

THE NODE OR SUBREGION NUMBERS ARE :

NUMBER :	1	1	2	2	3	3	4	4	5	5
LAYER :	1	2	1	2	1	2	1	2	1	2

enter number of points for plotfile ----- ? 5
 enter node or subregion and layer number ----- ? 1,1
 enter node or subregion and layer number ----- ? 2,1
 enter node or subregion and layer number ----- ? 3,1
 enter node or subregion and layer number ----- ? 4,1
 enter node or subregion and layer number ----- ? 5,1

do you want to merge the results with other data files

- 0 = no merging to be done
- 1 = merge with already merged data
- 2 = merge with field data

----- ? 0
 Number of characters behind decimal point
 (0 , 1 , 2 , 3) ----- ? 2

GROUNDWATER SYSTEM

- 0 = end of sub-program
- 1 = create data file to plot from the results (.PRS)
- 2 =

MODULE ----- ? 0

TIME-HEAD GRAPHS

WHICH MODULE ?

- 0 = end of module time-head graphs
- 1 = graphs for groundwater system
- 2 = graphs for surface water system
- 3 = create option file for program GRAFIEK
- 4 = create plot with program PLOTWAT

MODULE ----- ? 0

WHICH MODULE ?

- 0 = end of program FEMSIN
- 1 = compile file with contact points
- 2 = data management for time-head graphs
- 3 = data management for plotting isolines
- 4 = network generator and set up basic data files
- 5 = calculation of parameters unsaturated zone
- 6 = calculate absolute deviation

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MODULE ----- ? 0
\$ set noverify

The data to plot are written to file SIMGRO.PRO, now one can make the actual plot as shown below. The file SIMGRO.PLT is send to the actual plotting device using the utility SIMPLOT.

\$ RUN FEMSIN

***** PROGRAM F E M S I N *****
DATA MANAGEMENT PROGRAM

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files
- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 2

TIME-HEAD GRAPHS

WHICH MODULE ?

- 0 - end of module time-head graphs
- 1 - graphs for groundwater system
- 2 - graphs for surface water system
- 3 - create option file for program GRAFIEK
- 4 - create plot with program PLOTWAT

MODULE ----- ? 4

WAT WORDT DE FILENAAM VAN DE PLOTFILE ? SIMGRO.PLT

Give code for unknown value (e.g. 999.9) ? 999.

Give file name with plot data ----- ? : SIMGRO.PRO

Give number of colums (incl day, year) -- ? : 7

Number of lines in one plot (< 9) ----- ? : 5

Minumum day number and year on time axe ---- ? : 270,1982

Maximum day number and year on time-axe ---- ? : 300,1983

Minimum and max. value Y-axis ----- ? : 24,30
 Line 1 in column number ----- ? : 3
 Line 2 in column number ----- ? : 4
 Line 3 in column number ----- ? : 5
 Line 4 in column number ----- ? : 6
 Line 5 in column number ----- ? : 7

Cursus planvorming in het waterbeheer

Length of time-axis in mm (A4-format=180) --- ? : 250
 Length of Y-axis in mm (A4-format=??) ----- ? : 200
 Description for time-axis ----- ? : time
 Description for Y-axis ----- ? : head (m)
 Text below plot (left hand side) --- ? : Example
 Description of line from column 3 ----- ? : subr. 1
 Description of line from column 4 ----- ? : subr. 2
 Description of line from column 5 ----- ? : subr. 3
 Description of line from column 6 ----- ? : subr. 4
 Description of line from column 7 ----- ? : subr. 5
 Do you want another plot [J/N] ----- ? : N

TIME-HEAD GRAPHS

WHICH MODULE ?

- 0 - end of module time-head graphs
- 1 - graphs for groundwater system
- 2 - graphs for surface water system
- 3 - create option file for program GRAFIEK
- 4 - create plot with program PLOTWAT

MODULE ----- ? 0

WHICH MODULE ?

- 0 - end of program FEMSIN
- 1 - compile file with contact points
- 2 - data management for time-head graphs
- 3 - data management for plotting isolines
- 4 - network generator and set up basic data files

Nov 1988

- 5 - calculation of parameters unsaturated zone
- 6 - calculate absolute deviation

MODULE ----- ? 0
\$ set noverify