COMPARISON OF SIMULATED WATER BALANCE FOR ORDINARY AND SCALED SOIL HYDRAULIC CHARACTERISTICS

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Dr. M. Cislerova
Dept. of Irrigation and Drainage
Technical University
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Milena Cislerova

Abstract

Using the SWATRE model simulations of the summer water balance were done for various combinations of soil hydraulic functions for seven locations of a 0.5 ha area of one soil type in the Hupselse Beek watershed. Based on van Genuchten's expression for the retention curve three expressions for hydraulic conductivities were tested. Then scaling was used for the description of the soil inputs, at first in a deterministic approach and later for the creation of randomly generated soil data sets. The effects of two lower boundary conditions - the measured groundwater levels and the prescribed outflow rate developed from groundwaterlevel-discharge relationship were studied. The groundwaterlevel-discharge relationship used as the lower boundary condition appeared suitable for simulation purposes especially in the stochastic approach. The results of the simulation depend critically on the shape of the assumed soil hydraulic functions. When an approximate mathematical expression for the retention curve is applied together with the prediction of hydraulic conductivities then the estimated values of the retention curve parameters are decisive for the results of the simulations. By scaling, certain departures from reality can be introduced. Attention has to be paid to the development of mean scaled curves, since the routine fitting procedure of the retention curve parameters can increase the measured dissimilarity. Comparison was made between the deterministic and the stochastic approaches to the soil hydraulic functions as inputs for the deterministic model of water balance. When the shape of the mean scaled curves is reliable, the stochastic approach seems to be a very convenient tool to cover the effects of the spatial variability of soils within the known distribution of the scaling factors.

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My gratitude for their understanding and kind help belongs also to Ir.Piet Warmerdam, Dr.Paul Torfs, Jacque Cole and other collegues, especially to Annemarie for her patience with the typing.

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1. Introduction

With growing attention paid in soil physics during the last decade to the actual field conditions it has appeared that the spatial variability of soil hydraulic properties has much higher significance than was expected. Even within one soil type large variations in soil hydraulic characteristics, represented by the retention curve and the hydraulic conductivities, are usually obtained. The question of great importance is thus how to treat the spatial variability of hydraulic characteristics when the soil water movement is modeled. The target is to get the most reliable and representative answers for any environmental assesments like pollutant transport and nutrient dynamics or any water resources management and hydrological studies.

A large project, which has been in progress since 1983 under the leadership of the Department of Hydraulics and Hydrology of the Agricultural University in Wageningen, is dealing with this problem in the experimental watershed area of the Hupselse Beek. As an adequate tool to describe the spatial variability of soil hydraulic characteristics, scaling was chosen in the final stage of the project for the water balance simulations. From reports already published about the project, the one of Hopmans and Stricker (1987) contains a complete overview. The complex picture of the seasonal one-dimensional simulation with a stochastic approach to the soil hydraulic characteristics and groundwater levels is in the final report of Hopmans (1987).

Scaling, based on the similar media theory, is considered as one of the efficient methods which allows us to develop a simple relationship between various soil hydraulic retention curves and hydraulic conductivities. The relationship is described by the scaling factors and the mean scaled characteristics. Within the known statistical distributions of scaling factors the stochastic approach can then be used to express the realistic variability of the soil hydraulic characteristics as they input into the water balance simulation models. On the other hand, by replacing the measured data, or their closest mathematical approximation, by the scaled characteristics, we are introducing certain deviations from the measured reality. The objective of this study is to find out how sensitive the results of the soil water flow simulations are to the variations in the shapes of the input soil hydraulic functions, and what are the effects of scaling.

The other aim is a comparison of sets of simulations by means of the deterministic model with deterministically and stochastically treated input soil hydraulic characteristics derived in both cases from the same experimental data.

The SWATRE model (Feddes at al.,1978, Belmans at al.,1981) was employed for simulation. Based on the numerical solution of Richard's equation this one dimensional finite difference model simulates the vertical transient saturated-unsaturated flow of water through a layered soil profile with the vegetation effects included. With the general boundary conditions and the built-in options which allow the optimization of the irrigation rates or the drainage system developement, this model represents a tool widely used for many practical and theoretical purposes. The version which was used has the soil inputs adapted for scaling (Hopmans,1986b).

The measured points for the retention curves and the hydraulic conductivities in seven locations within the 0.5 ha area of one soil type (Brom, 1983) were used as the basic data in all the variations of the soil sets. The data are described in the report of Hopmans and Stricker (1987) under sampling scheme two and represent one soil type only. In the soil profile there is continuous presence of groundwater level all over the area. For simplicity the area included in the study will be called the B-area. The water balance is simulated separately for each of the 7 locations.

In the following chapters at first the basic information about the input data used in the study is presented, then the significance and accuracy of the particular components of the water balance as calculated by the model are looked at. Calculations were done for two types of lower boundary conditions represented by the measured and calculated groundwater-levels. The suitability of both types for the simulation purposes is discussed. The detailed description of the input sets of the ordinary and scaled soil hydraulic functions as they were formed for all the various simulation runs are the content of the next chapter together with the discussion of their mutual relations.
Then the results of the simulations for particular locations are presented followed by the average results for the area and by a discussion of the results. In the last chapter a comparison is made between the results for deterministicly treated inputs and randomly generated inputs of soil hydraulic functions and these are discussed.

2. Input data

2.1 Invariant part of the inputs

Some simulations for the area under study have already been done and the results published (van Immerzeel 1985, Hopmans and van Immerzeel 1986). To provide continuity, the soil profile was described in the same way as in the study of van Immerzeel; also the same season was selected. In the simulatons, the soil profile of the B-area is described by two layers, the upper layer representing the surface horizon A and the lower layer the subsoil BC- horizon. The depth of the upper layer was assumed in all calculations to be 40 cm. The depth of the root zone was also constant at 30 cm, with the Darcian flux calculated at its bottom. The total depth of the profile was 300cm in all cases. The original sink term of Feddes (1978) was used. The relatively dry summer season April 1st to September 30th 1982 was considered, with daily values of precipitation, potential transpiration and minimum allowed pressure heads prescribed as the upper boundary condition. Only for this period are the daily groundwater level data at each location of B-area available; their values were taken from van Immerzeel.

2.2 Options used for the soil hydraulic functions

Van Genuchten's expressions for the soil hydraulic functions were implemented into SWATRE (Hopmans, 1986b) in the form

$$\Theta = [\ 1+|\alpha\ h|^{n}]^{-m} \quad ; \quad \Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r} \qquad (1)$$

and

$$K = K_s.K_r \ ; \qquad K_r = \Theta^{1/2}[\ 1 - (1 - \Theta^{1/m})^{m}]^{2} \qquad (2)$$

where θ, θ_s, θ_r are the volumetric soil water content and its saturated and residual values, and Θ is the effective soil water content;
K_s and K_r are the saturated [L/T] and the relative hydraulic conductivities (dimensionless); n, α and m are fitting parameters, where m=1-1/n.

In each of two layers for each of seven locations in the B-area the soil characteristics were treated separately. Initially, the van Genuchten's expression was fitted to the measured retention curve data and represents the ordinary soil retention curve. In connection with this, three different types of hydraulic conductivities were formed.

1) the eye-ball fit through the measured hydraulic conductivity data (van Immerzeel, 1986)

2) van Genuchten's prediction of relative conductivities

(K_r) in combination with measured saturated hydraulic conductivity values K_s

3) van Genuchten's prediction of K_r in combination with the fitted saturated hydraulic conductivities K_s* developed from the unsaturated hydraulic conductivity data (Hopmans and Overmars,1986)

The values of the parameters of the ordinary retention curves are listed in Table 1. The retention curves and hydraulic conductivities are given in Fig. 1a,b,c to 7a,b,c.

When the soil hydraulic characteristics are described by means of scaling the scaled curves for the i-th location were expressed from mean scaled curves (Hopmans,1986a) through scaling factors α_{hi} and α_{ki} as

$$K_i = \alpha_{hi}^2 K_m \qquad \text{or} \qquad K_i = \alpha_{ki}^2 K_m \tag{3}$$

$$C(h_i) = \alpha_{hi} C(h_m), \quad C(h_i) = \frac{\delta\theta_i}{\delta h_i} \tag{4}$$

the index m denotes the mean scaled variables and C is water capacity.

The parameters of Equations (1) and (2) for the mean scaled retention curves derived for the B-area are given in Table 2. The values of the scaling factors for particular locations and horizons are given in Table 3. The scaled hydraulic functions are in Figures 1a,b,d to 7a,b,d. The four various combinations of scaled curves were formed to study the effects of scaling. Their detailed description is given later.

For the stochastic approach the log-normal distribution of α_h and the normal distribution of θ_s for each layer (Hopmans,1986) were calculated for the B-area. These were required for the Monte Carlo generation of scaling factors α_h and saturated moisture content θ_s to create in combination with the mean scaled curves the set of randomly generated soil inputs for the comparison of the deterministic and stochastic approaches in the last part of the work. The parameters of the distributions used in the random generation of the retention curves for each layer are given in Table 4.

2.3 Options used for the lower boundary condition

Simulations were done for two types of lower boundary conditions:

1) Measured groundwater levels (mGWL) as the input; the fluxes at the bottom of the profile were calculated as output of the model
2) Fluxes derived from the groundwater level-discharge relationship (GWL-D) were taken as the input, then the groundwater levels were calculated (cGWL) as the output

An exponential groundwater level-discharge relationship is built into the SWATRE in the form

$$q_t = A_g \cdot \exp(B_g \cdot GWL) , \qquad (5)$$

q_t is the outflow flux at the bottom of the profile in cm/day (negative downwards)
and GWL is the daily depth of the groundwater level in cm (in absolute values).
A_g and B_g are parameters found by regression analysis from the Hupselse Beek discharge and the measured GWL values. The parameters together with the initial groundwater level for each location are given in Table 5. In addition there are parameters derived for an arbitrary extreme GWL-D relationship and for the GWL-D of the whole Hupselse Beek area (from Hopmans, 1986c).

3. Water balance as simulated by the model

3.1 Description of the modelled water balance components

Reduction, actual evapotranspiration, changes in the water content of the root zone and of the total profile, fluxes at the bottom of both the root zone and the total profile and variations of groundwater level were subjects of interest. Cumulative values for the whole period and in some cases also for a selected period of five days at the end of rather long dry period, were compared.

Actual evapotranspiration (AE),(evap) is one of the most important components in water balance mainly for its practical use. In the growing season it represents the highest contribution to the water balance. Correspondingly it should have the smallest variances. The values of simulated AE are strongly influenced by the sink-term chosen. Differences between actual and potential evapotranspiration (E_{pot}) are marked as deficit and shown for all cases. Another evaluation of evapotranspiration appears in the reduction [%] calculated as

$$red. = (1 - \Sigma EA/\Sigma E_{pot})*100$$

from cumulative actual and cumulative potential evapotranspiration. A disadvantage of this expression is that with the growing sum of cumulative values during the growing season, the day-to-day changes have less influence. For the period of five days an extra value was calculated using sums of five days only.

The two fluxes q_r and q_t are Darcian fluxes. The flux at the bottom of the root zone is q_r, the cumulative flux through the lower boundary is q_t. An accurate estimate of q_t is important for water management purposes, since it represents an output of the soil profile water balance. In the model its value depends fundamentally on the type of lower boundary condition. It varies greatly also within one type of lower boundary condition, showing a high dependence on soil hydraulic functions, especially in the case of the measured GWL.

Two quantities, vol_r and vol_t, are the cumulative changes of water stored in the root zone and whole soil profile. They are calculated from the moisture content distribution and could be easily checked if some soil moisture content measurements had been done. They have the smallest error due to the chosen model scheme, and are ideal components for comparisons with reality. They represent the depletion of the profile during the season. Again, their values, as simulated by the model, are profoundly affected by the type of lower boundary condition. Vol_r has a high variation while vol_t is relatively stable within one type of lower boundary condition as the soil characteristics are changed.
The preassure head h is the average pressure head over the root zone at the end of the calculated period.

3.2 The discussion of the discharge boundary condition

From the seven options of the lower boundary conditions offered in the SWATRE model, the daily measured values of GWL prescribed as inputs is the most commonly used and recommended condition in the case of the presence of GWL in the soil profile. In the case of the randomly generated lower boundary condition inputs, the boundary condition using the measured GWL could hardly be employed. The other possible option is the prescribed GWL-D flux condition with the calculated GWL. This option was studied mainly because a convenient description of the general lower boundary condition for the stochastic approach was looked for.

The choice of the lower boundary condition in one -dimensional vertical models is questionable. When an exponential groundwater level-discharge relationship is imposed at the bottom of the profile, the only possible flux is the outflow from the profile. Such a situation could be realistic for modeling larger blocks where the lateral flow smoothes out differences at the bottom layers. However, in the case of a single vertical column, due to water demands caused by evapotranspiration in combination with the conductive properties of the soils of each particular vertical column, the upward flow can take place with the same chance. On the other hand when measured groundwater levels are imposed as the boundary condition, very deformed fluxes can be produced due to slightly incorrect soil characteristics since in each case the boundary condition has to be held. In the ideal case the agreement of the groundwater levels calculated and measured in one vertical column would mean that the description of the soil profile is fair. The comparison of the simulations for both types of lower boundary conditions supplies very interesting material for the analysis of the influence of soil hydraulic functions. For cases where only simulations with the calculated GWL were done, the agreement with measured values of GWL at the end of calculated period was used as the main measure in judging of the best simulated results.

The construction of the simulation model SWATRE creates two basic sources of discrepancies:

a) When the daily values of GWL measured and calculated are compared, it appears that, after some heavy precipitation, the values of the calculated GWL are not able to follow the sudden increase of the real GWL. Partly this is caused by the daily mean rainfall as input which has all the peaks which actually cause the GWL increase flattened, and partly it is due to the construction of the simulation model itself. In the model, changes of water level can only happen due to transfer through the soil medium, ignoring that in reality an increase of GWL is governed also by the existence of preferential pathways and by the increase of level of open-water surfaces (channels, etc.). An example is shown in Figure 8.

b) Because of the iteration process used in the GWL calculation, in the case of a quick fall of GWL when depletion of the profile takes place, the calculated values of GWL oscillate around the value it should achieve. For this reason the daily values can be up to + 2.5 cm incorrect. In the five days period example this feature already played a significant role. Also it was causing long calculation times (too many iterations were needed). The effect described can be seen in Figure 9.

Besides the above objections there are problems with the evaluation of the GWL-D relationship itself. In the area under study the only available discharge for the groundwaterlevel-discharge relationship was the discharge from whole Hupselse Beek area (approximately 650 ha), of which the B-area only constituted 0.1% . The daily GWLs for each location in the B-area were obtained from a regression analysis of weekly values of each location with Assink data (van Immerzeel, 1985). The data used for the regression analysis were all for GWL deeper than 120 cms since measurements in the B-area started late in the summer. From the regression analysis it was concluded that during the wet extreme the GWLs in the B-area are about 40 cm higher than in Assink (see Figure 10). This is reflected in the GWL-D relationship for the B-area.

3.3 Effects of the GWL-D relationship determination

The GWLs of the B-area do not vary much between particular locations. As well as the particular GWL-D for each site the mean GWL-D for all seven locations was tested, together with three variations of the initial water level, the mean and the upper and lower extremes of all seven location. To see the effects of the GWL-D determination, the arbitrary extreme GWL-D relationship and the mean GWL-D of the whole watershed (Hopmans,1986c) were applied as well (Figure 11). In all these simulations the mean scaled parameters were used as the soil hydraulic functions.

From the results in Table 6 it is evident that the changes of the initial water level in B-area do not influence much the cumulative actual evapotranspiration and groundwater levels, but effects can be seen in both volumes and fluxes. The influence of an extreme GWL-D relationship is stronger in the changes of outflow flux and the total volume of water content but less in the root zone balance. It hardly changes the modelled actual evapotranspiration but it decreases GWL. The effects of the GWL-D of the whole Hupselse Beek watershed are the same.

The total cumulative discharge in Hupselse Beek for the period under study is 22 mm. In comparison with the cumulative potential evapotranspiration, which is 448 mm per season, the proportion of the discharge in the total water balance in the studied area is very low, about 5%. The value of the cumulative precipitation is 228 mm. Cumulative fluxes calculated in the model for various groundwaterlevel -discharge relationships were within the range 11-20 mm for particular locations. The extreme relation gave, in combination with mean scaled soil curves, a total of 19.7 mm. The GWL-D derived for the whole Hupselse Beek watershed produced 17.0 mm. On the other hand, the combination of mean scaled soil curves and the mean GWL-D for the B-area only resulted in 14,9 mm. The discrepancies which appeared in the calculated GWL due to a changing GWL-D relationship (see Table 6) are within 5 cm at the end of the calculated season, also for the case of the arbitrary extreme GWL-D relationship and one derived for the whole watershed. Obviously no significant error in the simulated results can be introduced using the lower boundary condition with the calculated GWL. From the interpretation of results presented in later chapters it is evident that the role of soil hydraulic functions is much more important.

3.4. A remark about the wet reduction

As a consequence of the chosen sink term in the simulations with the measured GWL installed as the lower boundary condition, a reduction in the actual evapotranspiration appeared in results due to the wet conditions at the beginning of growing season. It was caused by the daily values of measured GWL which are in extremes higher than the calculated GWL. Additional values of the reduced cumulative actual evapotranspiration and its deficit (marked with * in the tables) were thus calculated by subtracting the reduction due to wet conditions to get comparable results of reduction for both types of lower boundary conditions. Values of reduced reduction are given in Table 7. Wet conditions also influenced all other components of the water balance simulation, but the effect cannot be eliminated. This was the reason why, as well as the whole summer season, a period of five days (day 211-215) with no rain was also studied in some cases. Results are given in Tables 8-12 and are not discussed here.

4. Formation of the soil data inputs for particular runs

Simulations were done for two expressions for the retention curves, the ordinary one and the scaled one, in combination with five hydraulic conductivity runs, of which three belong to the ordinary retention curve and two are supplied with the scaled retention curve. As already mentioned, from three versions of hydraulic conductivity used with the ordinary retention curve one case should represent the raw data. The values are taken from the work of van Immerzeel (1986). In the tables, figures and further discussion this case is marked as SET 1. In SET 2 the measured saturated K_s values are used with the Mualem-van Genuchten prediction of K_r to express hydraulic conductivity from parameters of the ordinary retention curve. This expression of hydraulic conductivity is often recommended as a satisfactory alternative when there are no measured data of unsaturated conductivities. SET 3 is again based on van Genuchten's prediction of K_r but in connection with the fitted values of saturated hydraulic conductivity K_s*. The new value K_s* is created in such a way that in combination with van Genuchten's prediction of K_r the developed hydraulic conductivities represent the best fit through the measured unsaturated conductivities (Hopmans and Overmars, 1986). This set was used as the base for the scaling study.

The scaling analysis gives an alternative expression for the soil inputs. It seems very suitable for the description of hydraulic properties of soils in the stochastic approach. Scaling factors can be derived at the basis of the similar media concept, with one scaling factor representing the behaviour of the soil in question. The theory can be used when the scaling factors obtained from retention curves are identical to those obtained from hydraulic conductivity data. When this is not true, the similarity concept of geometrically dissimilar soils can be applied, in such case two sets of scaling factors have to be used, one for the retention curves and one for the hydraulic conductivities. Figure 12 shows the relationship of the α_h and α_k scaling factors for the B-area. It can be seen that their mutual distribution towards the symmetry axis is rather scattered to prove the fit of the similarity concept. The number of points (seven) is too small to form any significant statistical conclusions. The scatter of the second layer is slightly less. In the form in which the scaling theory is introduced here, the α_h scaling factor represents the variations of the α parameter of van Genuchten's expression (Eq.1), the effective water content is the same for all locations (compare Eq.1 and 3). Two modifications were investigated. In the first, SET α_h, the saturated water content was taken as the mean value of θ_s from all locations and stayed constant. Thus the scaled retention curves which vary within the limits given by the extreme scaling factors α_h, reflect only changes in van Genuchten's parameter α, as can be seen in Fig 13. To describe the variations of the retention curves more generally, the saturated soil moisture contents have to be scaled as well. Thus, in the second modification, SET α_h+θ_s, the saturated moisture content of each location was introduced to vary θ_s. In SET α_h and SET $\alpha_h+\theta_s$ the hydraulic conductivities were calculated from the values of mean scaled hydraulic conductivities using the α_h scaling factor.

As mentioned above, in combination with one scaled retention curve, two cases of hydraulic conductivities can be used, given by the different values of saturated hydraulic conductivity K_s for each scaling factor α_h and α_k. Together with the unchanged K_r it means a similar variation in hydraulic conductivities as in the case of SET 2 and SET 3 of ordinary retention curves. Runs which take into account α_k were done for both modifications of the θ_s approach. For constant θ_s the input set is marked SET $\alpha_h+\alpha_k$ and for varying θ_s SET $\alpha_h+\alpha_k+\theta_s$. All K_s values are given in Table 13.

Changes of α_h together with changes of θ_s imitate to a certain limited extent also variations of the parameter n of van Genuchten's expression for the retention curve.

For reference in the following discussion the description of all the sets is listed below. Values of the parameters of the ordinary retention curves and the scaling factors vary for each location.

SET	retention curve	hydraulic conductivities K_r	K_s
1	ordinary	eye-balled fit through data	
2	ordinary	ordinary	measured
3	ordinary	ordinary	fitted
α_h	scaled α_h, constant θ_s	mean scaled	scaled α_h
$\alpha_h+\alpha_k$	scaled α_h, constant θ_s	mean scaled	scaled α_k
$\alpha_h+\theta_s$	scaled α_h, variant θ_s	mean scaled	scaled α_h
$\alpha_h+\alpha_k+\theta_s$	scaled α_h, variant θ_s	mean scaled	scaled α_k

At each location simulations with the measured GWL as the boundary condition and with GWL-D boundary condition as well were done for SET 1, SET 2, SET 3, SET α_h and SET $\alpha_h+\alpha_k$. For SET $\alpha_h+\theta_s$ and SET $\alpha_h+\alpha_k+\theta_s$ only runs with the GWL-D boundary condition were simulated. In the case of ordinary soils the GWL-D derived separately for each location was used. For SET 3 the mean GWL-D was applied as well. For scaled soils only the mean GWL-D was taken.

5. Description of the simulated results

Initially the results of all input combinations will be considered for each particular location. Then means Ø, standard deviations σ and coefficients of variation Cv for the whole group of seven locations for each input set will be looked at. For the first reading it is recommended to skip the whole of Chapter 5.

5.1 Results at particular locations

To understand the following description the tables of results together with figures of soil characteristics and tables of its parameters should be looked at (Figures 1-7 and Tables 14-20). The verbal description is not systematic, it is just hinting at the most important points. The characteristics of SET $\alpha_h+\theta_s$ and SET $\alpha_h+\alpha_k+\theta_s$ are not plotted. Also their results in each particular location will be discussed later for all location at the same time in the next subchapter.

Location 1

Scaled and ordinary retention curves of the first layer are almost identical. K α_h are very similar to K3, lower near saturation; Kα_k are higher over the whole range. In the second layer the scaled curve shows significantly higher moisture contents in the wet part of the curve and is less sharply s-shaped. Conductivities K3 in the saturated part are more than ten times less than the data. Scaled K α_h fit K3 up to 1000 cm of h, be,ing slightly, then follow the course of the raw data. K α_k are in whole course slightly lower than K α_h. In both layers, the unsaturated K2 are higher than the raw data. The saturated K_s* is lower than the raw K_s.

Scaled SET α_h gives the best agreement between the two lower boundary conditions runs, SET α_h+α_k is even better in GWL, but much worse in AE. The original conductivity data (SET 1) cause a too high deficit of AE but reasonable GWL. SET 2 (v.G.prediction) has no reduction but the GWL are too deep. SET 3 is between these two as a mean on both sides, AE and GWL. The mean GWL-D causes less deficit of AE and only slightly lower GWL, but there are no important changes.

Ordinary soils have a too high water uptake for mGWL. Looking at the θ-h and K-h relationships, the obvious reason seems to be the shape of the retention curve of the second layer.

In this location another eye-ball fit of hydraulic conductivity was used rather than that used in the van Immerzeel work. It is not seen in the picture.

Location 2

The retention curve of the 1st layer fits quite well the measured data in the saturated part. K2, K3 and Kα_k are almost equal. Kα_h is less in the whole course, as well as K1, which does not express ideally the raw data. In layer two, both retention curves are almost identical. K3 are much lower than K2 in the whole run, both are crossing K1 in the middle range between 100-1000cm of h, where K1 are lower. The scaled K are both quite similar, in between K2 and K3.

All sets produce very deep GWL and have as a contrast a very high upward flow for mGWL. Deficits of AE are less than 1mm per season. The only exception is SET 1 with cGWL, where the deficit is 11.8mm and GWL decrease only 171.5 cm.

Location 3

The greatest differences in simulations caused by the soil characteristics appeared in this location. SET 2 (van Genuchten) shows the most reasonable results for both GWL cases, the most reasonable GWL and upward flow, two other real sets go deeper in GWL, both scaled very deep. With the large drop in cGWL corresponds a high upward flow in the case of mGWL. There is an extreme upward flow for the scaled curves.
At the top of the profile the highest reduction takes place for SET 2 in both GWL cases. A slight reduction is for SET α_h and SET 1, the rest shows no reduction at all.
This location behaves as a lavish profile with no reduction, high upward flow and deep GWL.

Location 4

This location shows the opposite behaviour from that of location 3; it behaves as the least conductive location.

In the first layer the scaled retention curve is slightly higher than the ordinary curve in the area near to saturation. K2 are the lowest of all the approximations.
In the second layer the scaled retention curve varies very much from the ordinary one. V.G. K2 are again lowest, K3 are highest, the fitted K_s* is about nine times higher than the measured one. Both scaled Ks came back to the measured value, $Ks\alpha_k$ being lowest of all. Due to differences in both retention curves, the scaled unsaturated hydraulic conductivities are much higher (except near to saturation) than all K1, K2, and K3.
The scaling factor of the second layer is near to 1, a consequence is that the results of scaled sets for location 4 do not differ much from results of runs in other locations, but are very different in comparison with results of ordinary soil sets at location 4 itself. With the ordinary curves there are very high

reductions, highest in the v.G. case, lowest for fitted K2. Profile produces in the case of mGWL an outflow which is almost ten times higher than the total cumulative discharge of the Hupsel area. On the other hand the decrease of cGWL is too small. The least difference between the results of the two boundary conditions is given for SET 3.

Location 5

The scaled and ordinary retention curves are again very different, in layer one as well as in layer two. Scaled K_s of the upper layer are similar to the K_s measured, here fitted K_s* causes the lowest estimate of K in the saturated part. K2 are highest in the whole run. The eye-ball fits in both layers are not ideal especially in sturated part. $K\alpha_H$, almost the same as $K\alpha_K$, are very similar to K3. For the second layer, v.G. conductivities K2 are lowest, except for high K_s* also K3 are lower than the eye-ball fit K1. Saturated $K_s\alpha_H$ and $K_s\alpha_K$ are lower than K_s* but both scaled unsaturated conductivities, which are practically equal, in this case give higher values than K3.

Location 5 is the only location which behaves as an "ideal" one. There is a fair agreement between the results of the two boundary condition runs. When SET 1 is used, it supplies the nearest results for the bottom flux, and a small difference between GWL calculated and measured. There is a difference in deficits of AE. For SET 3 more similar results are obtained in evapotranspiration, at the bottom flux and GWL the difference increases. SET 2 supplies the highest gap in the bottom fluxes, but very small difference in GWL. The difference in AE is average.
Results of scaled runs, as could be expected from the shapes of the retention curves, differ very much in the GWL decrease. In the case of mGWL it gives upward flow instead. In evapotranspiration there are not big differences.

Location 6

The retention curves for the upper layer are almost identical, for the lower layer they differ in the saturated part. K2 are highest, with K_s three times higher than K_s*. K1 do not match too well with data neither with both K2 and K3. K α_h are almost the same as K3, except for the saturated part, where they are higher. K α_k are insignificantly less. For the lower layer, K2 are again highest, the fitted K_s* is five times less. K1 are in saturated part very low and do not follow the data. Kα_h are almost identical with K3, but much higher in the saturated part. K α_k are almost the same as K α_h. The results of sets with K1, K2 and K3 are all different, the fastest conductivities (K2) giving the least deficit and the deepest cGWL, SET 1 gives a modest AE deficit and the nearest fit for mGWL from all three runs. The upward flows in the case of mGWL are corresponding, smallest for SET 1, biggest for SET 2. Due to the fact that ordinary and scaled retention curves are so uniform, except for the saturated part of the second layer, and K3 and K α_h are similarly equal, the difference between the results of SET 3 and SET α_h reflects the variation of θ_s of the second layer (0.339 for scaled, 0.298 for ordinary retention curve). From the results it can be seen that while the actual evapotranspiration stayed unchanged, the bottom flux of the scaled run increased.Its cGWL are less deep, in GWL the same as for SET 1. Since in the second layer α_h is almost the same as α_k, the cGWL for the SET α_k run stayed unchanged from the cGWL of the SET α_h run. Rather surprising is a great increase of reduction in mGWL for SET α_k.

Location 7

In both layers the ordinary retention curves do not coincide with the scaled curves in the middle and dry part. Differences are greater in the second layer. V.G. K2 are higher than K1 and K3 in the first layer, lower in the second layer, through the whole range, including K_s. $K\alpha_h$ of the first layer are higher than K3, except for the saturated part, where they differ very little (see K_s* and $K_s\ \alpha_h$). $K\ \alpha_k$ are in its course the same as K3 and are lower near saturation.

Location 7 represents a relatively dry profile with deficits of AE of about 10 mm per season. The GWL decrease is the least for SET 1 but in the case of SET 2 and SET 3 does not vary much. AE deficit is greatest for SET 1 and least for SET 2.

For SET α_h there is less AE deficit but the decrease of cGWL is rather big. With the SET α_k there is a high upward flow for mGWL and an increase of reduction.

5.2 Some general effects which appeared for particular locations

Results of SET α_h+θ_s and SET α_h+ α_k+θ_s for each location can be described for all locations at once since introducing θ_s into α_h runs causes easily explainable effects as well as introducing K_s into α_h+θ_s runs. These effects can be taken as a contribution to the general conclusions about simulation behaviour.

In all locations differences between runs of SET 3 with particular GWL-D and runs of SET 3 with mean GWL-D are only negligible in comparison with differences introduced by the change of soil characteristics.

5.3 Mean results for the group of seven locations

The mean results of all combinations calculated for 7 locations are visible in Fig 14. Means of all sets are plotted in order: SET 1, SET 2, SET 3, SET α_h, SET α_h+α_k; together with their standard deviation plotted as the limit. Plots are done separately for measured and calculated GWL, in the latter case also the SET 3 with mean GWL-d relationship is added for comparison. Values of all results are given in Tables 21 and 22.

There is a trend which appears along the series: higher depletion of the profile represented by higher actual evapotranspiration and in the case of the calculated GWL by a higher depletion of the total volume of water and a deeper groundwater recession in sequence raw data - K_s fitted - one scaling factor. For the measured GWL where due to fixed GWL the balance situation is very different, here the total volume of water is increasing, together with the value of upward flow. The set with two scaling factors is showing results which are for all components a step nearer to the results of SET 3 from which scaling factors were derived, the actual evapotranspiration is even less than for SET 3, but at the bottom part of the profile changes are only small in comparison with the results of the set with one scaling factor only. Introducing θ_s produces a further decrease of cGWL accompanied in comparison with α_h run by higher variance. In AE there is a steep increase of deficit which is almost four times higher than for SET α_h, two times higher than for SET 3 and slightly less than for SET 1. Adding α_k as well, the results are similar to those of run α_h+ α_k, with only slightly deeper cGWL and slightly less deficit of AE. All scaled runs show the deepest GWL and no combination improves on it.

It can be seen that the mean GWL-D relationship in connection with SET 3, when compared with results of the runs where the particular GWL-D relationships for each location were used, has a very small effect. Van Genuchten's prediction supplies means which are within those of the SET 1 and SET 3 but they are accompanied by extremely high variances, especially for actual evapotranspiration and calculated GWL, coefficients of variation are 2 - 3 times higher than for other sets. The lowest variances are in the results of SET α_h, followed by SET α_h+ α_k.

As has already been mentioned, the diversity of the final water balance caused by two different boundary conditions is very apparent in Fig. 14. Fewer differences are seen in the actual evapotranspiration , which is almost equal for SET 1 and SET α_h in both cases, for SET 2, SET 3 and SET $\alpha_h + \alpha_k$ higher for the calculated GWL. For measured GWL the variances are higher. Differences in fluxes vary for each set, for measured GWL with higher variances in the case of ordinary soils and smaller variances in the case of scaled soils. Cumulative water content of the root zone shows less decrease for the measured GWL but higher variance. Basic differences are seen in the cumulative water content and in the bottom flux. For measured GWL less depletion of water for the whole soil profile takes place, together with high upward fluxes. The variability of cumulative water content vol_t and flux q_t is high. Cumulative water contents in the case of the calculated GWL are higher (in absolute value) but less variable. Fluxes q_t are negative, also less variable.

When extremely high upward flow appears in the case of the measured GWL installed as the lower boundary condition, for the same soil inputs there is an extreme decrease in the calculated water levels for the GWL-D relationship.

To get the picture about the range of all the simulated results, the extremes of the particular simulations and the average results of defined soil sets and their Cv are given in Table 23. The variance in the results for all calculated combinations of soil sets for both types of lower boundary conditions is given in Table 24.

6. Discussion of results

Of the 7 locations under consideration, Location 5 behaves as an "ideal" profile, since for sets of ordinary soils there is an agreement between the measured and calculated GWL. It is the only profile which produces the same outflow in both cases of lower boundary conditions. It produces very similar results for all three sets of ordinary soils, SET 1, SET 2 and SET 3. For all other locations there are differences between the two lower boundary runs increasing with extreme behaviour at particular locations (location 4 is very dry, locations 2 and 3 are very wet); the more extreme the corresponding retention curve in relation to case 5, the bigger is the difference between the results for both lower boundary conditions. For the runs with scaled hydraulic functions the situation in comparison of the behaviour of a particular location has another character as will be shown later.

The existence of two layers with nonuniform behaviour due to independently varying soil characteristics is the reason why the processes in a particular soil layer cannot always be clearly traced, since there is a combined effect from both layers. In a few extreme cases the other layer has a stronger influence than the one we are looking at. Also the allied influence of all parameters of soil hydraulic functions can be intricate in tracing the effects of particular parameters.

6.1 Effects of α_h

The set of calculations with scaled characteristics and calculated GWL supplies results in which the virtual effect of each layer can be partly seen, since only parameter α_h is changing, for the second layer often has values near 1. This is the reason why so much attention has been paid to this set. In Table 25, the results are classified with decreasing groundwater levels at the end of the calculated period. A number of arbitrary additional simulations for combinations with α_h equal to 1 are added. When the influence of scaling factors of both layers is looked at, it is evident that in most cases the scaling factors of the bottom layer have the strongest influence on GWL movement regardless of what the value of the upper layer scaling factor is (Tab.25, cases marked 6-9). However, for example in case 11 (results for location 4), which has the same scaling factor α_h for the upper layer as in case 9, the smaller α_h of the second layer

means drastic changes of the whole water balance, including GWL. Only q_t stayed unchanged. This means that the role of the upper layer was also governing the GWL movements here.
The actual evapotranspiration seems in a few cases to depend more on the upper layer parameters but the effect is not so straightforward.

To judge the influence of the α_h parameter, the conclusion can be drawn that deeper calculated GWLs are obtained by shifting the scaled retention curve of the second layer up (by smaller α_h). By shifting the scaled retention curve of the upper layer up, higher actual evapotranspiration can take place (Remark: changes of retention curve due to changes of α can be regarded as vertical shifting only when h is taken on a log-scale, on a normal scale the changing of α introduces a slight rotation of the retention curve).

6.2 Effects of θ_s

Large effects can be introduced due to changes in θ_s. The differences in saturated soil moisture content are the significant reason for large discrepancies between the results of simulations with real and scaled (α_h) soil characteristics. A good example is shown in the results for location 6 in the comparison of real and scaled runs, where only θ_s of the second layer varies for the scaled retention curve, with the rest of the soil characteristics practically unchanged. Here the decrease of α_h causes a large fall in the calculated GWL for SET 3 soils. When θ_s is introduced together with α_h, cGWL is deeper than in SET 3 but the discrepancy in AE then appears. Comparison of runs α_h and α_h+θ_s in particular locations indicates a clear negative relationship between the size of θ_s and the decrease of cGWL (see Table 26). It is evident from the same table that in the first layer there is a general negative dependence of AE on the size of θ_s for the first layer although in two cases this is not true. It has already been mentioned that variations of the α_h and θ_s parameters together substitute variations of n but not in the whole range of effects which variations of n itself could introduce.

6.3 Effects of K_s

The effects of K estimation can be studied on three different combinations of runs and are shown in Tables 27, and 28.
The clearest picture is given in the comparison of SET 2 and SET 3 (fitted K_s*) since the greatest differences in hydraulic conductivities arise due to the K_s* fitted. Looking at the second layer there is a positive relationship between K_s and the GWL depth, the increase of K_s is followed by a deeper GWL in all locations. In the upper layer the relation between K_s and the AE deficit is opposite, with higher K_s there is less reduction. For two locations this is not true.
In the remaining two comparisons where the change of K_s is introduced through α_k scaling factors the differences of K_s are much smaller, nevertheless the same rules appeared as in the ordinary soil comparison (K2-K3) already described, only with more exceptions (especially in the upper layer on AE effects).

7. The comparison of deterministic and randomly generated results

In Table 29 are the mean results of 36 runs in which the scaling factors α_h and the saturated moisture contents θ_s of each layer are randomly generated and used then with the mean scaled retention curves to create the soil input sets. These sets represent the stochastic approach to the treatment of soil hydraulic characteristics. Since α_h and θ_s are generated from whole distributions of α_h and θ_s, higher variances can be expected. Results should correspond to the results of SET α_h+ θ_s where the soil inputs were built up in the same way (this means with the scaling factors α_h and the original saturated moisture contents θ_s in combination with the mean scaled retention curves) and resemble the deterministic approach as well as other sets discussed in previous chapter. It can be seen that for the randomly generated (RG) soil inputs, in the results at the end of the calculated season a slightly less deep mean GWL appears with less variance, and less mean EA deficit also with smaller variance. When compared with the results of SET 3 which was the base for scaling then the RG set gives equal mean AE values with higher variance, but much lower mean cGWL with smaller variance. In comparison with the mean daily value of the mean measured GWL for the B-area at the end of calculated period, the related mean value of cGWL for SET 3 is approximately 30 cm deeper, for RG set 46 cm deeper (for SET $\alpha_h + \theta_s$ is 49cm deeper). There are no measured data to compare AE values.

Since the RG results fit very well with the corresponding results of the deterministic SET $\alpha_h + \theta_s$, the chosen procedure of Monte Carlo generation of soil parameters within their known distribution (Hopmans,1987) has proved to produce very reliable results. Thus the stochastic treatment of the soil inputs used in the deterministic model can be highly recommended for analysis of the spatial variability effects. A careful choice of combinations of α_h and θ_s at critical confidence limits of their frequency distributions could keep the number of necessary simulations quite low and still within the safe range of outputs. It would avoid the long computer-time needed to create the large randomly generated set.

In this study, the reason why the results of all the scaled runs including the RG set differ from the results supplied by ordinary soils SET 1, or better from the measured reality in GWL, has to be looked for in the prócess used for the determination of the scaled retention curves, or in the fitting of the retention curve parameters through the measured data, respectively.

The retention curve and the hydraulic conductivity together represent for each soil the strict rule of behaviour. When we want to obtain reliable simulation results from our models this rule has to be the closest one to the rule which is hidden in the scatter of measured data. The fitting of approximation curves, so important for smooth computing, can introduce departures from the original law. Here the effects of various departures have appeared.

It is known that van Genuchten's prediction of hydraulic conductivities in many cases does not give good results in the near saturation part since the decrease of K_r is too steep there (van Genuchten and Nielsen 1985, Vogel et al.1985). The similar media concept and van Genuchten's K prediction are both built on the capillary models theory (Miller and Miller 1956, Childs and Collis-George 1953, Brooks and Corey 1964, van Genuchten 1978). Thus, when conductivities are expressed from the v.G. formulae, and retention curves are similar, also K_r are similar, and only the K_s distribution can cause differences in scaled α_k. Here, from two sets of K_s distribution which were in combination with the ordinary soil under consideration, the original measured K_s represent one extreme of the estimated saturated hydraulic conductivity and the fitted K_s the opposite extreme. It can be seen from a comparison of the scaling factors (see Fig 12) that the dissimilarity was introduced by the extrapolation of the K_s*. The scaling factors of the original K_s were not developed but the scatter of this set of K_s is apparently much smaller (less variance; see Table 13) than for the fitted K_s*. Also the mean cGWL of the run of SET 2 with the original K_s is nearer to the mean of the measured GWL. All data here represent one soil type and similarity can be expected. From the point of view of other soil types they should be regarded as homogenous. Nevertheless this was not found, since the parameters of the retention curves, as developed by the routine fitting program, are too diverse for each site. From discussion of the influence of the particular parameters it is evident that a great variation of results can be introduced by little variation in the retention curve parameters. Thus after all it seems more convenient to try to reach more similar effects of hydraulic properties by evaluating more similar retention curves than by fitting the new K_s*. Then also the mean scaled retention curve could represent better the whole set of data and would allow the RG results to be closer to reality. There is a question of the number of retention curve and hydraulic conductivity data needed for reliable scaling analysis when one soil type is considered. The best way to determine the mean scaled curve needs to be studied further.

Here only the description of the results and their discussion has been done to document the work for purposes of any further use, a more detailed analysis will be reported in a short time. In Apendix there are examples of seasonal courses of water balance components for combinations of soil input sets and lower boundary conditions.

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	α	n	θ_s	K_s	K_s^*
	[1/cm]	-	[cm³/cm³]	[cm/day]	[cm/day]
			surface layer		
location					
1	0.00879	1.373	0.403	76.0	10.3
2	0.01463	1.346	0.378	75.0	80.13
3	0.00834	1.261	0.446	18.0	25.46
4	0.03770	1.371	0.391	35.0	96.33
5	0.01090	1.504	0.353	25.0	11.03
6	0.01960	1.400	0.395	94.0	31.14
7	0.02640	1.330	0.426	91.0	40.06
Ø	0.01716	1.3693	0.399		
σ	0.00966	0.0686	0.028		
C_v%	56.0	5.0	7.1		
			subsurface layer		
location					
1	0.00984	1.851	0.280	95.0	3.53
2	0.00898	1.628	0.354	40.0	9.92
3	0.03880	1.319	0.354	73.0	695.00
4	0.07070	1.312	0.403	52.0	420.19
5	0.03290	1.412	0.332	48.0	138.50
6	0.01330	1.626	0.298	110.0	19.06
7	0.01611	1.427	0.374	15.5	47.32
Ø	0.0272	1.5107	0.339		
σ	0.0207	0.184	0.0393		
C_v%	76.0	12.0	11.6		

Table 1. Parameters of soil hydraulic functions

	surface layer	subsurface layer
θ_r	0.0	0.0
θ_s	0.399	0.339
α [1/cm]	0.01743	0.01387
n	1.3757	1.6024
K_{sm}cm/day]	29.75	45.34

Table 2. Parameters of mean scaled characteristics derived for the B-area

	surface layer		subsurface layer	
	α_h	α_K	α_h	α_K
location				
1	0.5007	0.7052	1.2934	0.8168
2	0.7151	1.4179	0.7170	0.7887
3	0.3196	0.6332	0.8369	1.4023
4	2.0356	1.4355	1.1716	0.9439
5	1.0347	0.9848	1.1763	1.1719
6	1.2672	1.0177	1.1063	1.0445
7	1.1270	0.8058	0.6985	0.8318
Ø	1.000	1.000	1.000	1.000
σ	0.5284	0.2986	0.2254	0.2081
C_v%	52.8	29.9	22.5	20.8

Table 3. Parameters of scaling factors derived for B-area

		surface layer	subsurface layer	distribution
α_H	μ	-0.06615	-0.01182	
	σ	0.26924	0.11125	log-normal
θ_s	μ	0.399	0.339	
	σ	0.0283	0.0393	normal

Table 4. Parameters of α_H and θ_s distributions for the B-area

GWL - D of location	A_a	B_a	GWL_{90}
1	0.1622	-0.02352	-57.0
2	0.1581	-0.02751	-51.5
3	0.1781	-0.03105	-49.5
4	0.2155	-0.02894	-59.7
5	0.1348	-0.02516	-50.0
6	0.1809	-0.02516	-61.7
7	0.1678	-0.02516	-58.7
mean of 7 locat.	0.1687	-0.02674	-55.45
arbitrary extreme	1.0400	-0.04250	-55.45
mean of Hups.Beek	0.8523	-0.03592	-78.0

Table 5. Parameters of discharge-groundwaterlevel relationship [cm]

	evap	deficit	q_r	q_t	vol_r	vol_t	GWL_{90}	GWL_{273}	h
	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]
GWL-D									
mean	44.31	0.07	15.79	-1.63	-3.08	-20.51	-49.5	-218.4	-167
mean	44.30	0.08	16.18	-1.35	-2.68	-20.14	-61.7	-219.9	-171
mean	44.30	0.08	15.99	-1.49	-2.88	-20.31	-55.4	-218.9	-169
extreme	44.29	0.09	15.93	-1.97	-2.93	-20.92	-55.4	-223.1	-173
whole Hupsel	44.27	0.11	15.84	-2.59	-3.00	-21.35	-55.4	-224.1	-178
whole Hupsel	44.24	0.14	16.50	-1.70	-2.30	-20.54	-78.0	-228.2	-184

Table 6. Effects of various groundwater-level discharge relationships in combination with various initial groundwater levels (GWL_{90}) on the water balance at the end of the calculated period

	with wet reduction			without wet reduction		
SET	3	α_h	$\alpha_h+\alpha_k$	3	α_h	$\alpha_h+\alpha_k$
location						
1	1.2	1.1	1.1	1.3	0.1	0.3
2	1.4	1.5	1.4	0.0	0.0	0.2
3	1.5	1.8	1.5	0.0	0.0	0.0
4	7.0	0.9	4.7	6.7	0.4	4.2
5	1.9	1.9	1.9	0.1	0.1	0.1
6	1.3	0.9	1.9	0.7	0.3	1.5
7	3.1	1.0	2.0	2.3	0.2	1.3

Table 7. Changes in reduction due to wet conditions, measured groundwater levels, whole period [%]

	evap	deficit	q_r	q_t	vol_r	vol_t	h	red
	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	%
location								
1	1.88	0.16	0.80	-0.01	-1.09	-1.81	-1170	7.8
2	1.99	0.05	1.30	0.	-0.69	-1.94	-489	2.45
3	2.03	0.01	1.56	0.	-0.38	-1.99	-284	0.5
4	1.75	0.29	0.77	-0.02	-0.97	-1.86	-2480	14.2
5	2.01	0.03	1.07	-0.01	-0.94	-2.05	-405	1.5
6	1.85	0.19	0.84	-0.01	-1.00	-1.86	-1600	9.3
7	1.64	0.40	0.78	-0.01	-0.86	-1.70	-2710	19.6
Ø	1.85	0.19	0.98	-0.0086	-0.90	-1.86		9.4
σ	0.15	0.13	0.33	0.0064	0.30	0.15		7.5
Cv%	8.20	68.4	33.80	74.50	33.30	8.10		80.0

Table 8. Soils SET 3, calculated groundwater level,dry period

	evap	deficit	q_r	q_t	vol_r	vol_t	h	red
	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	%
location								
1	1.98	0.08	1.00	0.21	-0.97	-1.77	-399	2.9
2	2.03	0.01	1.63	0.94	-0.40	-1.11	-193	0.5
3	2.04	0.0	1.82	1.20	-0.23	-0.84	-190	0.0
4	0.94	1.10	0.45	-0.38	-0.50	-1.32	-5380	53.9
5	1.99	0.05	0.98	0.05	-1.00	-1.93	-357	2.5
6	1.89	0.15	0.89	0.24	-1.00	-1.65	-710	7.4
7	1.61	0.43	0.74	0.09	-0.85	-1.49	-2890	21.1
Ø	1.78	0.26	1.05	0.31	-0.73	-1.46		12.6
σ	0.37	0.37	0.46	0.51	0.32	0.38		18.2
Cv%	20.80	142.3	43.30	164.00	44.00	26.00		144.0

Table 9. Soils SET 3, measured groundwater levels, dry period

	evap	deficit	q_r	q_t	vol_r	vol_t	h	red
	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	%
location								
1	2.01	0.03	1.30	0.40	-0.72	-1.61	-377	1.5
2	2.03	0.01	1.41	0.90	-0.62	-1.13	-295	0.5
3	2.03	0.01	1.64	1.18	-0.40	-0.85	-237	0.5
4	1.90	0.14	1.07	0.48	-0.85	-1.46	-1010	4.9
5	2.01	0.03	1.22	0.46	-0.79	-1.55	-421	1.5
6	1.96	0.08	1.08	0.33	-0.88	-1.62	-756	7.4
7	1.99	0.05	1.17	0.60	-0.81	-1.38	-543	2.45
Ø	2.00	0.05	1.27	0.62	-0.72	-1.41		2.68
σ	0.06	0.04	0.19	0.29	0.15	0.32		2.38
Cv%	2.90	80.0	14.80	46.00	21.00	22.50		89.00

Table 10. Soils SET α_h, measured groundwater levels, dry period

	evap	deficit	q_r	q_t	vol_r	vol_t	h	red
	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	%
location								
1	2.01	0.03	1.21	0.13	-0.80	-1.87	-411	1.5
2	2.04	0.0	1.79	1.25	-0.25	-0.79	-190	0.0
3	2.04	0.0	1.96	1.60	-0.08	-0.43	-152	0.0
4	1.27	0.77	0.68	-1.12	-0.58	-1.14	-4060	32.7
5	2.00	0.04	1.19	0.43	-0.82	-1.56	-462	2.0
6	1.78	0.26	0.87	0.18	-0.92	-1.61	-2010	12.7
7	1.80	0.24	0.91	0.44	-0.90	-1.37	-1820	11.80
Ø	1.85	0.19	1.23	0.42	-0.62	-1.25		8.57
σ	0.26	0.26	0.44	0.81	0.31	0.47		11.00
Cv%	13.90	136.8	36.10	195.00	48.80	37.20		128.00

Table 11. Soils SET $\alpha_h+\alpha_k$, measured groundwater levels, dry period

SET	GWL-D		evap [cm]	deficit [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t red [cm]	[%]
		Ø	1.78	0.26	1.13	0.34	-0.71	-1.59	12.6
3	mean	σ	0.37	0.37	0.46	0.51	0.30	0.57	18.2
		Cv%	20.8	142.3	41.6	151.0	42.3	17.3	144.0
		Ø	1.99	0.05	1.27	0.62	-0.72	-1.37	2.7
α_h	mean	σ	0.04	0.04	0.19	0.29	0.15	0.26	2.4
		Cv%	2.20	80.0	14.8	46.0	21.0	19.3	89.0
		Ø	1.85	0.19	1.23	0.42	-0.62	-1.25	8.6
$\alpha_h+\alpha_k$	mean	σ	0.26	0.26	0.44	0.81	0.31	0.47	11.0
		Cv%	13.9	134.0	36.1	195.0	48.8	37.2	128.0
		Ø	1.88	0.16	1.02	-0.009	-0.85	-1.89	7.9
3	of locat	σ	0.13	0.13	0.29	0.006	0.22	0.11	6.6
		Cv%	6.90	84.4	28.1	74.5	26.4	5.7	83.3
mean scaled	mean		1.98	0.06	1.10	-0.01	-0.88	-1.98	2.9

Table 12. Comparison of average results ; dry period of 5 days

	saturated hydraulic conductivity [cm/day]			
origin	measured	fitted	through α_h	through α_k
marked in text	K_s	K_s^*	$K_s\alpha_h$	$K_s\alpha_k$
used in SETs	1,2	3	$\alpha_h, \alpha_h+\theta_s$	$\alpha_h+\alpha_k, \alpha_h+\alpha_k+\theta_s$
		surface layer		
location				
1	76.0	10.3	7.46	14.79
2	75.0	80.13	15.21	59.81
3	18.0	25.46	3.04	11.93
4	35.0	96.33	123.3	61.30
5	25.0	11.03	31.9	28.85
6	94.0	31.14	47.8	30.8
7	91.0	40.06	37.8	19.3
Ø	59.1	42.06	38.07	32.4
σ	29.8	31.1	37.95	18.9
Cv%	50.3	73.9	99.7	58.4
		subsurface layer		
location				
1	95.0	3.53	75.8	30.25
2	40.0	9.92	23.3	28.20
3	73.0	695.0	31.75	89.16
4	52.0	420.19	62.23	40.40
5	48.0	138.5	62.7	62.3
6	110.0	19.06	55.5	49.46
7	15.5	47.32	22.1	31.37
Ø	61.9	190.5	47.6	47.3
σ	30.4	247.1	20.0	20.5
Cv%	49.0	130.0	41.9	43.3

Table 13. Values of saturated hydraulic conductivity as used in particular soil sets

SET	evap. [cm]	def. [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t [cm]	h [cm]	red [%]	GWL_{90} [cm]	GWL_{273} [cm]	ΔGWL [cm]	evap. [cm]	def. [cm]	Δdef. [cm]
					calculated GWL									
1	42.87	1.52	15.23	-1.41	-5.21	-18.86	-947	3.4	57.	-213.7	-156.7			
2	44.37	0.01	16.43	-1.32	-2.48	-20.26	-193	0.0	57.	-262.7	-205.7			
3	43.99	0.39	14.59	-1.40	-3.96	-20.04	-397	0.9	-57.	-232.6	-175.6			
3	44.03	0.35	14.71	-1.11	-3.89	-19.79	-378	0.8	-55.4	-232.3	-176.9			
α_h	44.36	0.02	16.85	-1.47	-2.08	-20.04	-162	0.0	-55.4	-208.2	-152.8			
$\alpha_h+\alpha_k$	44.34	0.04	16.70	-1.48	-2.21	-20.03	-173	0.1	-55.4	-203.9	-148.5			
$\alpha_h+\theta_s$	43.89	0.49	14.81	-1.27	-3.65	-19.76	-243	1.1	-55.4	-261.8	-206.3			
$\alpha_h+\alpha_k+\theta_s$	44.31	0.07	16.23	-1.37	-2.65	-20.33	-210	0.1	-55.4	-219.8	-164.4			
					measured GWL									
	evap.*	def.*												
1	44.25	0.13	15.20	4.98	-3.21	-13.43	-274	0.3				43.84	0.54	0.41
2	44.38	0.0	16.70	8.40	-1.85	-10.14	-141	0.0				43.97	0.41	0.41
3	44.25	0.13	16.15	5.99	-2.27	-12.43	-191	0.3	-57.	-191.1	-123.1	43.85	0.53	0.40
α_h	44.35	0.03	16.89	1.98	-1.55	-16.47	-128	0.1				43.88	0.50	0.47
$\alpha_h+\alpha_k$	44.25	0.13	16.58	1.11	-1.89	-17.36	-151	0.3				43.90	0.48	0.35

Table 14. Location 1. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.-def.*; E_{pot}= 44.38 cm)

SET	evap. [cm]	def. [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t [cm]	h [cm]	red [%]	GWL_{90} [cm]	GWL_{273} [cm]	ΔGWL [cm]	evap. [cm]	def. [cm]	Δdef. [cm]
					calculated GWL									
1	43.20	1.18	13.04	-1.12	-4.73	-18.93	-607	2.7	-51.5	-223.0	-171.5			
2	44.35	0.03	16.24	-1.08	-2.68	-20.10	-178	0.1	-51.5	-261.4	-209.9			
3	44.32	0.06	15.96	-1.10	-2.92	-20.11	-200	0.1	-51.5	-252.0	-200.5			
3	44.31	0.07	16.04	-1.16	-2.84	-20.12	-202	0.2	-55.4	-254.4	-199.0			
α_l	44.34	0.04	16.23	-1.21	-2.68	-20.03	-175	0.1	-55.4	-248.0	-192.6			
$\alpha_l+\alpha_k$	44.35	0.03	16.14	-1.21	-2.79	-20.07	-182	0.1	-55.4	-247.2	-191.8			
$\alpha_l+\Theta_s$	44.34	0.04	16.37	-1.18	-2.54	-20.09	-175	0.1	-55.4	-253.0	-197.6			
$\alpha_l+\alpha_k+\Theta_s$	44.35	0.03	16.27	-1.18	-2.65	-20.10	-183	0.1	-55.4	-251.4	-196.0			
					measured GWL									
	evap.*	def.*												
1	44.34	0.04	16.23	9.10	-2.05	-9.18	-138	0.1	-51.5	-173.3	-121.8	43.71	0.67	0.63
2	44.38	0.00	16.48	9.99	-1.86	-8.35	-119	0.0				43.77	0.61	0.61
3	44.38	0.0	16.44	9.79	-1.90	-8.54	-121	0.0				43.76	0.62	0.62
α_l	44.36	0.02	16.45	8.97	-1.83	-9.31	-114	0.0				43.71	0.67	0.65
$\alpha_n+\alpha_k$	44.29	0.09	16.33	9.1	-2.00	-9.22	-122	0.2				43.76	0.62	0.53

Table 15. Location 2. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.−def.*; E_{pot}= 44.38 cm)

SET	evap. [cm]	def. [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t [cm]	h [cm]	red [%]	G_{90} [cm]	G_{273} [cm]	ΔG [cm]	evap. [cm]	def. [cm]	Δdef. [cm]
					calculated GWL									
1	44.31	0.07	17.01	-1.32	-1.88	-20.20	-178	0.1	-49.5	-199.4	-149.4			
2	44.11	0.27	15.60	-1.38	-3.07	-19.91	-339	0.6	-49.5	-189.9	-133.4			
3	44.37	0.01	17.47	-1.30	-1.46	-20.23	-136	0.0	-49.5	-206.9	-157.4			
3	44.36	0.2	17.54	-1.61	-1.40	-20.48	-139	0.0	-55.4	-209.6	-154.2			
α_h	44.30	0.08	17.26	-1.09	-1.61	-20.12	-176	0.2	-55.4	-243.7	-188.3			
$\alpha_h+\alpha_k$	44.36	0.02	17.35	-1.07	-1.58	-20.01	-170	0.0	-55.4	-246.0	-190.6			
$\alpha_h+\Theta_s$	44.37	0.01	17.02	-1.12	-1.92	-20.08	-183	0.0	-55.4	-240.7	-185.3			
$\alpha_h+\alpha_k+\Theta_s$	44.37	0.01	17.18	-1.12	-1.76	-20.06	-170	0.0	-55.4	-240.7	-185.3			
					measured GWL									
	evap.*	def.*												
1	44.37	0.01	17.42	6.44	-0.85	-11.83	-100	0.0				43.70	0.68	0.67
2	44.26	0.12	16.21	3.71	-1.97	-14.46	-193	0.3				43.61	0.77	0.65
3	44.38	0	17.31	6.47	-0.97	-11.81	-97	0.0	-49.5	-157.4	-107.9	43.71	0.67	0.67
α_h	44.37	0.01	17.52	11.27	-0.62	-6.88	-84	0.0				43.57	0.81	0.80
$\alpha_h+\alpha_k$	44.38	0.0	17.39	11.35	-0.89	-6.94	-105	0.0				43.71	0.67	0.67

Table 16. Location 3. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.-def.*; E_{pot}= 44.38 cm)

SET	evap. [cm]	def. [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t [cm]	h [cm]	red [%]	G_{90} [cm]	G_{273} [cm]	ΔG [cm]	evap. [cm]	def. [cm]	Δdef. [cm]
					calculated GWL									
1	42.71	1.67	12.78	-2.48	-4.49	-19.70	-629	3.8	-59.7	-144.6	-84.9			
2	39.18	5.2	8.85	-2.77	-4.09	-16.51	-2280	11.7	-59.7	-125.7	-66.0			
3	43.72	0.66	15.31	-2.04	-2.97	-20.28	-195	1.5	-59.7	-157.0	-97.3			
3	43.82	0.56	15.23	-2.48	-3.16	-20.18	-191	1.3	-55.4	-157.8	-102.4			
α_h	44.12	0.26	15.62	-1.72	-3.06	-20.47	-165	0.7	-55.4	-207.6	-152.2			
$\alpha_h+\alpha_L$	42.52	1.86	13.54	-1.77	-3.56	-18.96	-233	4.2	-55.4	-194.6	-139.2			
$\alpha_h+\Theta_s$	40.85	3.53	11.67	-1.93	-3.75	-17.40	-370	8.0	-55.4	-171.9	-116.45			
$\alpha_h+\alpha_L+\Theta_s$	42.88	1.5	-14.26	-1.86	-3.19	-19.37	-194	3.4	-55.4	-184.9	-129.5			
	evap.*	def.*			measured GWL									
1	40.66	3.72	9.97	-12.57	-5.03	-27.57	-753	8.3				40.43	3.95	0.23
2	36.73	7.65	5.97	-14.90	-5.06	-25.93	-1740	17.2				36.47	7.91	0.26
3	41.43	2.95	11.45	-10.07	-4.31	-25.83	-623	6.7	-59.7	-175.4	-115.7	44.19	3.19	0.24
α_h	44.21	0.17	16.29	4.22	-2.26	-14.32	-122	0.4				43.98	0.40	0.23
$\alpha_h+\alpha_L$	42.52	1.86	13.95	1.62	-2.91	-15.23	-178	4.2				42.28	2.1	0.24

Table 17. Location 4. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.-def.*; E_{pot}= 44.38 cm)

SET	evap. [cm]	def. [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t [cm]	h [cm]	red [%]	G_{90} [cm]	G_{273} [cm]	ΔG [cm]	evap. [cm]	def. [cm]	Δdef. [cm]
					calculated GWL									
1	44.24	0.14	15.56	-1.79	-3.25	-20.62	-207	0.3	-50	-189.5	-139.5			
2	44.30	0.08	15.83	-1.83	-3.82	-20.64	-249	0.2	-50	-178.2	-128.2			
3	44.34	0.04	16.06	-1.77	-2.85	-20.74	-168	0.1	-50	-191.8	-141.8			
3	44.36	0.02	16.60	-1.76	-2.33	-20.6	-144	0.0	-55.4	-197.9	-142.5			
α_h	44.30	0.08	16.0	-1.60	-2.88	-20.51	-167	0.2	-55.4	-209.1	-153.7			
$\alpha_h+\alpha_k$	44.31	0.07	16.09	-1.60	-2.79	-20.41	-160	0.2	-55.4	-208.3	-152.9			
$\alpha_h+\Theta_s$	44.26	0.12	16.30	-1.54	-2.53	-20.41	-166	0.3	-55.4	-212.0	-156.55			
$\alpha_h+\alpha_k+\Theta_s$	44.27	0.11	16.40	-1.53	-2.44	-20.38	-159	0.2	-55.4	-213.1	-157.7			
					measured GWL									
	evap.*	def.*												
1	44.12	0.26	14.64	-1.72	-3.25	-19.6	-188	0.6				43.32	1.06	0.80
2	44.19	0.19	13.27	-4.87	-4.71	-22.86	-360	0.4				43.41	0.97	0.78
3	44.32	0.06	15.34	-1.16	-2.74	-19.25	-167	0.1	-50	-183.1	-133.1	43.52	0.86	0.80
α_h	44.35	0.05	15.61	2.27	-2.50	-15.84	-127	0.1				43.54	0.84	0.79
$\alpha_h+\alpha_k$	44.06	0.32	15.58	2.22	-2.52	-15.80	-129	0.1				43.53	0.85	0.53

Table 18. Location 5. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.−def.*; E_{pot}= 44.38 cm)

SET	evap. [cm]	def. [cm]	q_r [cm]	q_t [cm]	vol_r [cm]	vol_t [cm]	h [cm]	red [%]	G_{90} [cm]	G_{273} [cm]	ΔG [cm]	evap. [cm]	def. [cm]	Δdef. [cm]
					calculated GWL									
1	44.29	0.09	14.97	-1.68	-3.79	-20.43	-258	0.4	- 61.7	-213.7	-152.0			
2	44.35	0.03	16.11	-1.58	-2.81	-20.40	-164	0.1	-61.7	-237.0	-175.3			
3	43.94	0.44	14.97	-1.63	-3.54	20.05	-239	1.0	-61.7	-222.7	-161.0			
3	44.02	0.36	14.87	-1.48	-3.72	-20.16	-231	0.8	-55.4	-222.4	-167.0			
α_h	44.01	0.37	15.35	-1.62	-3.23	-20.24	-190	0.8	-55.4	-207.9	-152.5			
$\alpha_h+\alpha_k$	44.06	0.32	15.45	-1.62	-3.18	-20.21	-186	0.7	-55.4	-208.0	-152.6			
$\alpha_h+\Theta_s$	43.81	0.57	14.94	-1.55	-3.43	-20.0	-215	1.3	-55.4	-217.2	-161.8			
$\alpha_h+\alpha_k+\Theta_s$	43.88	0.50	15.07	-1.55	-3.38	-20.05	-209	1.1	-55.4	-218.2	-162.8			
	evap.*	def.*			measured GWL									
1	44.22	0.16	14.92	0.75	-3.61	-17.78	-251	0.4				43.96	0.42	0.26
2	44.37	0.01	16.37	4.91	-2.32	-13.78	-139	0.0				44.12	0.26	0.25
3	44.07	0.31	15.56	3.29	-2.83	-15.09	-173	0.7	-61.7	-194.8	-133.1	43.81	0.57	0.26
α_h	44.26	0.12	16.16	1.70	-2.41	-16.87	-143	0.3				44.00	0.38	0.26
$\alpha_h+\alpha_k$	43.73	0.65	15.45	0.85	-2.67	-17.27	-164	1.5				43.55	0.83	0.18

Table 19. Location 6. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.−def.*; E_{pot}= 44.38 cm)

SET	evap.*	def.*	q_r	q_t	vol_r	vol_t	h	red.	G_{90}	G_{273}	ΔG	evap.	def.	Δdef.
	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[%]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]
					calculated GWL									
1	43.15	1.23	13.88	-1.73	-3.84	-19.41	-323	2.8	-58.7	-207.7	-149.			
2	43.91	0.47	14.71	-1.78	-3.77	-20.34	-270	1.1	-58.7	-207.3	-148.6			
3	43.45	0.93	14.60	-1.73	-3.42	-19.67	-234	2.1	-58.7	-210.3	-151.6			
3	43.53	0.85	14.56	-1.64	-3.54	-19.64	-230	1.9	-55.4	-208.4	-153.0			
α_h	44.07	0.31	15.33	-1.33	-3.31	-19.90	-201	0.7	-55.4	-243.8	-188.4			
$\alpha_h+\alpha_t$	43.30	1.08	14.20	-1.34	-3.67	-19.29	-247	2.4	-55.4	-240.0	-184.6			
$\alpha_h+\Theta_s$	44.20	0.18	15.35	-1.41	-3.42	-20.22	-198	0.4	-55.4	-238.3	-182.3			
$\alpha_h+\alpha_t+\Theta_s$	43.68	0.70	14.47	-1.42	-3.78	-19.60	-229	1.6	-55.4	-227.1	-171.7			
					measured GWL									
	evap.*	def.*												
1	43.12	1.26	13.98	0.82	-3.34	-16.50	-150	2.8				42.74	1.64	0.37
2	43.85	0.53	14.36	-0.36	-3.70	-18.43	-258	1.2				43.49	0.89	0.36
3	43.34	1.04	14.48	1.02	-3.05	-16.51	-192	2.3	-58.7	-191.8	-133.1	42.96	1.42	0.38
α_h	44.30	0.08	16.17	6.57	-2.43	-11.94	-134	0.2				43.94	0.44	0.36
$\alpha_h+\alpha_t$	43.79	0.59	15.50	5.88	-2.57	-12.90	-153	1.5				43.50	0.88	0.29

Table 20. Location 7. The results of the last day (273rd) of calculated period. (* values are without wet reduction in case of measured GWL; Δdef.=def.−def.*; E_{pot}= 44.38 cm)

soils	GWL-D		evap. (cm)	def. (cm)	q_r (cm)	q_t (cm)	vol_r (cm)	vol_t (cm)	red (%)	GWL_{273} (cm)	ΔGWL (cm)
SET 1	of locat.	Ø	43.54	0.84	14.21	-1.65	-3.88	-19.74	1.9	-198.8	-143.3
		σ	0.66	0.66	1.59	0.41	1.02	0.65	1.49	24.3	25.5
		Cv %	1.50	78.6	11.20	24.70	26.00	3.30	78.6	12.2	17.8
SET 2	of locat.	Ø	43.51	0.87	14.82	-1.68	-3.25	-19.74	2.0	-207.9	-152.4
		σ	1.77	1.77	2.49	0.51	0.59	1.35	3.99	46.3	46.4
		Cv %	4.00	203.4	16.80	30.30	18.20	6.80	203.0	22.2	30.5
SET 3	of locat.	Ø	44.02	0.36	15.57	-1.57	-3.02	-20.15	0.8	-210.5	-155.0
		σ	0.32	0.32	0.95	0.30	0.74	0.30	0.74	28.2	29.4
		Cv %	0.7	88.9	6.1	18.9	24.40	1.50	89	13.4	19.0
SET 3	mean	Ø	44.06	0.32	15.65	-1.61	-2.98	-20.24	0.7	-211.8	-156.4
		σ	0.29	0.29	1.03	0.42	0.82	0.41	0.66	28.0	28.0
		Cv %	0.6	90.6	6.6	26.3	27.4	2.0	92.4	13.2	17.9
SET α_m	mean	Ø	44.21	0.17	16.09	-1.43	-2.69	-20.22	0.4	-224.0	-168.6
		σ	0.13	0.13	0.69	0.22	0.58	0.23	0.31	18.3	18.3
		Cv %	0.3	80.0	4.2	15.0	37.1	1.1	80.0	8.1	10.9
SET $\alpha_m+\alpha_k$	mean	Ø	43.89	0.49	15.63	-1.44	-2.83	19.89	1.1	-221.1	-165.7
		σ	0.66	0.66	1.25	0.23	0.69	0.51	1.49	20.7	20.7
		Cv %	1.5	135.0	8.0	15.9	24.3	2.6	135.0	9.3	12.5
mean scaled	mean		44.30	0.08	15.99	-1.49	-2.88	-20.31	0.2	-218.9	-163.5
SET $\alpha_m+\theta_s$	mean	Ø	44.69	0.71	15.23	-1.43	-3.03	-19.73	1.6	-228.0	-172.4
		σ	1.13	1.17	1.58	0.25	0.64	0.92	2.5	27.8	28.2
		Cv %	2.6	165.8	10.4	17.8	21.2	4.6	164.	1.22	16.3
SET $\alpha_m+\alpha_k+\theta_s$	mean	Ø	43.96	0.42	15.70	-1.33	-2.84	-19.98	0.9	-222.2	-166.8
		σ	0.51	0.51	1.02	0.17	0.62	0.34	1.2	19.7	19.7
		Cv %	1.2	121.2	6.5	12.5	21.9	1.7	124.5	8.9	11.8

Table 21. The average results of 7 locations for particular soil combinations , GWL are calculated, whole period

Soils		evap. (cm)	deficit (cm)	q_r (cm)	q_t (cm)	vol_r (cm)	vol_t (cm)	red (%)	GWL_{273} (cm)	ΔGWL (cm)	evap.* (cm)	def.* (cm)	red.* (cm)
SET 1	Ø	43.10	1.28	15.05	1.11	-3.05	-16.56	2.9	-179.4	-125.4	43.58	0.81	1.8
	σ	1.15	1.15	2.46	6.57	1.20	5.59	2.61	11.6	9.64	1.26	1.25	2.8
	Cv %	2.60	89.8	16.30	590.00	39.60	33.80	90.0	6.5	7 7	2.9	154.4	157.0
SET 2	Ø	42.69	1.69	14.19	2.00	-3.06	-16.27	3.8	the same		43.17	1.21	2.7
	σ	2.55	2.55	3.56	7.94	1.30	5.99	5.7	as above		2.63	2.63	5.9
	Cv %	5.90	150.9	25.10	398.00	42.20	36.80	151.0			6.1	216.8	217.0
SET 3	Ø	43.26	1.12	15.25	2.19	-2.58	-16.27	3.8	the same		43.74	0.64	1.44
	σ	0.89	0.89	1.76	6.03	0.96	5.99	5.7	as above		1.00	1.00	2.27
	Cv %	2.00	79	11.50	275.0	37.20	36.80	151.0			2.30	156.3	157.0
SET α_h	Ø	43.80	1.3	16.44	5.28	-1.93	-13.09	1.3	the same		44.31	0.07	0.16
	σ	0.18	0.4	0.56	3.49	0.62	3.56	0.4	as above		0.05	0.05	0.14
	Cv %	0.40	30.0	3.40	66.00	32.00	27.20	30.0			0.10	79.3	89.0
SET $\alpha_h+\alpha_k$	Ø	43.46	0.92	15.83	4.59	-2.21	-13.43	2.1	the same		43.86	0.52	1.09
	σ	0.50	0.50	1.01	3.93	0.63	3.79	1.11	as above		0.59	0.50	1.39
	Cv %	1.2	54.4	6.40	85.70	28.70	28.20	48.3			1.4	114.1	128.0

Table 22. The average results of 7 locations for particular soil combinations done for measured GWL, whole period (* values are without wet reduction)

	absolute extremes from all simulations in particular locations				extremes of average results of all sets				extremes of Cv% of average results			
	GWL				GWL				GWL			
	calcul.		measured		calcul.		measured		calcul.		measured	
	min	max	min	max	min	max	min	max	min	max	min	max
act. evap (cm)	39.18	44.36	36.73	44.38	43.51	44.21	43.17	44.31	0.3	4	0.1	6.1
deficit (cm)	0.02	5.20	0	7.65	0.17	0.87	0.07	1.21	76.6	203.4	79	216.8
q_r (cm)	8.85	17.54	5.97	17.52	14.21	16.09	14.19	16.44	4.2	16.8	3.4	35.1
q_t (cm)	-2.77	-1.07	-14.90	11.35	-1.43	-1.43	1.11	5.28	15.0	30.3	66.0	590.0
vol_r (cm)	-5.21	-1.40	-5.06	-0.62	-3.88	-2.69	-3.05	-1.93	18.2	37.1	28.7	42.0
vol_t (cm)	-20.87	-16.51	-25.93	-6.88	-20.24	-19.74	-16.56	-13.09	1.1	6.8	27.3	36.8
GWL (cm)	-262.7	-125.7	-194.8	-157.4	-221.1	-198.8	-179.4		8.1	22.2	--	--
ΔGWL (cm)	-209.9	-66.0	-133.1	-107.9	-168.6	-143.3	-125.4		10.9	30.5	--	--

Table 23. Extremes of results of particular simulations and of average results of defined soil sets, exteremes of Cv of average results

Soils	GWL	Cv%												
		evap.	def.	evap.*	def.*	red.	red.*	q_r	q_t	vol_r	vol_t	GWL_{90}	GWL_{273}	ΔGWL
SET 1	measured	2.60	89.8	2.9	154.4	90.0	157.0	16.30	590.0	39.60	33.80	8.4	13.4	19.0
	GWL-D	1.5	76.6	1.5	76.6	78.6	78.6	11.20	24.70	26.00	3.30	8.4	12.2	17.8
SET 2	measured	5.9	150.9	6.1	216.8	151.0	217.0	25.1	398	42.2	36.80	8.4		
	GWL-D	4	203.4	4	203.4	203.0	203.0	16.80	30.30	18.20	6.80	8.4	22.2	30.5
SET 3	measured	2	125	2.30	156.3	78.0	157.6	11.5	275	37.20	33.70	8.4		
	GWL-D	0.7	88.9	0.7	88.9	89	89	6.10	18.9	24.4	1.50	8.4	13.4	19.0
SET 3	GWL-D	0.6	90.6	0.6	90.6	92.4	92	6.6	26.3	27.4	2.0	0	13.2	17.9
SET α_m	measured	0.40	28.5	0.10	79.3	30	89	3.4	66	32	27.2	8.4		
	GWL-D	0.3	80.0	0.3	80.0	80.0	80.0	4.2	15.0	37.1	1.1	0	8.1	10.9
SET $\alpha_m+\alpha_k$	measured	1.2	54.4	1.4	114.1	48.3	128	6.4	85.7	28.7	28.2	8.4		
	GWL-D	1.5	135.0	1.5	135.0	135	135	8.0	15.9	24.3	2.6	0	9.3	12.5

Table 24. The variance of average results for all calculated combinations of soil sets, both types of lower boundary conditions compared (* values are without wet reduction)

No.	1. layer α_h	1. layer α_k	2. layer α_h	2. layer α_k	evap. (cm)	def. (cm)	q_r (cm)	q_t (cm)	vol_r (cm)	vol_t (cm)	h (cm)	red (%)	GWL_{273} (cm)	ΔGWL (cm)
1	0.7151	1	0.7170	1	44.34	0.04	16.23	-1.21	-2.68	-20.03	-175	0.1	-248.0	-192.6
2	1.127	1	0.6985	1	44.07	0.31	15.33	-1.33	-3.31	-19.9	-201	0.7	-243.8	-188.4
3	0.3196	1	0.8369	1	44.30	0.08	17.26	-1.09	-1.61	-20.02	-176	0.2	-243.7	-188.3
4	0.5007	1	1	1	44.36	0.02	16.79	-1.29	-2.14	-20.22	-167	0.0	-225.8	-170
5	1	1	1	1	44.30	0.08	15.99	-1.49	-2.88	-20.31	-169	0.2	-218.9	-163.5
6	1.0347	1	1.1763	1	44.30	0.08	16.00	-1.60	-2.88	-20.51	-167	0.2	-209.1	-153.7
7	0.507	1	1.2934	1	44.36	0.02	16.85	-1.47	-2.08	-20.4	-162	0.0	-208.2	-152.8
8	1.2672	1	1.0177	1	44.01	0.37	15.35	-1.62	-3.23	-20.24	-190	0.8	-207.9	-152.5
9	2.0356	1	1.1716	1	44.12	0.26	15.62	-1.72	-3.06	-20.47	-165	0.7	-207.6	-152.2
10	1	1	1.2934	1	43.92	0.45	15.89	-1.65	-3.65	-21.26	-228	1.0	-200.7	-145.3
11	2.0356	1	1	1	40.56	3.82	10.96	-1.72	-4.17	-16.94	-539	8.7	-189.0	-133.6

Table 25. Effects of scalling factors of both layers on GWL and AE ($\Delta GWL = GWL_{273} - GWL_{90}$)

Location	1 layer Θ_{s1}	2 layer Θ_{s2}	2 layer: change of mean Θ_{s2}	2 layer: change of decrease of GWL SET $\alpha_h+\Theta_s$ (*)		2 layer: change of decrease of GWL SET $\alpha_h+\alpha_k+\Theta_s$ (*)		1 layer: change of mean Θ_{s1}	1 layer: change of deficit of AE SET $\alpha_h+\Theta_s$ (*)		1 layer: change of deficit of AE SET $\alpha_h+\alpha_k+\Theta_s$ (*)	
1	0.403	0.280	-	-	+	-	+	+	+	+		+
2	0.387	0.332	-	-	+	-	+	-	0	0	0	0
3	0.446	0.354	+	-	-	-	-	+	-	-	-	-
4	0.391	0.403	+	-	-	-	-	-	-	+	+	-
5	0.353	0.332	-	-	+	-	+	-	-	+	-	+
6	0.395	0.298	-	-	+	-	+	-	-	+	-	+
7	0.426	0.374	+	-	-	-	-	+	-	-	-	-
mean Θ_s	0.339	0.339										

* denoted if relation is positive (+) or negative (−)

Table 26. Relative effects of Θ_s changes on calculated GWL and deficit of AE: for SET $\alpha_h+\Theta_s$ in relation to SET α_h; and for SET $\alpha_h+\alpha_k+\Theta_s$ in relation to SET $\alpha_h+\alpha_k$. Values compared are given in Tables 14 – 20.

Location	1 layer		2 layer		2 layer					1 layer						
	$K_s\alpha_h$	$K_s\alpha_k$	$K_s\alpha_h$	$K_s\alpha_k$	change of $K_s\alpha_h$	*	change of decrease of GWL SET $\alpha_h+\alpha_k$	*	change of decrease of GWL SET $\alpha_h+\alpha_k+\theta_s$	change of $K_s\alpha_h$	*	change of deficit of AE SET $\alpha_h+\alpha_k$	*	change of deficit of AE SET $\alpha_h+\alpha_k+\theta_s$	α_{k1}	α_{k2}
1	7.46	14.79	75.8	30.3	-	+	-	+	-	-	-	+	+	-	0.7052	0.8168
2	15.21	59.81	23.3	28.2	-	+	-	+	-	+	-	-	-	-	1.4179	0.7887
3	3.04	11.93	31.75	89.2	+	+	+	0	0	-	+	-	0	0	0.6332	1.4023
4	123.3	61.30	62.23	40.4	-	+	-	-	+	+	+	+	-	-	1.4355	0.9439
5	31.9	28.85	62.7	62.3	+	-	-	+	+	-	+	+	+	-	0.9848	1.1719
6	47.8	30.8	55.5	49.5	+	+	+	+	+	+	-	-	-	-	1.0177	1.0445
7	37.8	19.3	22.1	31.4	-	+	-	+	-	-	-	+	-	+	0.8058	0.8318

Table 27. Relative effects of K_s (through α_k) changes on calculated GWL and deficit of AE: for SET $\alpha_h+\alpha_k$ in relation to SET α_h;
and for SET $\alpha_h+\alpha_k+\theta_s$ in relation to SET $\alpha_h+\theta_s$.
Values compared are given in Tables 14 - 20.

Location	1 layer		2 layer		2 layer			1 layer		
	K_s	K_s^*	K_s	K_s^*	change of K_s	*	change of decrease of GWL	change of K_s	*	change of deficit of AE
1	76.0	10.3	95.0	3.53	+	+	+	+	-	-
2	75.0	80.1	40.0	9.92	+	+	+	-	+	-
3	18.0	25.5	73.0	695.0	-	+	-	-	-	+
4	35.0	96.3	52.0	420.2	-	+	-	-	-	+
5	25.0	11.0	48.0	138.5	-	+	-	+	+	+
6	94.0	31.1	110.0	19.1	+	+	+	+	-	-
7	91.0	40.1	15.5	47.3	-	+	-	+	-	-

* denoted if relation is positive (+) or negative (-)

Table 28. Relative effects of K_s changes on calculated GWL and deficit of AE: for SET 3 (fitted K_s*) in relation to SET 2(measured K_s)
Values compared are given in Tables 14 - 20.

	GWL-d		evap. (cm)	def. (cm)	q_t (cm)	GWL_{273} (cm)	α_{h1}	α_{h2}	Θ_{s1}	Θ_{s2}
random	mean	Ø	44.06	0.32	1.45	-225.6	1.2422	0.9671	0.4001	0.3384
3G		σ	0.39	0.39	0.22	20.8	0.709	0.241	0.0278	0.0424
		Cv %	0.9	123.1	15.2	9.2	57.1	24.94	6.95	12.53

Table 29. Average results from the group of 36 randomly generated soil inputs; average values of scaling factors α_H and Θ_s of both layers which were generated by Monte Carlo method within the their statistical distribution

Figure 1 - 7. Retention curves and hydraulic conductivities for particular locations 1 - 7

a) retention curves in log|h| scale and

b) retention curves in normal scale

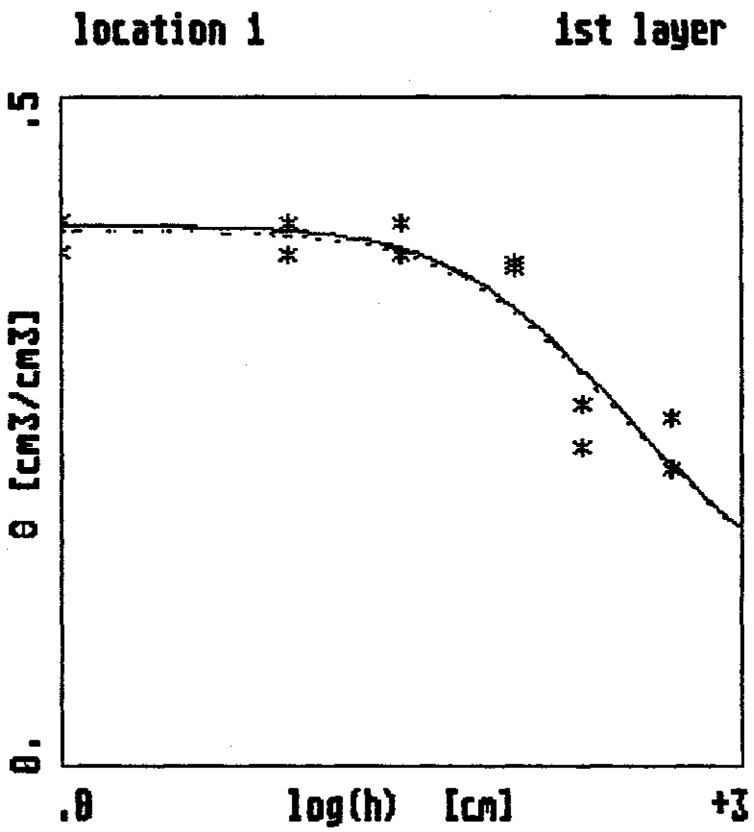
*	measured points
———	SET 1, SET 2, SET 3
.....	SET α_h, SET $\alpha_h+\alpha_k$
- - -	SET $\alpha_h+\theta_s$, SET $\alpha_h+\alpha_k+\theta_s$

c) hydraulic conductivities

*	measured points
- - -	SET 1
.....	SET 2
———	SET 3

d) hydraulic conductivities

*	measured points
———	SET 3 (base for scaling)
- - -	SET α_h, SET $\alpha_h+\theta_s$
.....	SET $\alpha h+\alpha k$, SET $\alpha_h+\alpha_k+\theta_s$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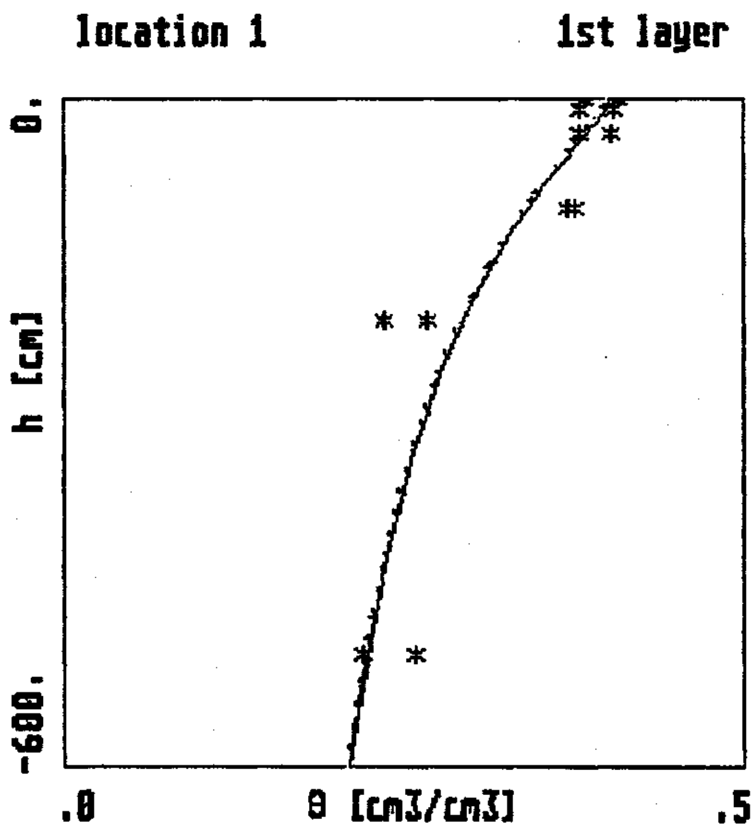
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3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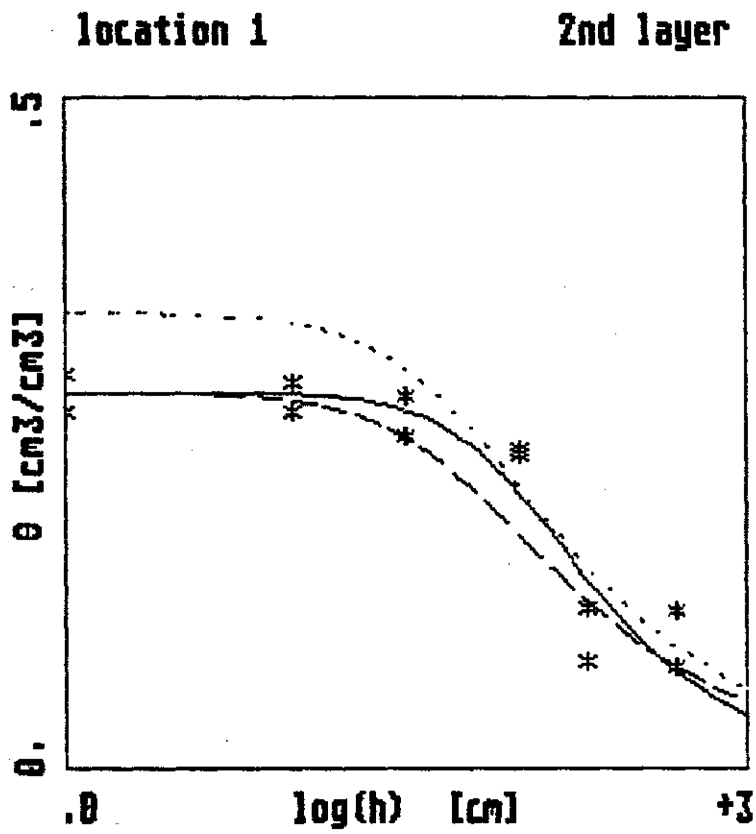
h [cm]
-600.
.0
θ [cm3/cm3]
.5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2nd layer
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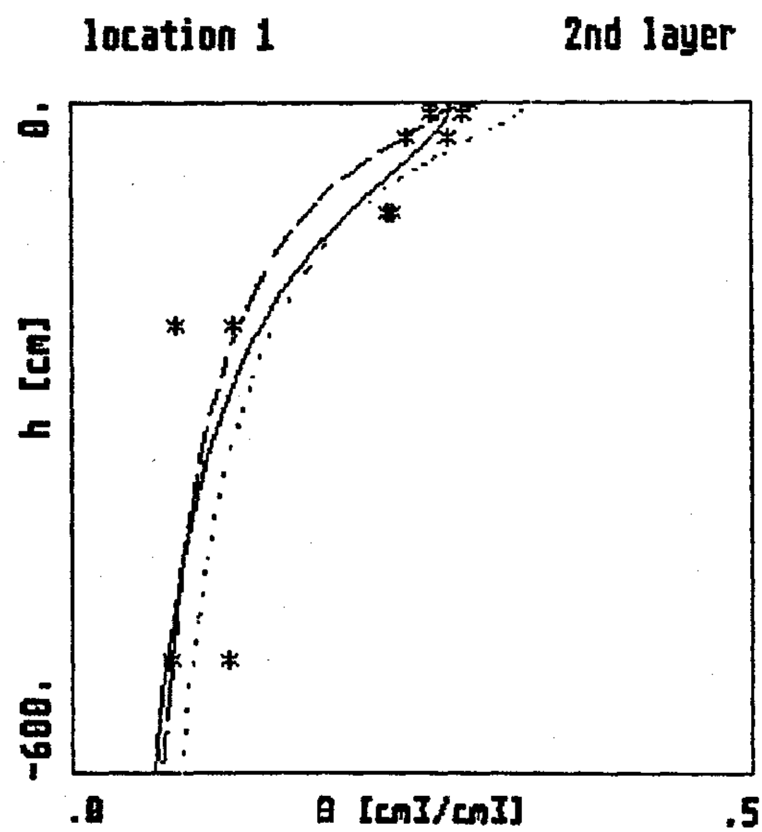
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3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2nd layer
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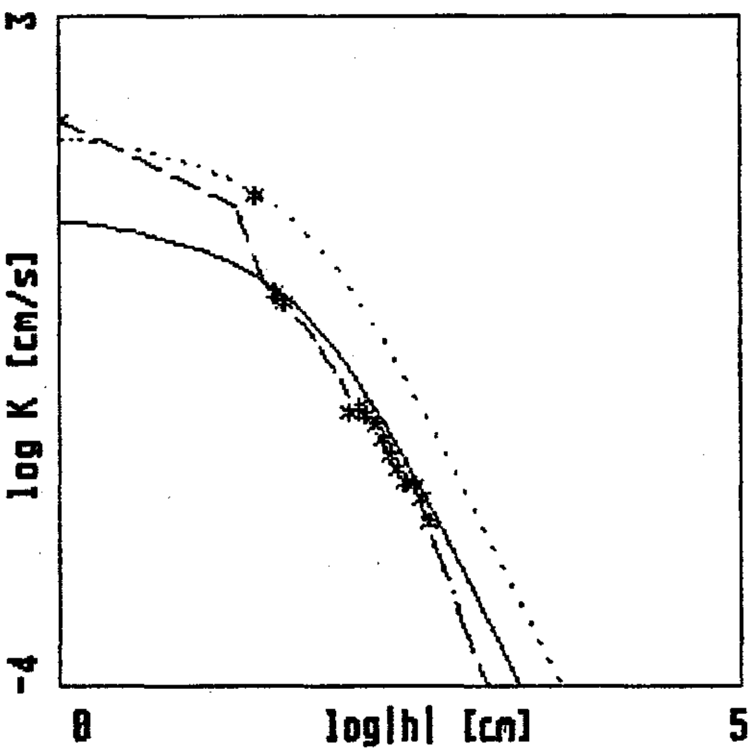
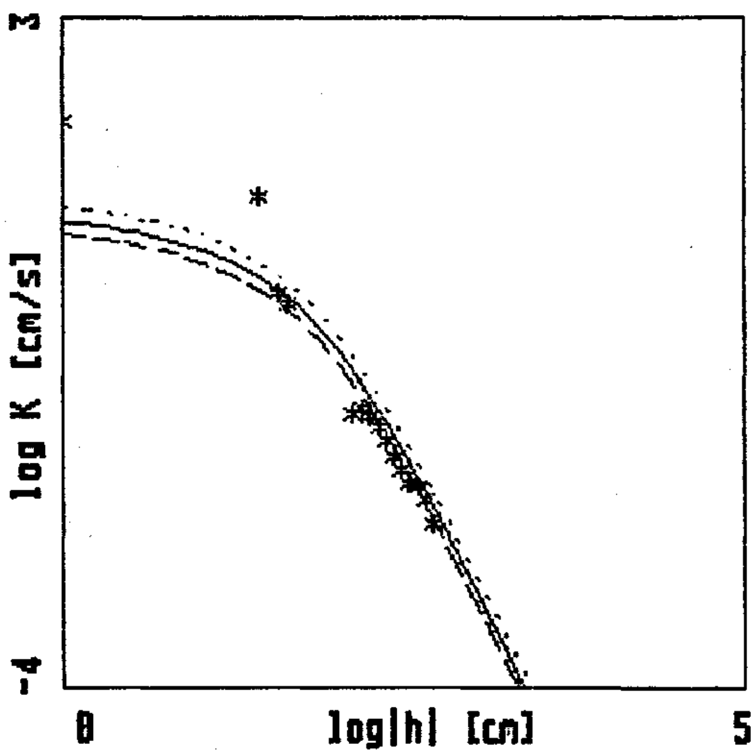
h [cm]
-600.
.0
θ [cm3/cm3]
.5

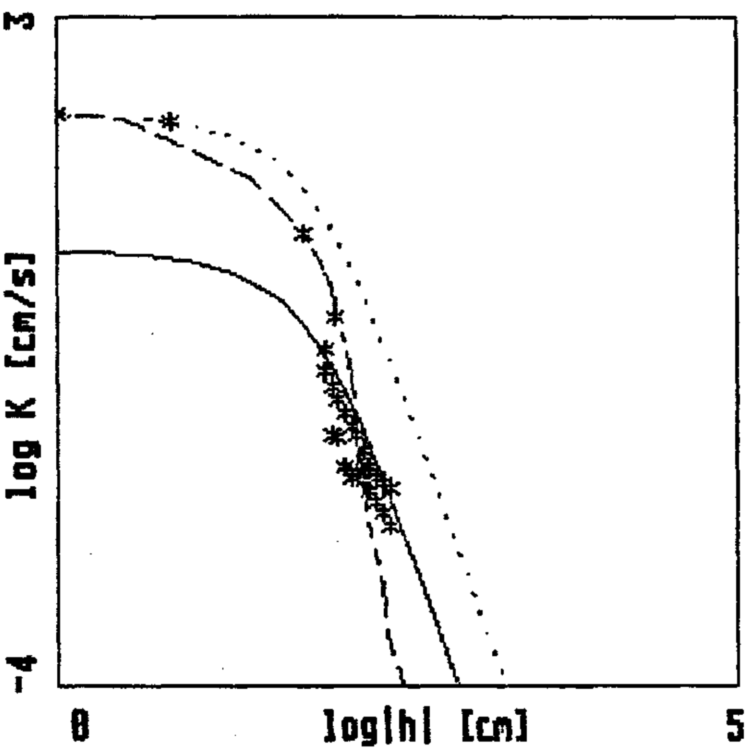
location 1 ordinary 1st layer



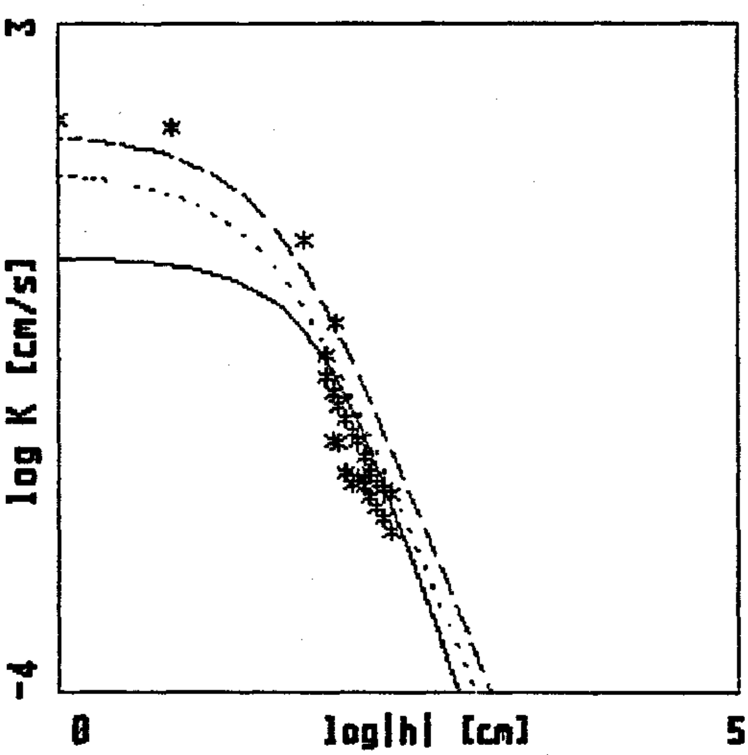
location 1 scaled 1st layer

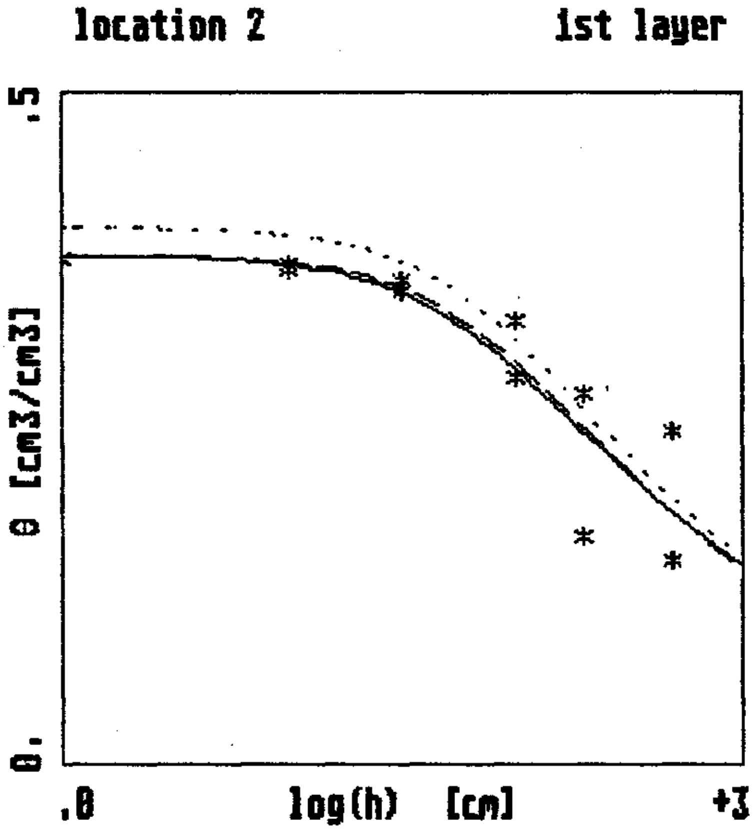


location 1 ordinary 2nd layer



location 1 scaled 2nd layer

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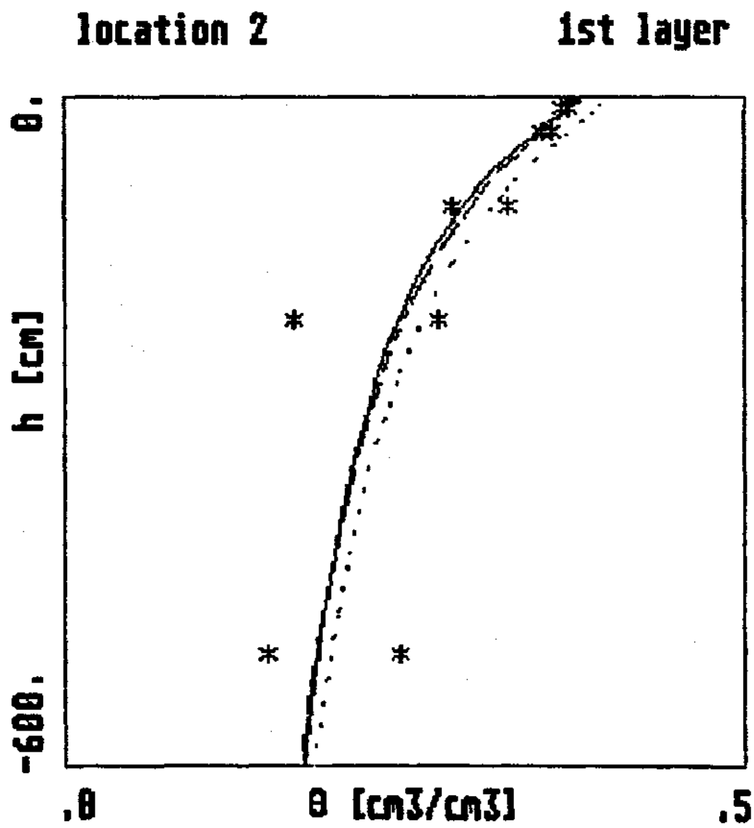
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3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h [cm]
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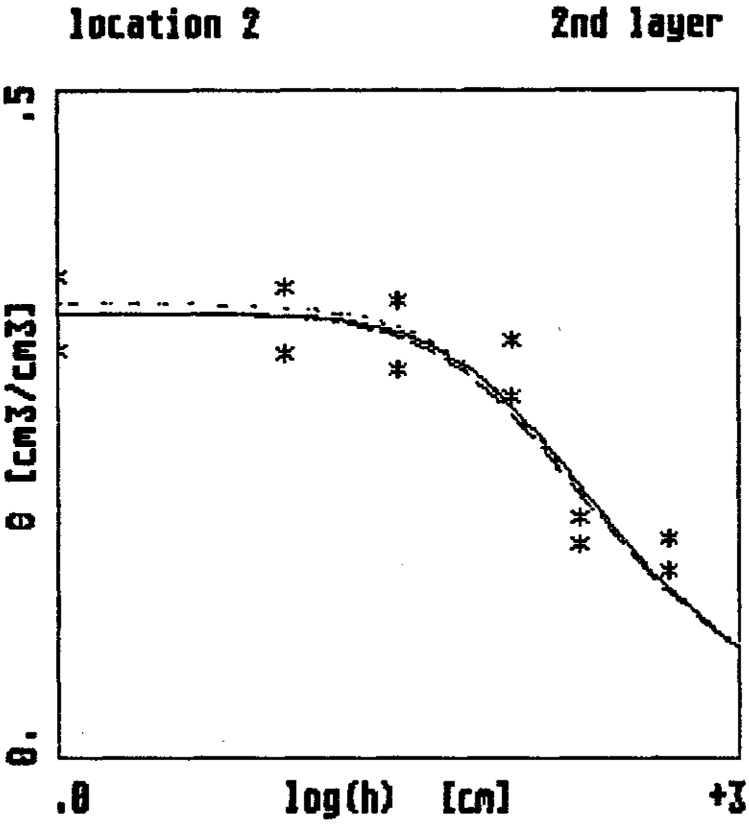
θ [cm3/cm3]
.5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2nd layer
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θ [cm3/cm3]
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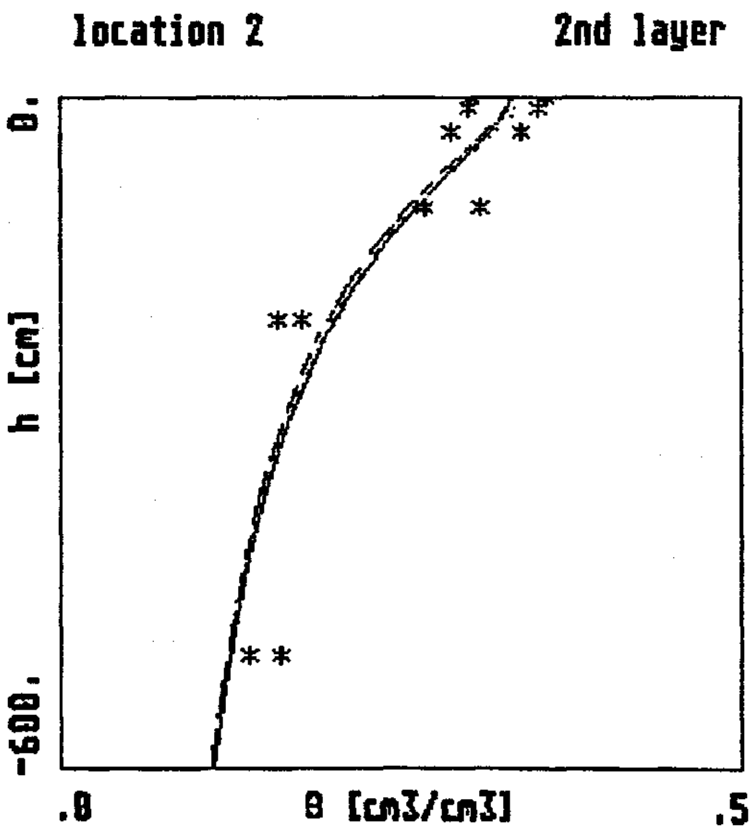
.0
log(h) [cm]
+3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2nd layer
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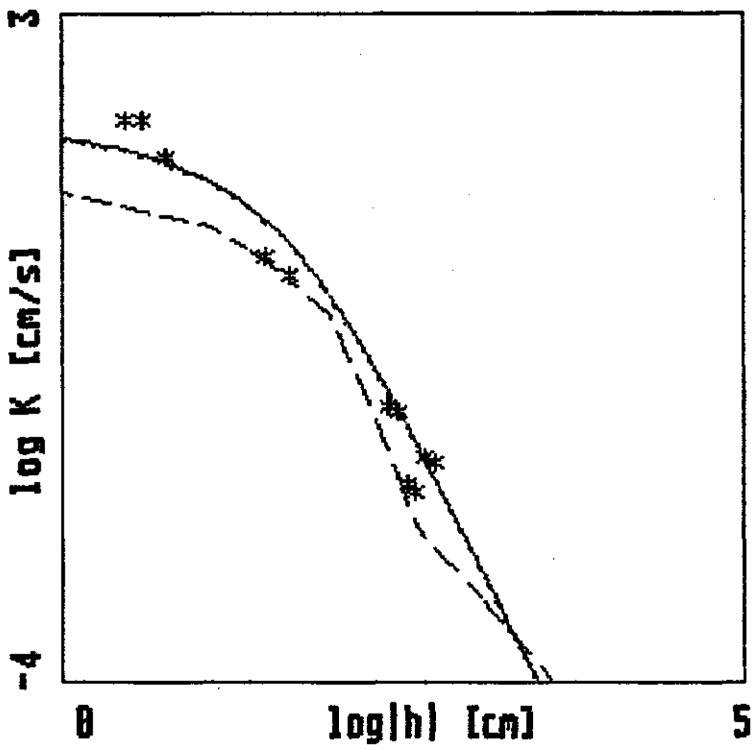
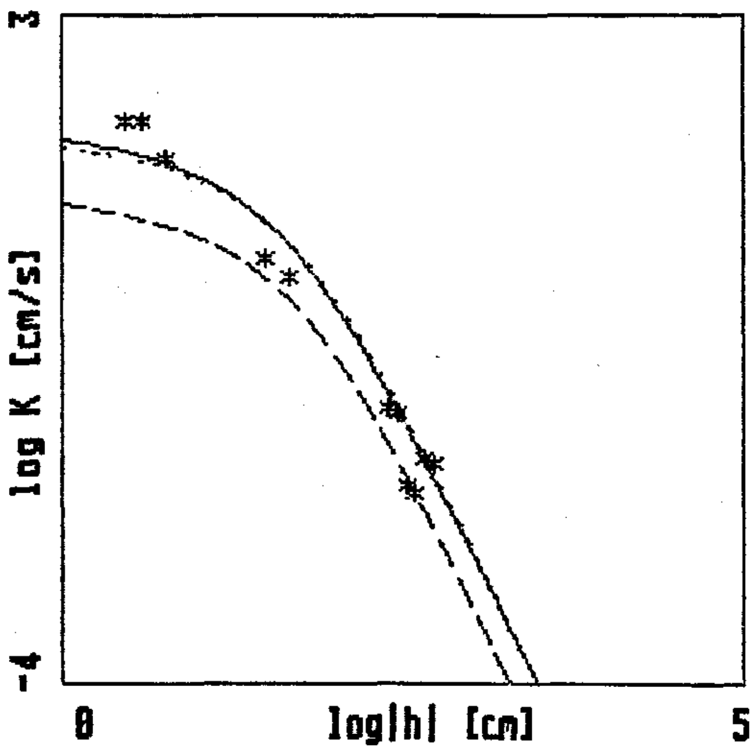
h [cm]
-600.
.0
θ [cm3/cm3]
.5

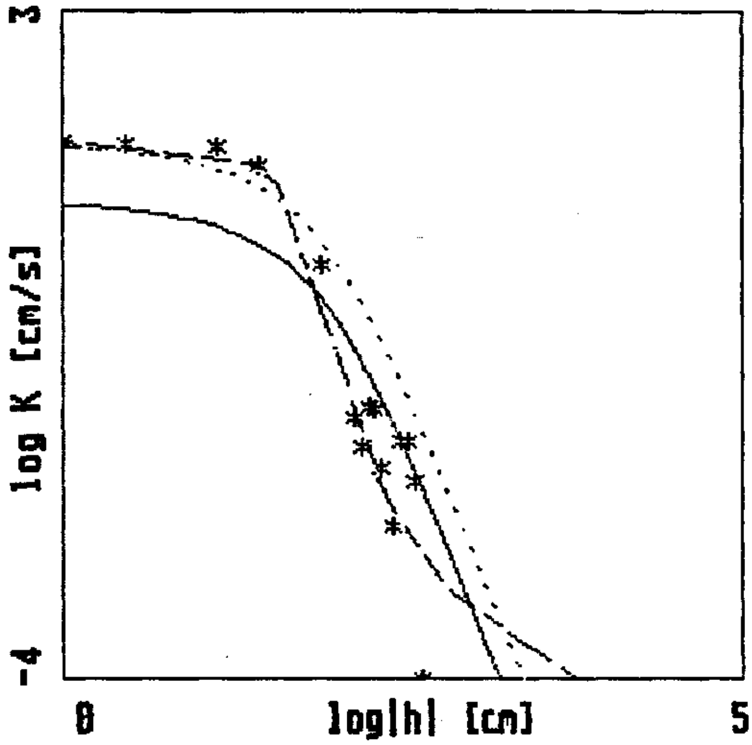
location 2 ordinary 1st layer



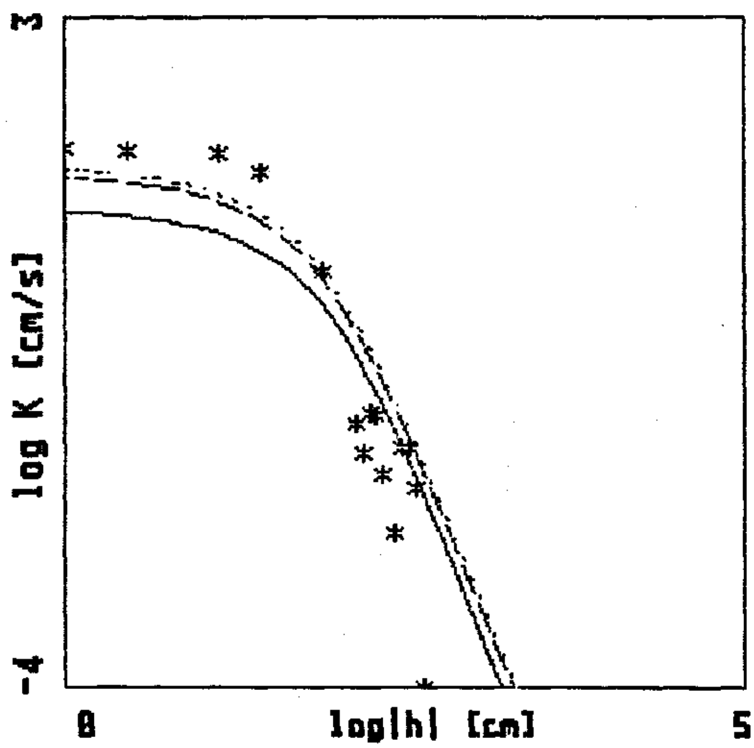
location 2 scaled 1st layer

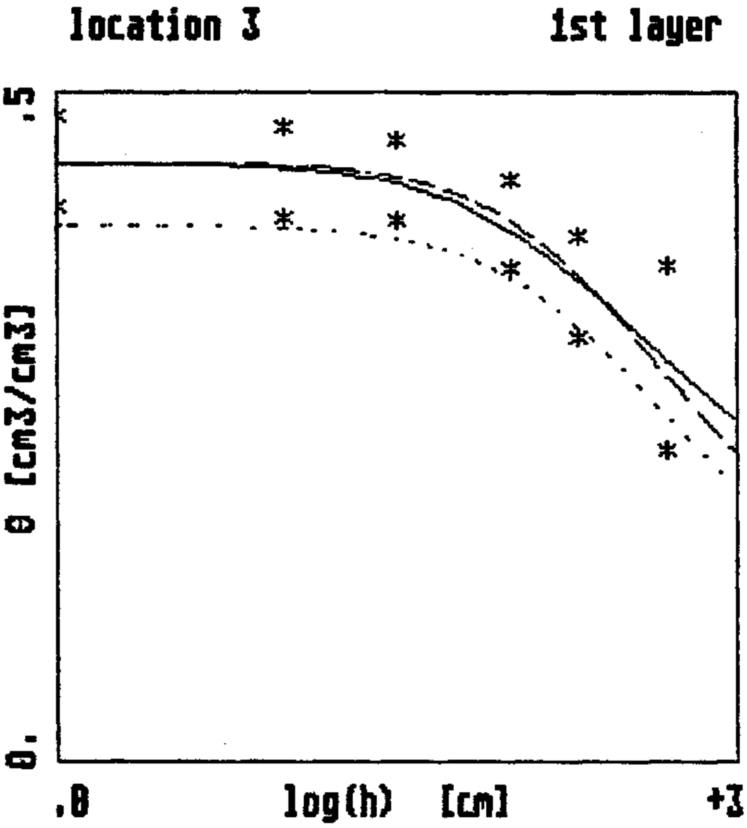


location 2 ordinary 2nd layer



location 2 scaled 2nd layer

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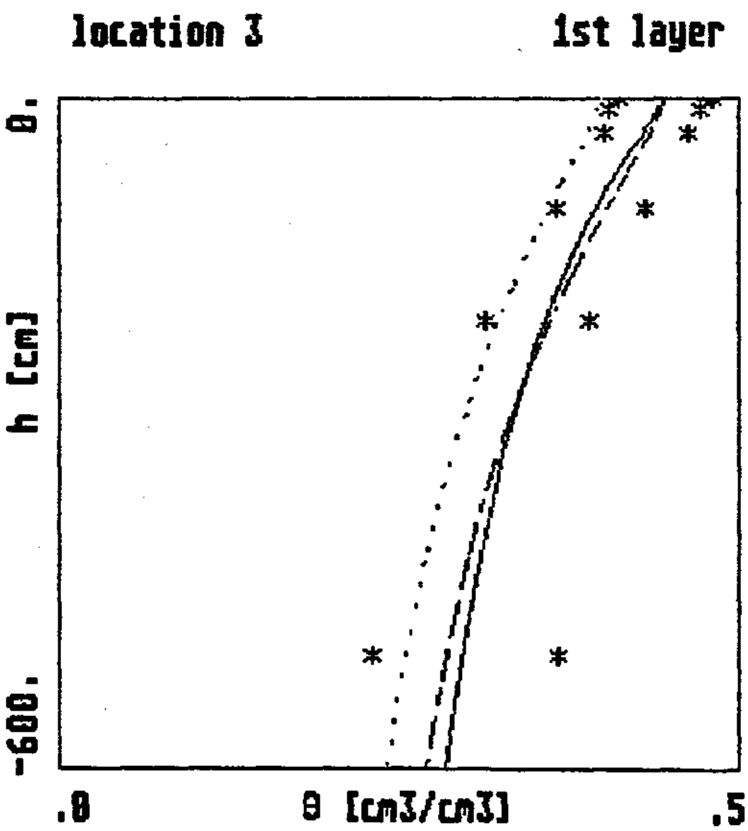
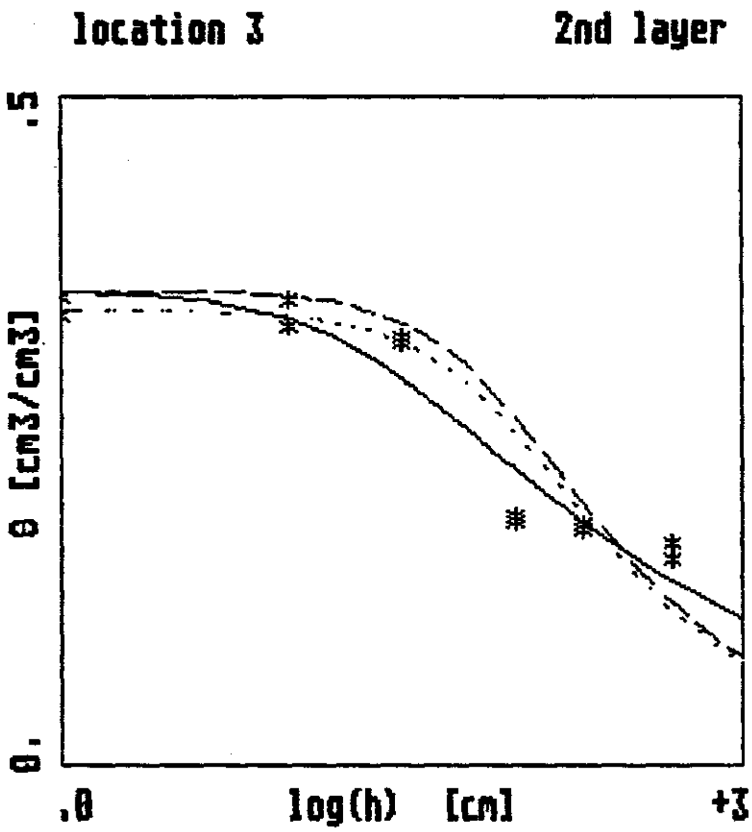
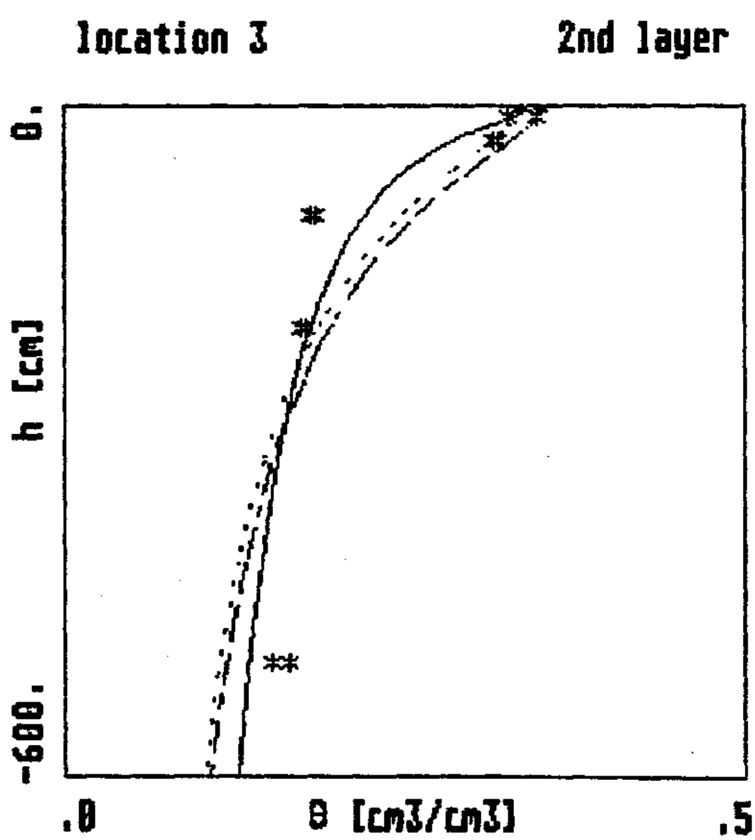
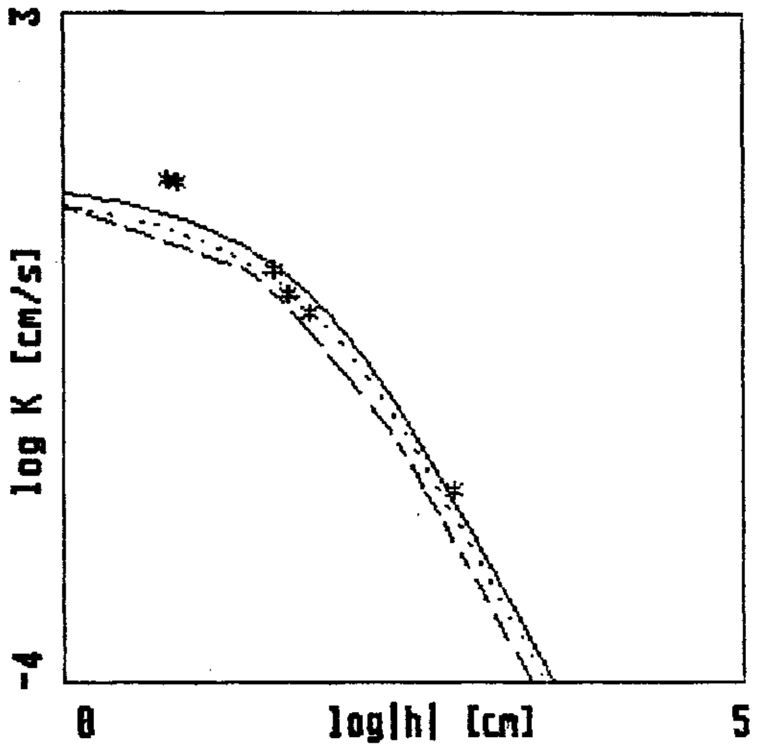
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3


location 3
1st layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

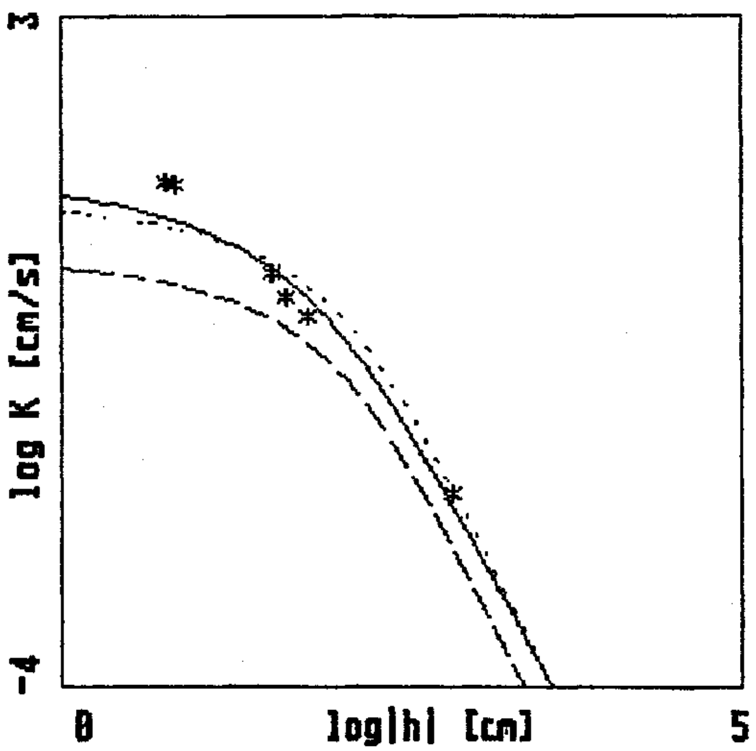

location 3
2nd layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3

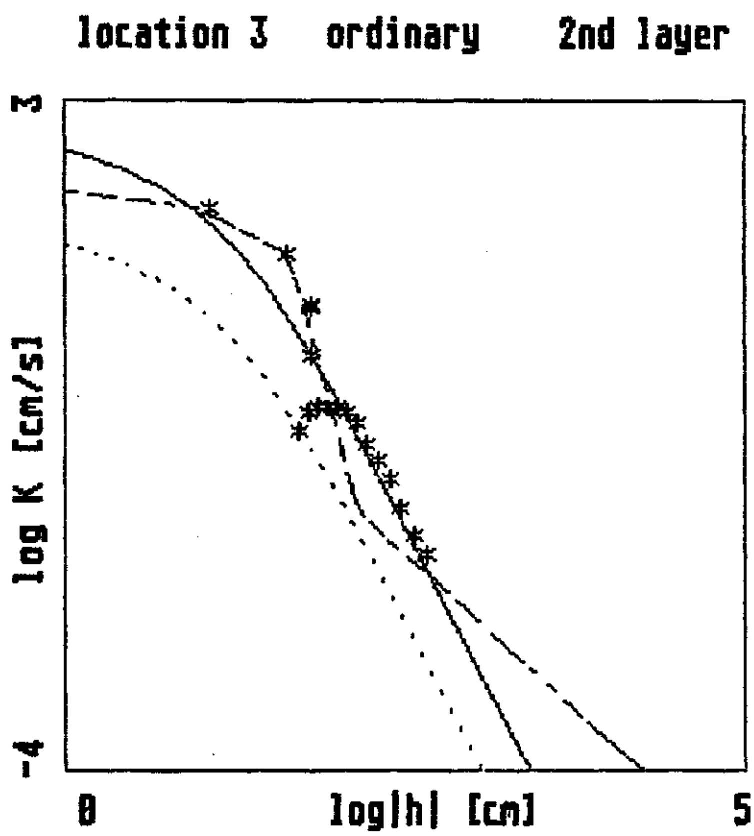

location 3
2nd layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

location 3 ordinary 1st layer

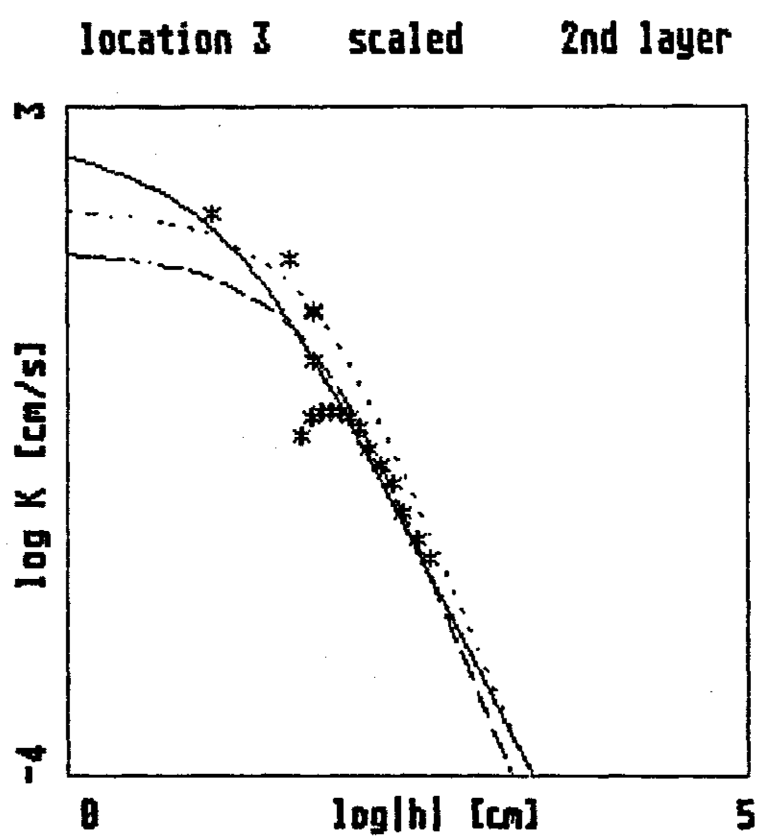


location 3 scaled 1st layer

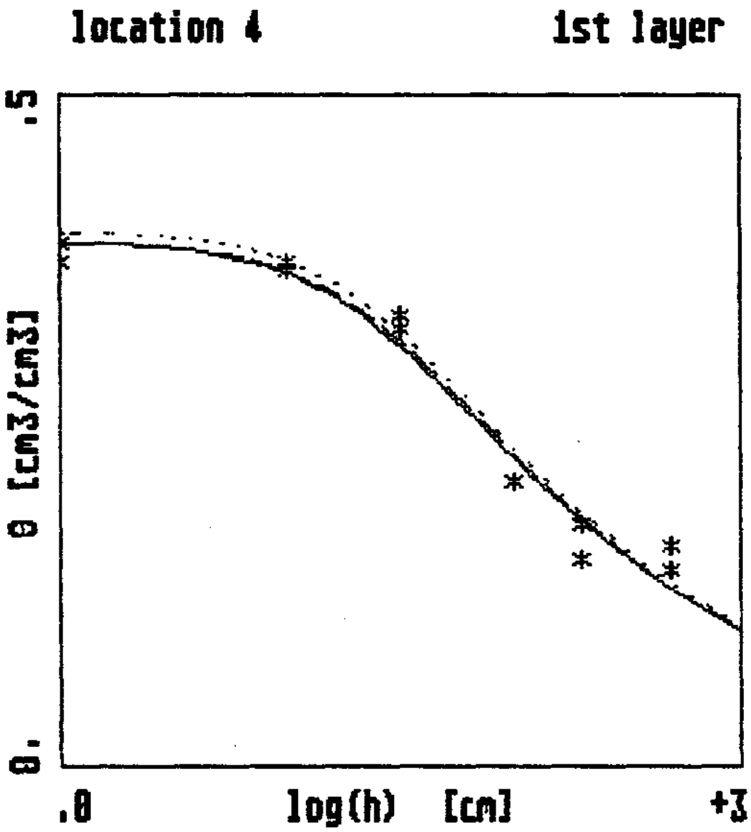


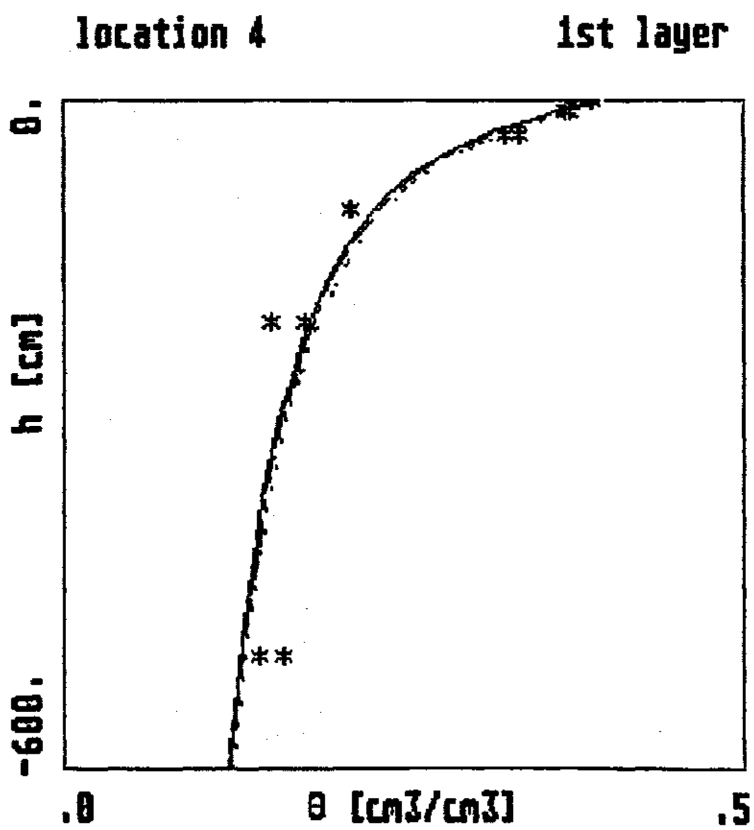


location 3 ordinary 2nd layer
3
-4
log K [cm/s]
0
log|h| [cm]
5

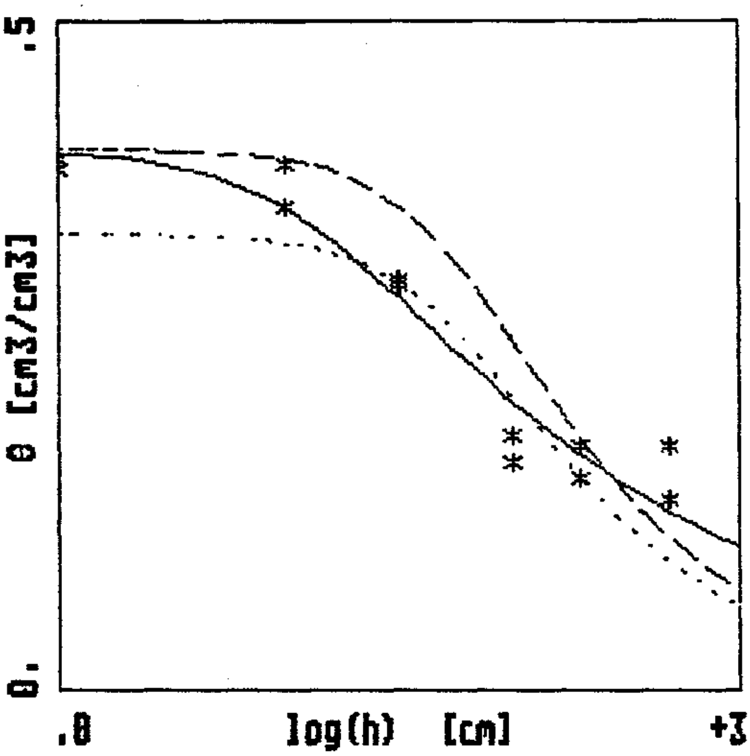


location 3 scaled 2nd layer
3
-4
log K [cm/s]
0
log|h| [cm]
5

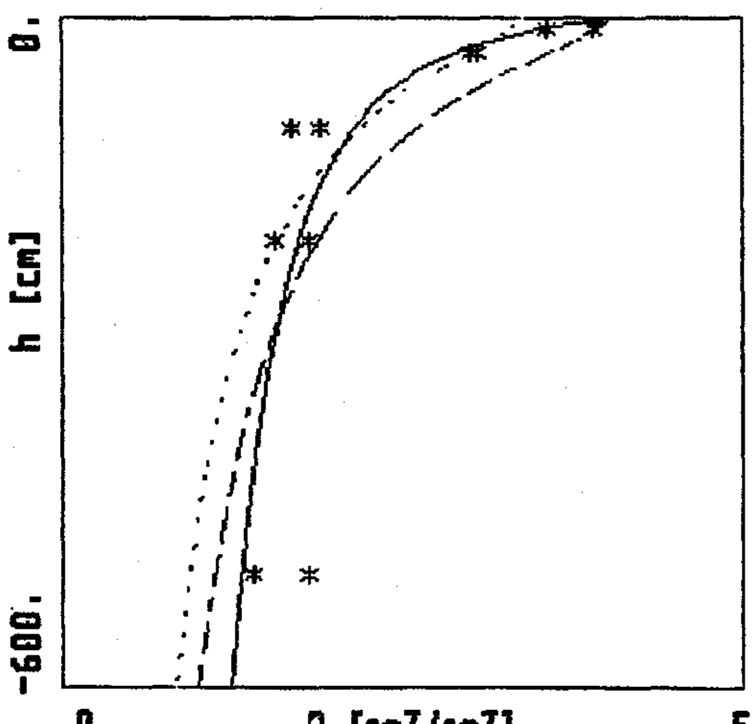

location 4
1st layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3

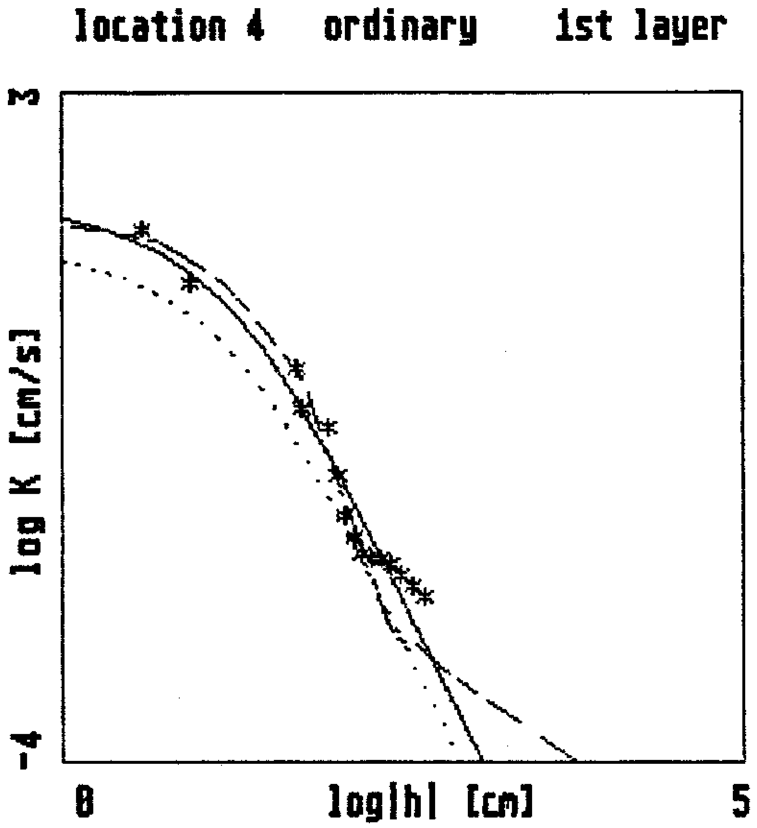

location 4
1st layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

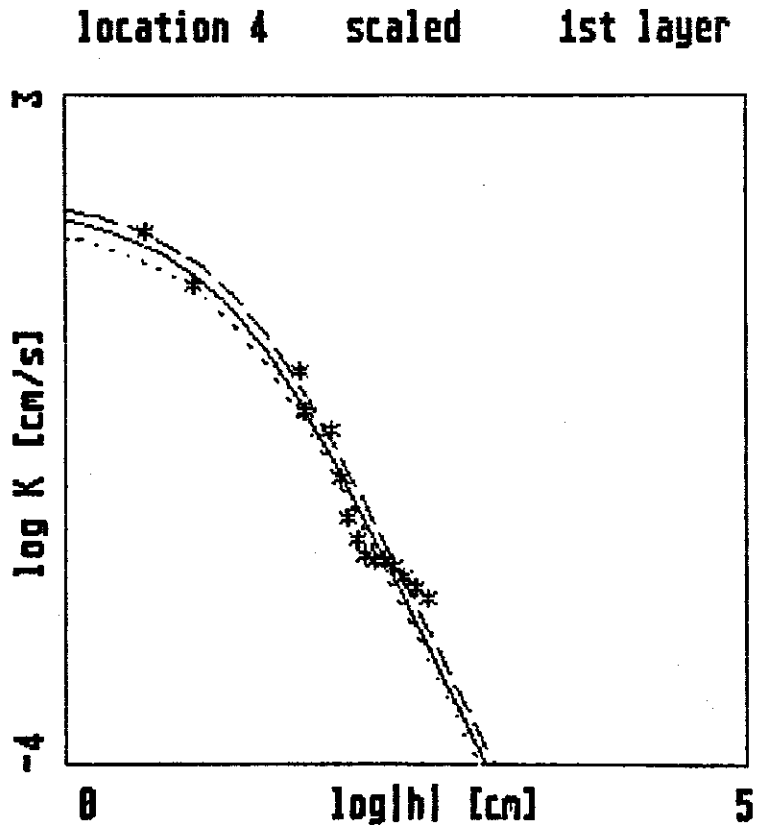
location 4 2nd layer

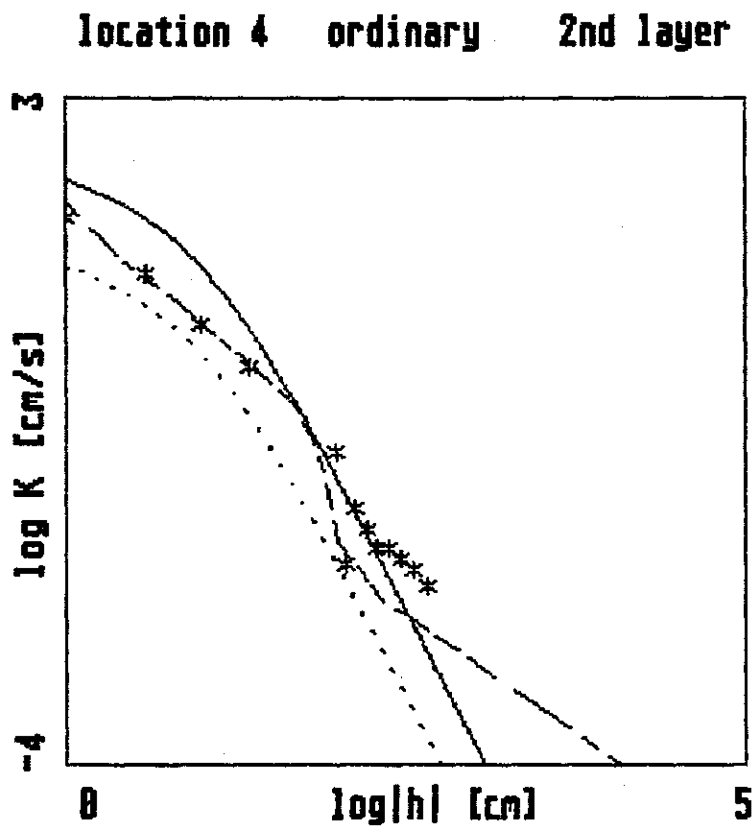


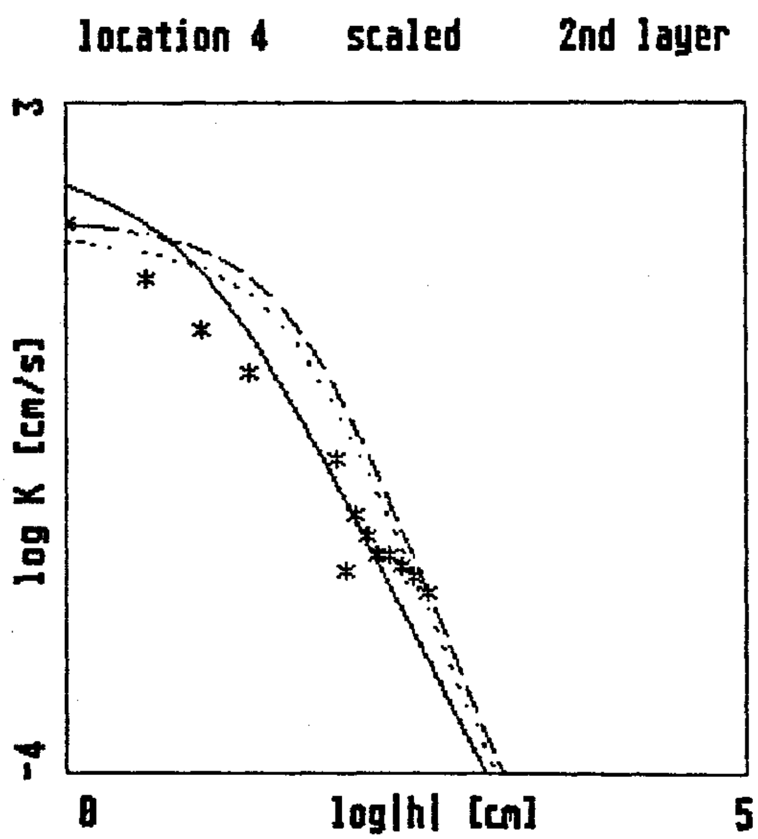
location 4 2nd layer

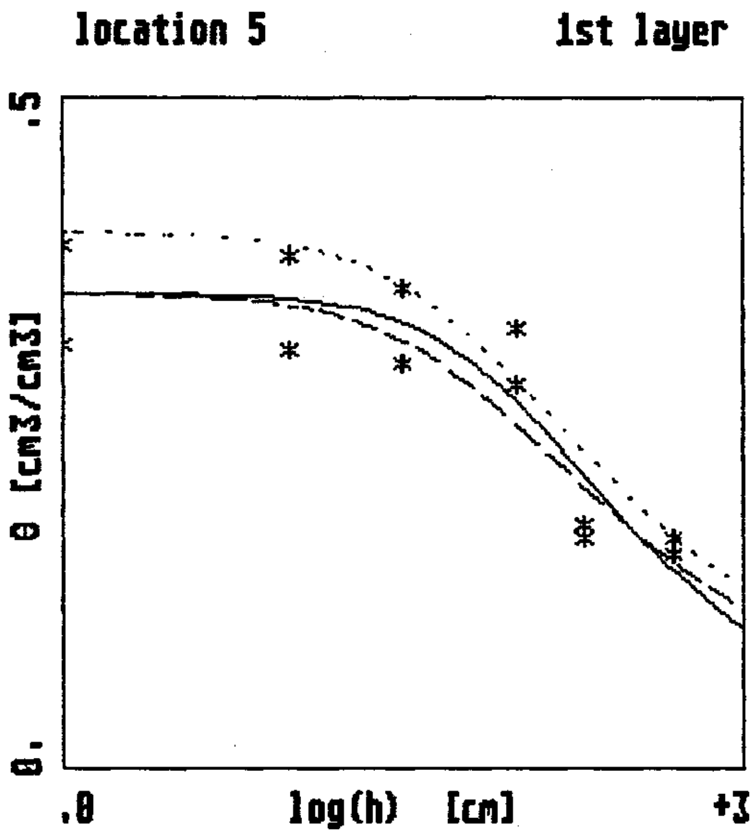


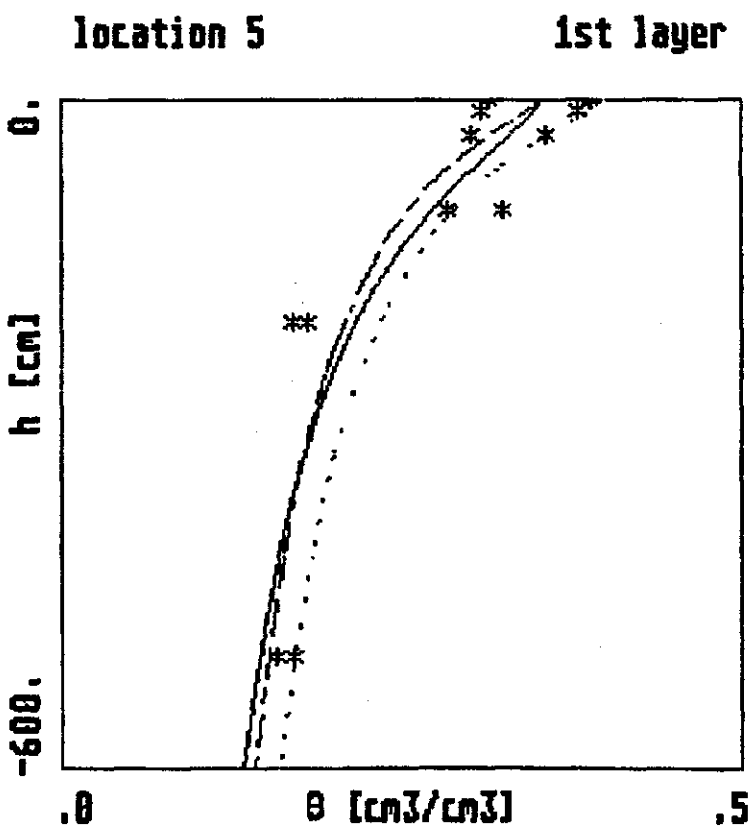

location 4 ordinary 1st layer
3
log K [cm/s]
-4
0
log|h| [cm]
5

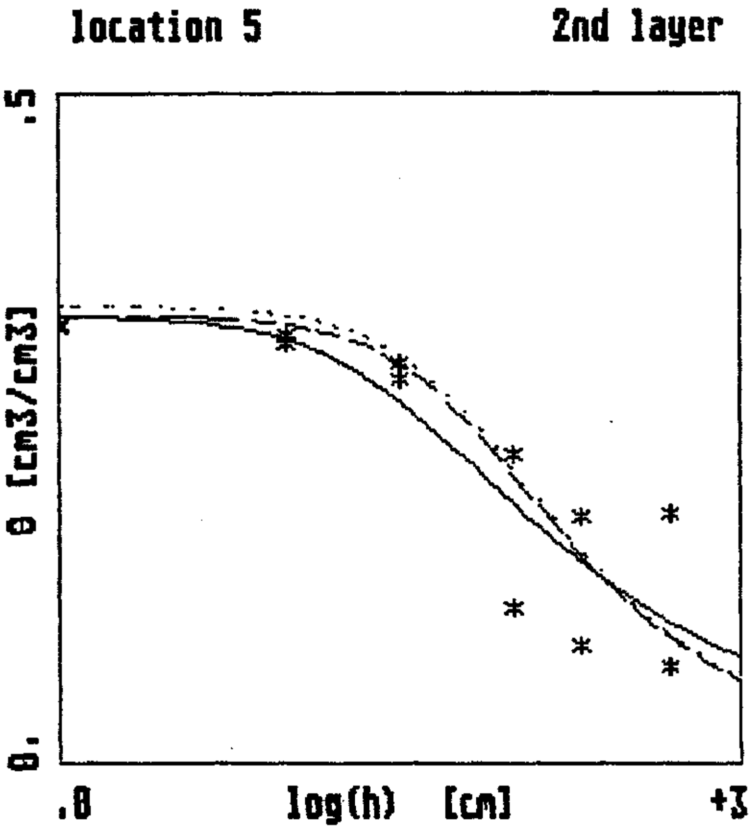

location 4 scaled 1st layer
3
log K [cm/s]
-4
0
log|h| [cm]
5

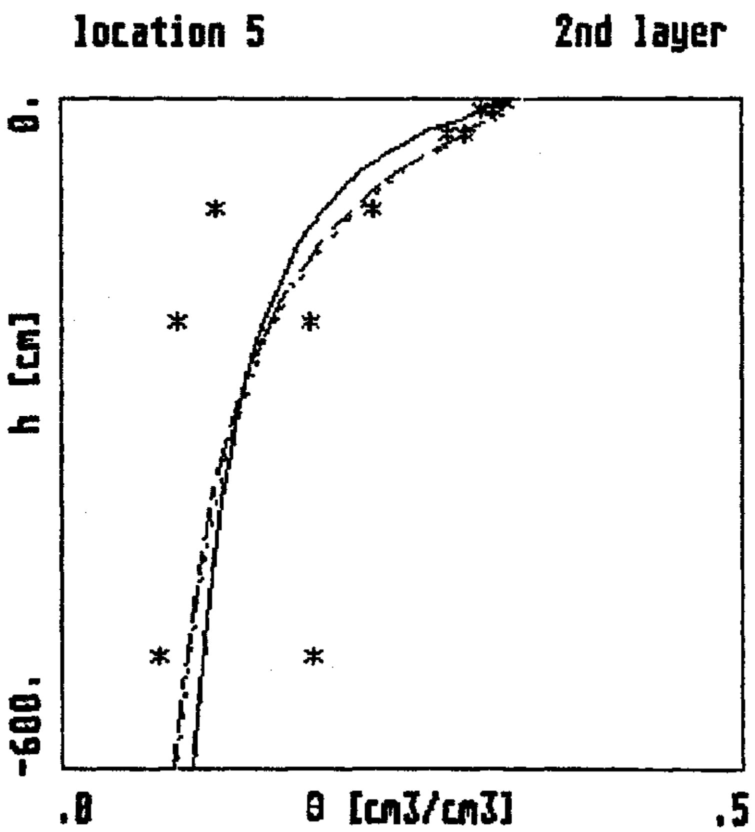

location 4 ordinary 2nd layer
3
-4
log K [cm/s]
0
log|h| [cm]
5


location 4 scaled 2nd layer
3
-4
log K [cm/s]
0
log|h| [cm]
5

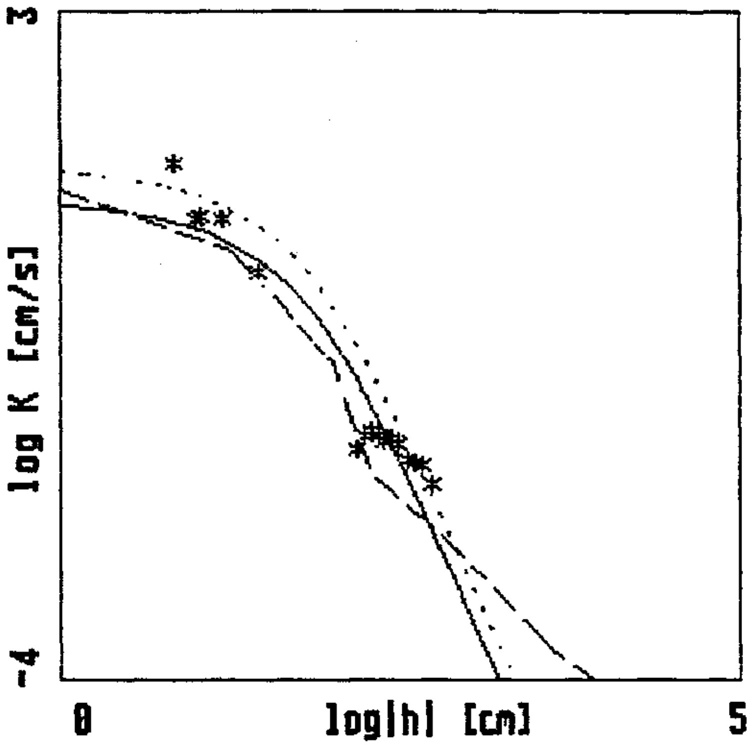

location 5
1st layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3


location 5
1st layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

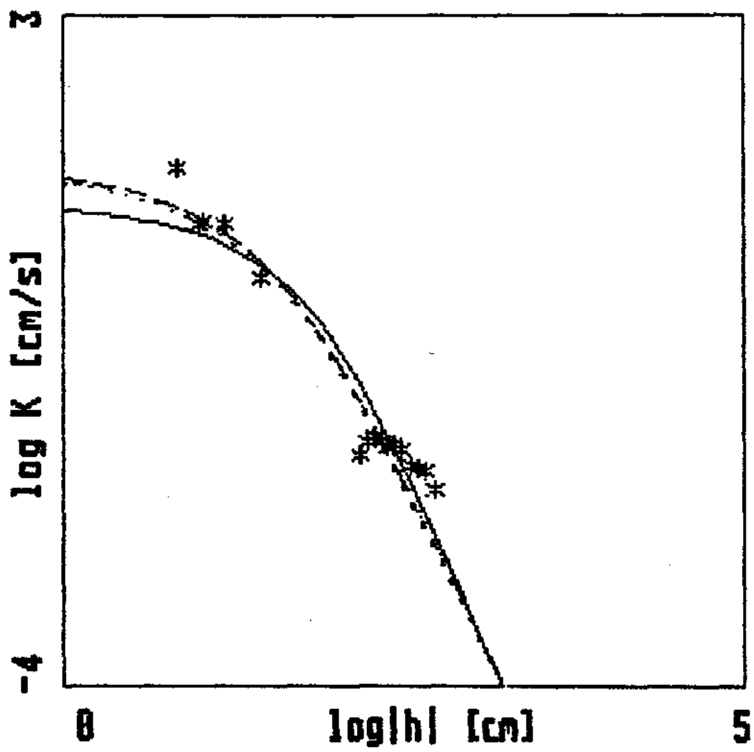

location 5
2nd layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3

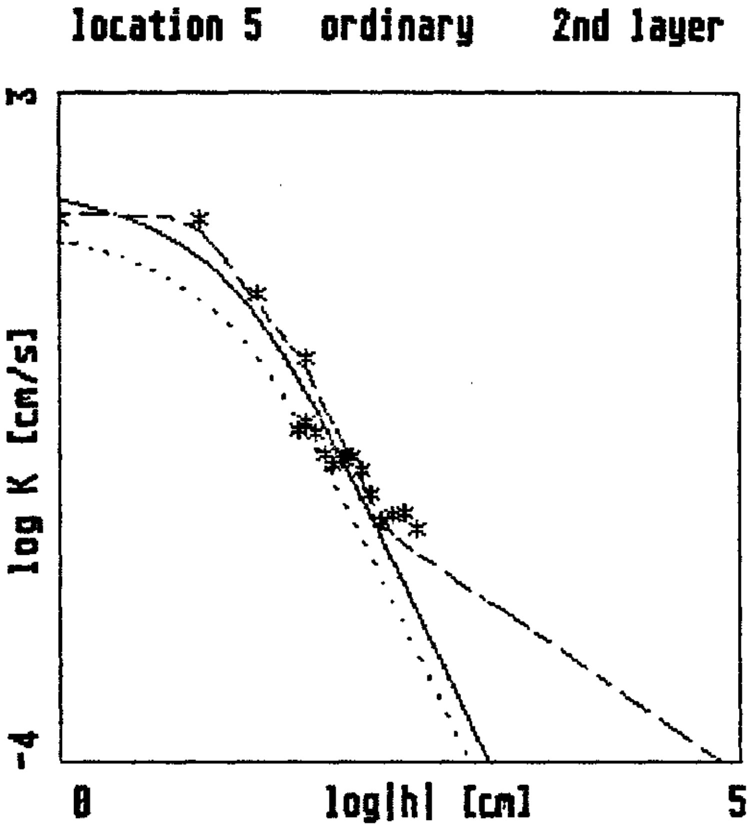

location 5
2nd layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

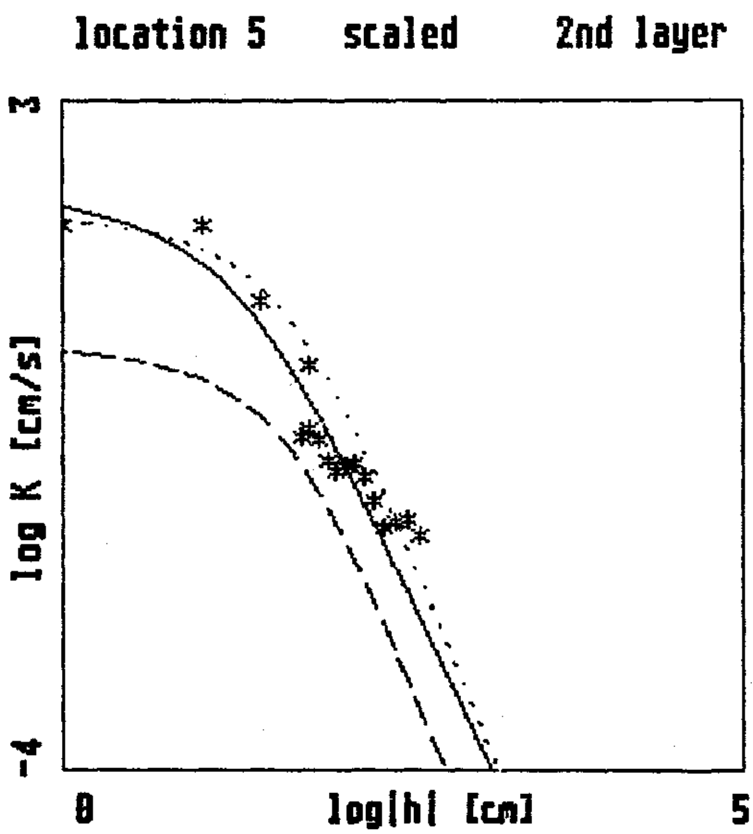
location 5 ordinary 1st layer

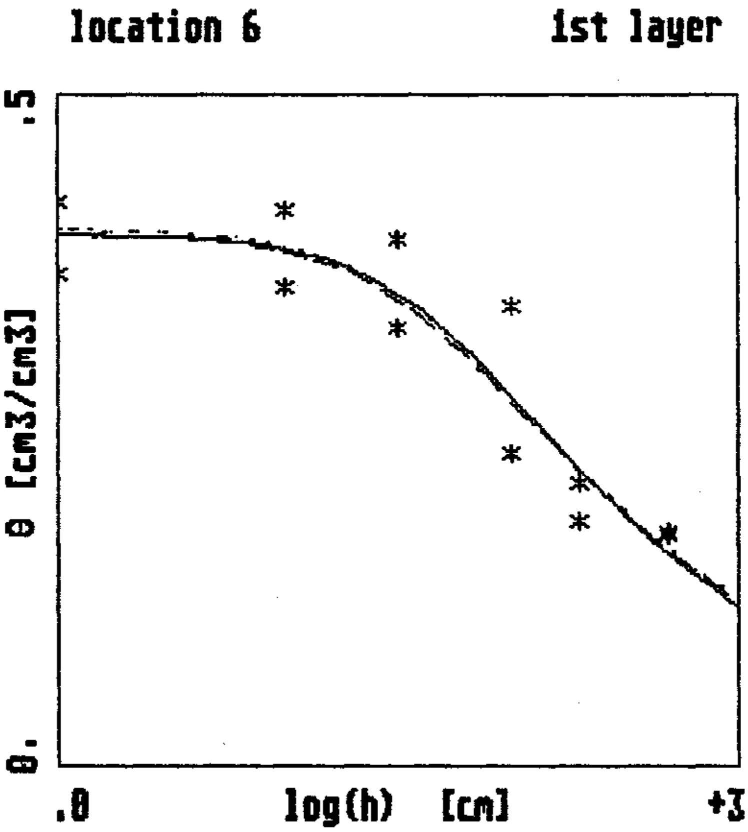


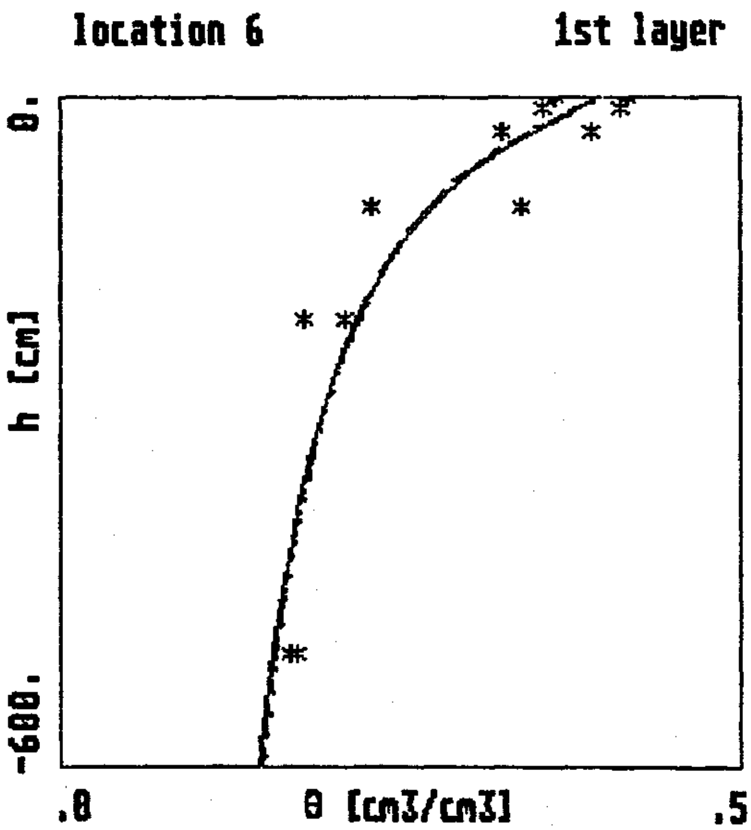
location 5 scaled 1st layer

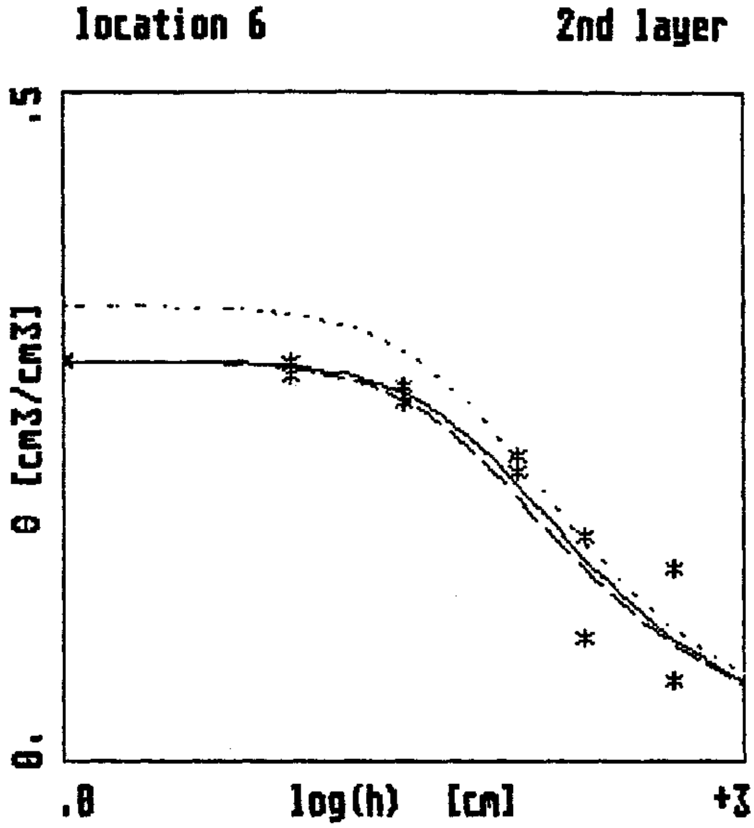


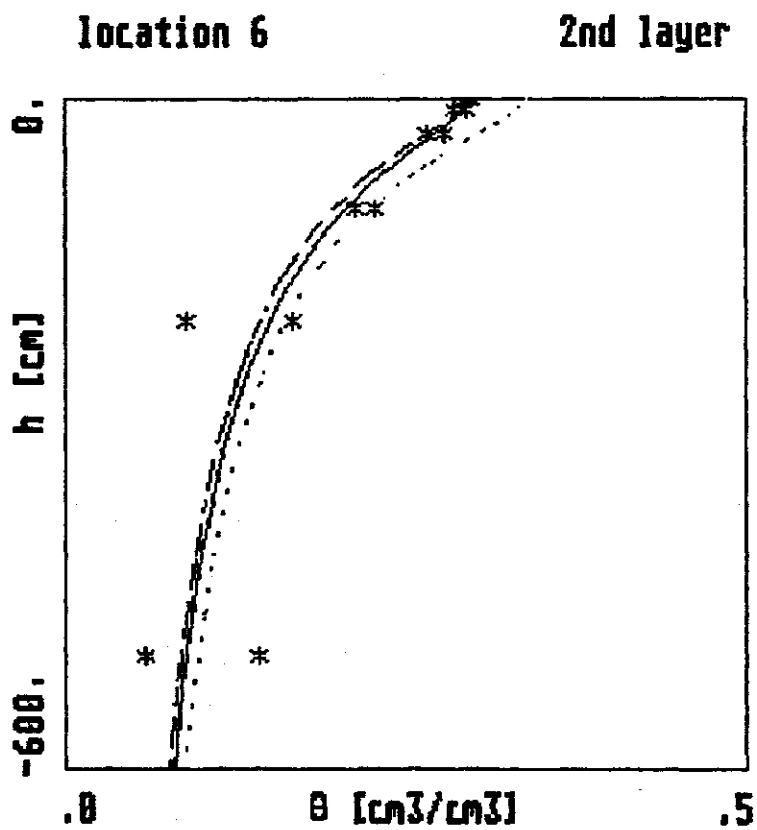

location 5 ordinary 2nd layer
log K [cm/s]
3
-4
0
log|h| [cm]
5

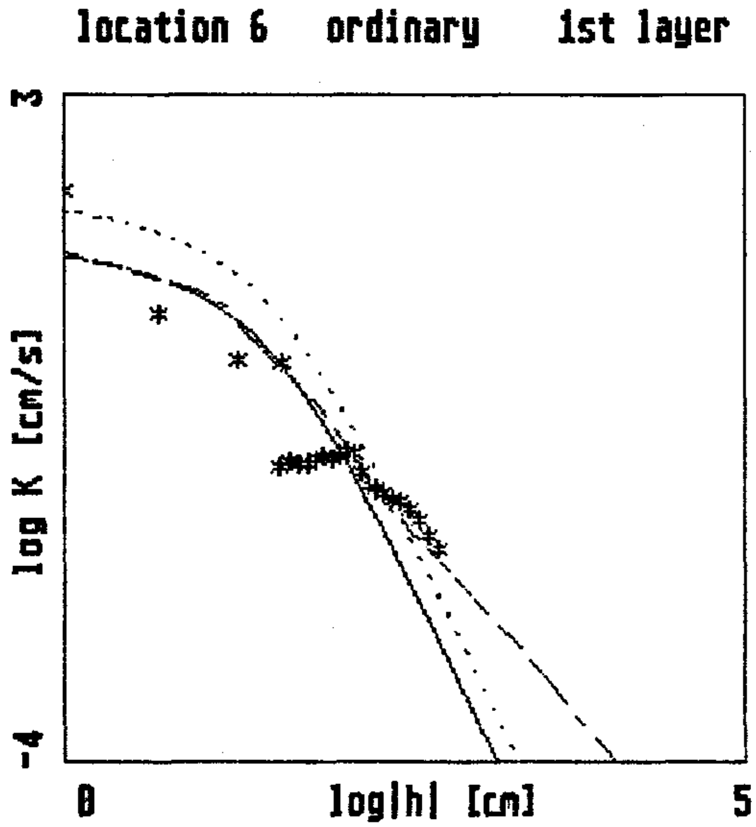

location 5 scaled 2nd layer
log K [cm/s]
3
-4
0
log|h| [cm]
5

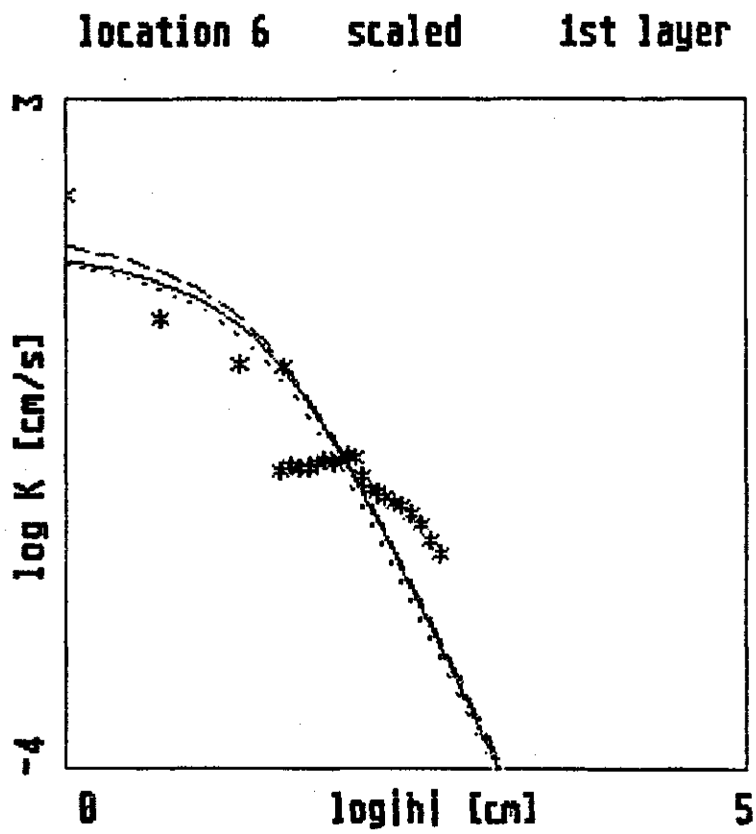

location 6
1st layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3

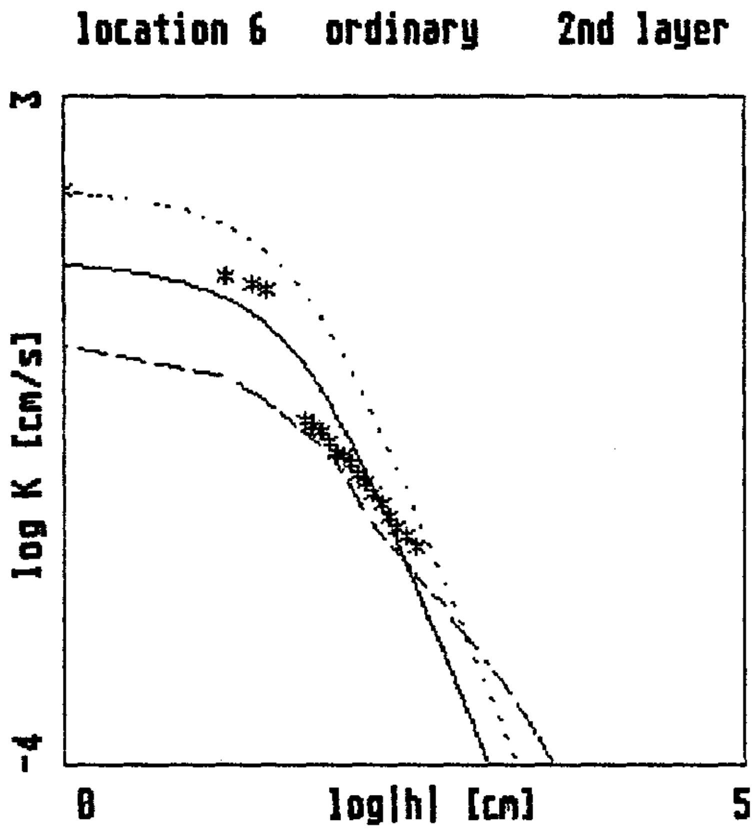

location 6
1st layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

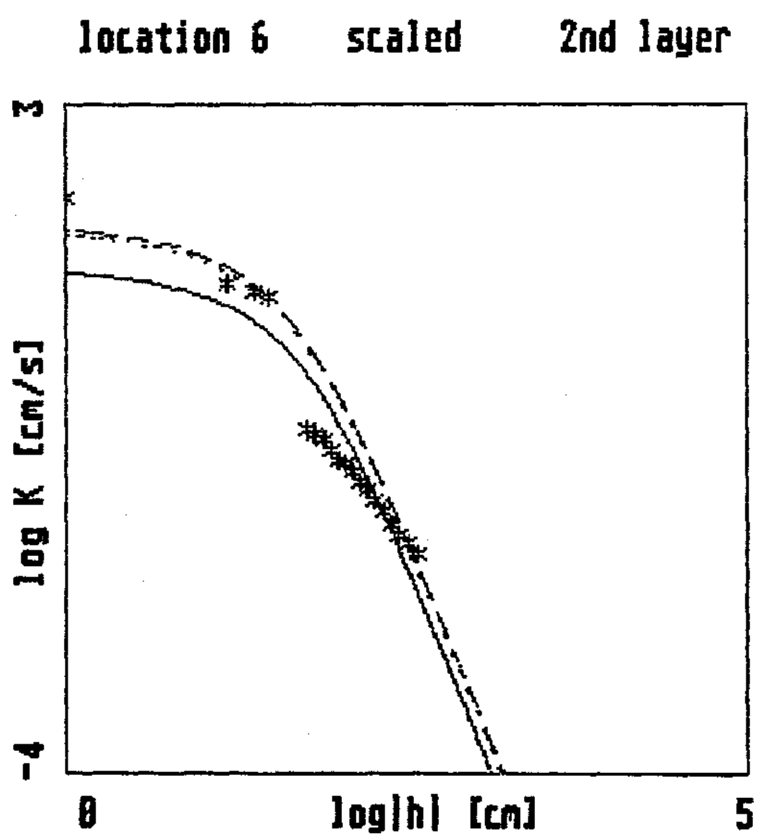

location 6
2nd layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3

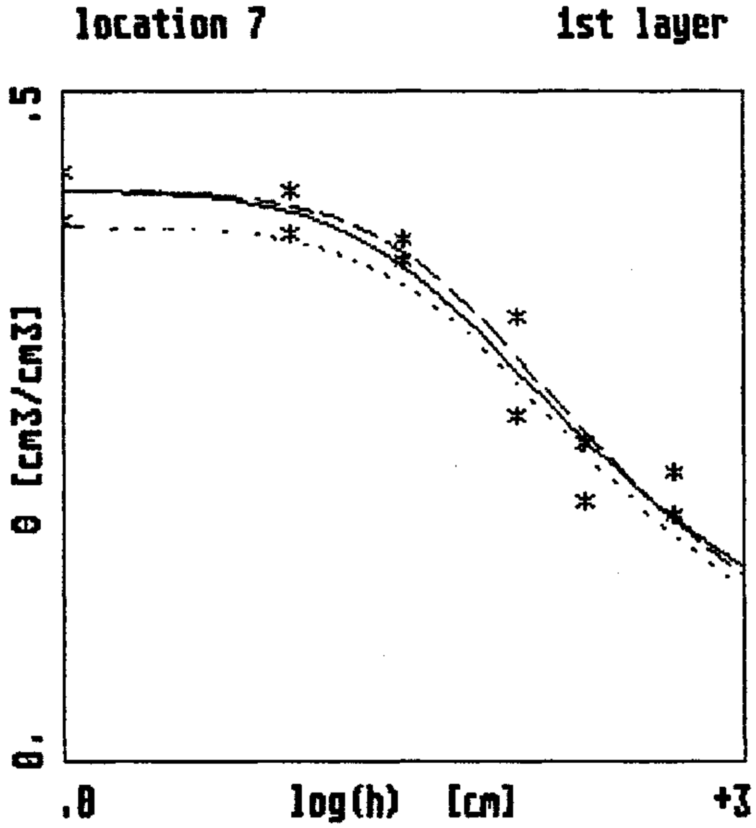

location 6
2nd layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

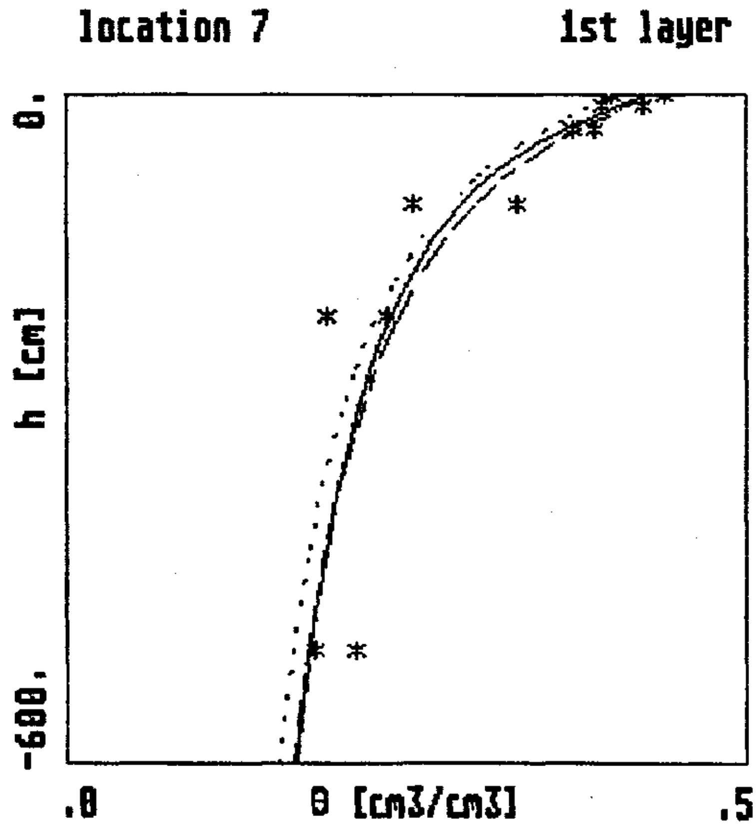

location 6 ordinary 1st layer
3
-4
log K [cm/s]
0
log|h| [cm]
5

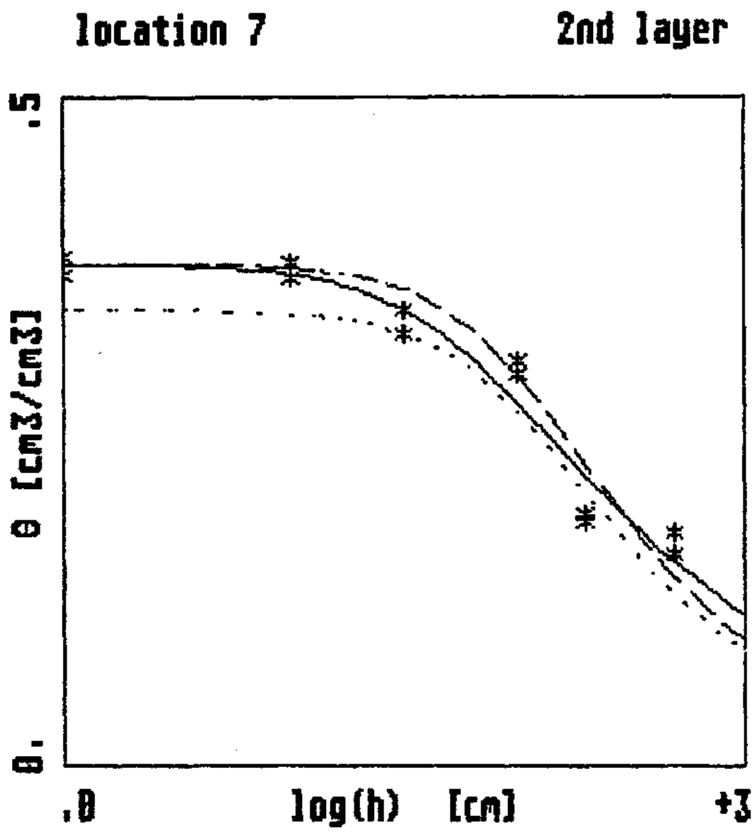

location 6 scaled 1st layer
3
-4
log K [cm/s]
0
log|h| [cm]
5

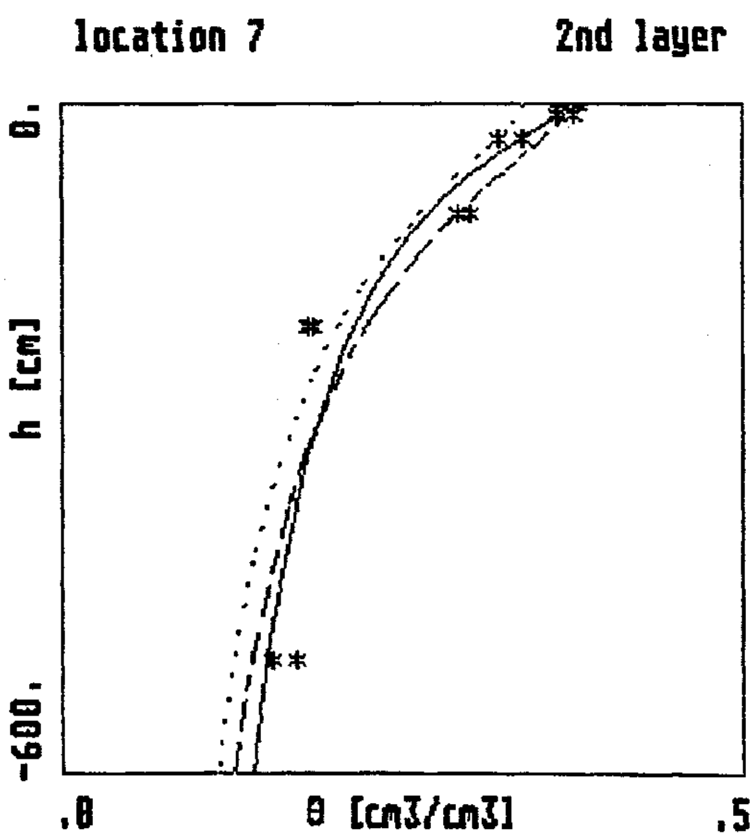

location 6 ordinary 2nd layer
3
-4
log K [cm/s]
0
log|h| [cm]
5

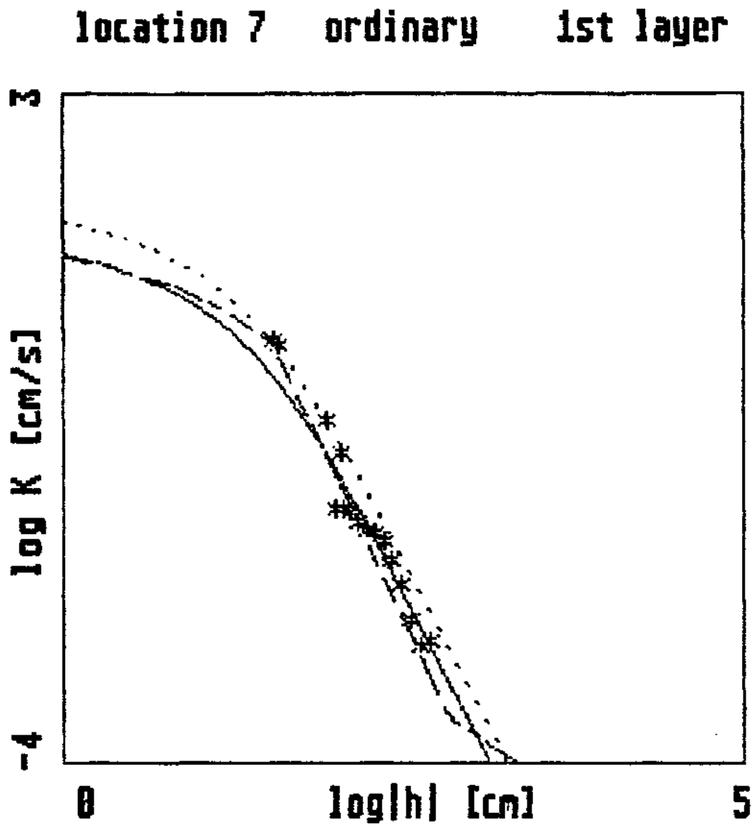

location 6 scaled 2nd layer
3
-4
log K [cm/s]
0
log|h| [cm]
5


location 7
1st layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3

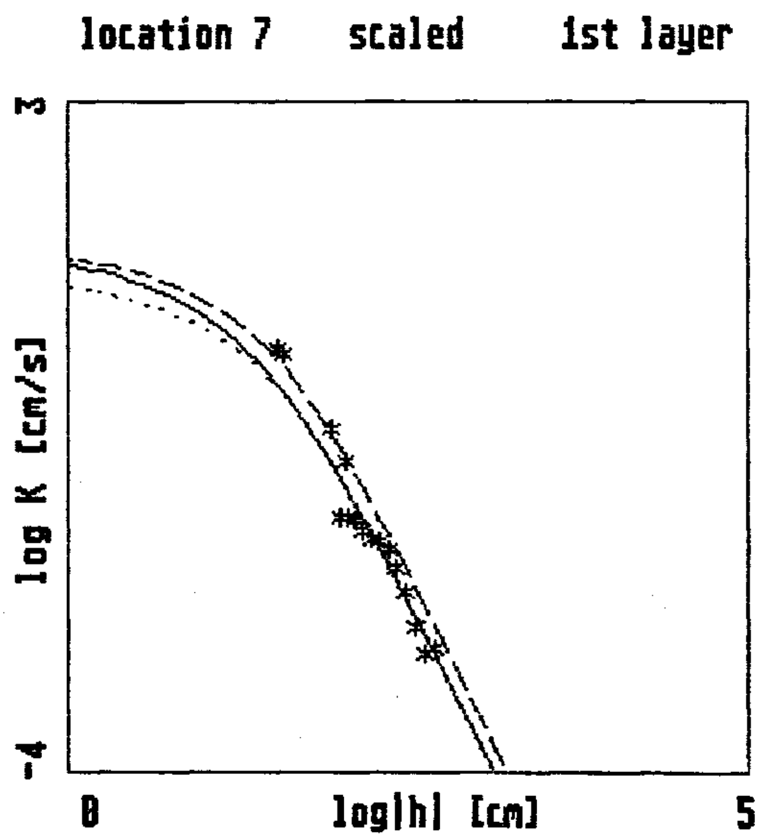

location 7
1st layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5


location 7
2nd layer
.5
θ [cm3/cm3]
0.
.0
log(h) [cm]
+3


location 7
2nd layer
0.
h [cm]
-600.
.0
θ [cm3/cm3]
.5

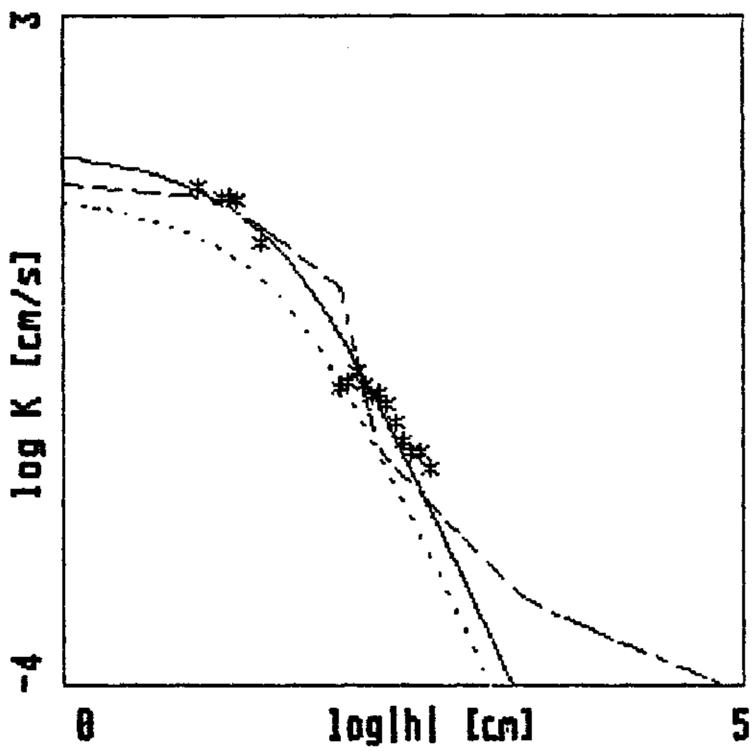


location 7 ordinary 1st layer
3
log K [cm/s]
-4
0
log|h| [cm]
5

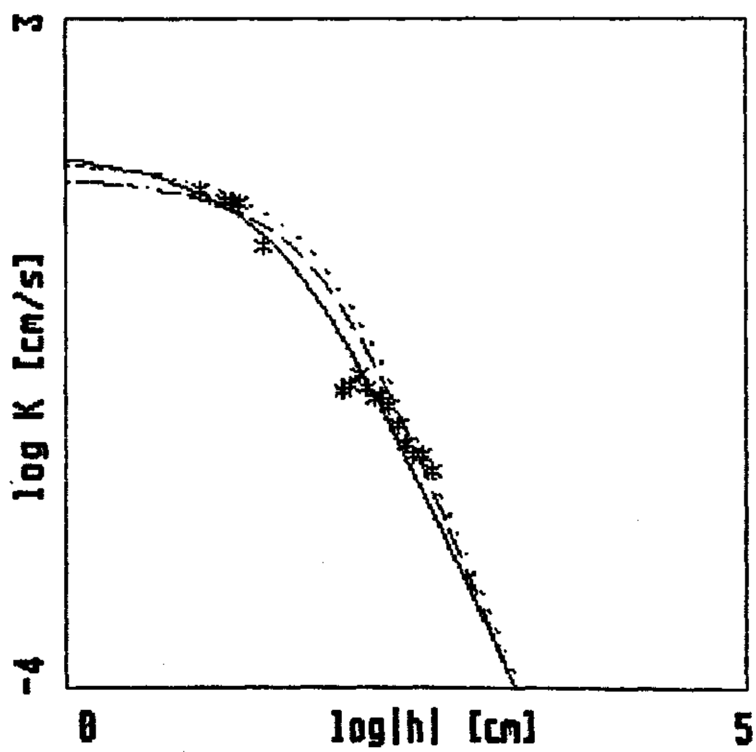


location 7 scaled 1st layer
3
log K [cm/s]
-4
0
log|h| [cm]
5

location 7 ordinary 2nd layer



location 7 scaled 2nd layer



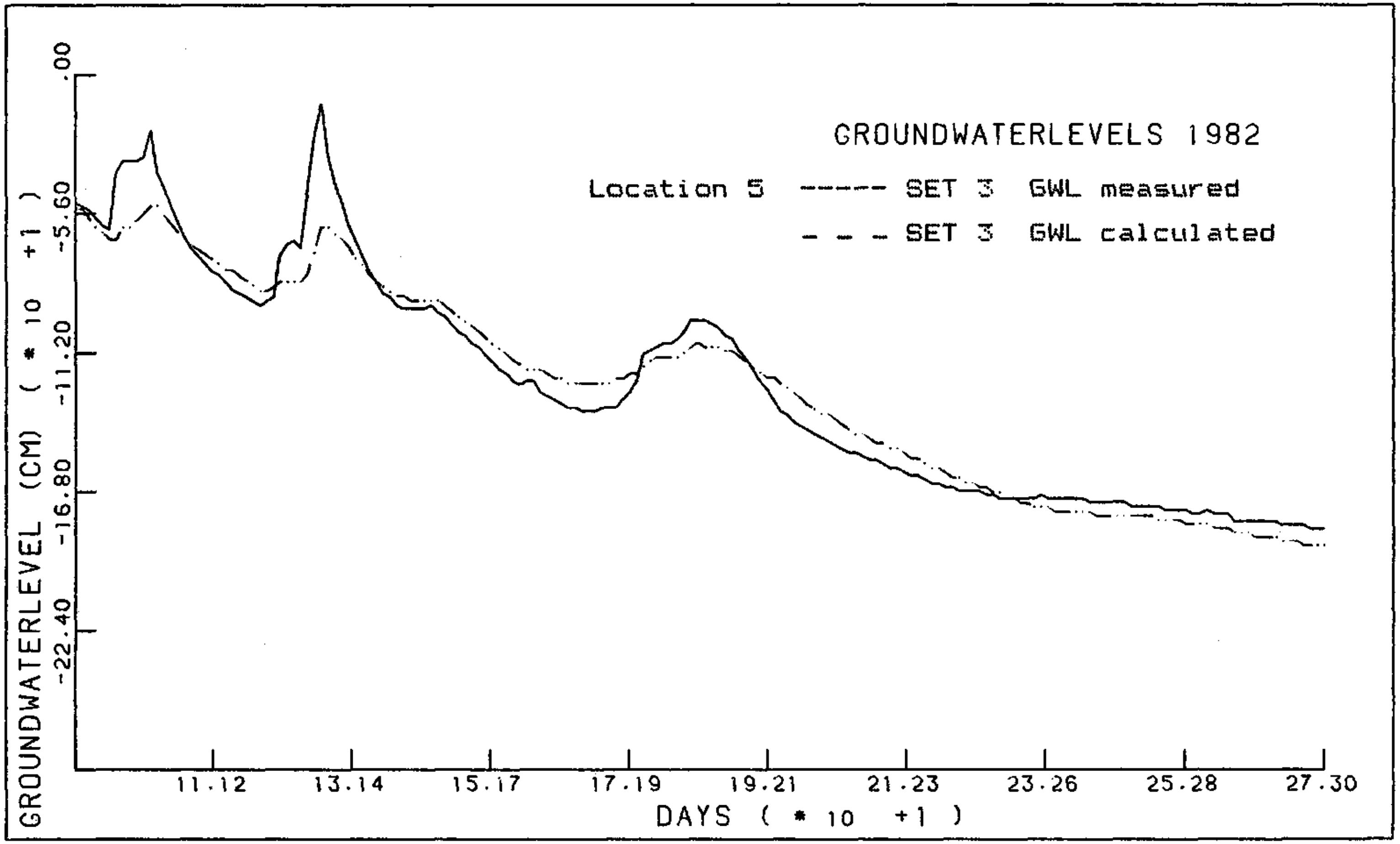


Figure 8. Comparison of courses of measured and calculated GWL

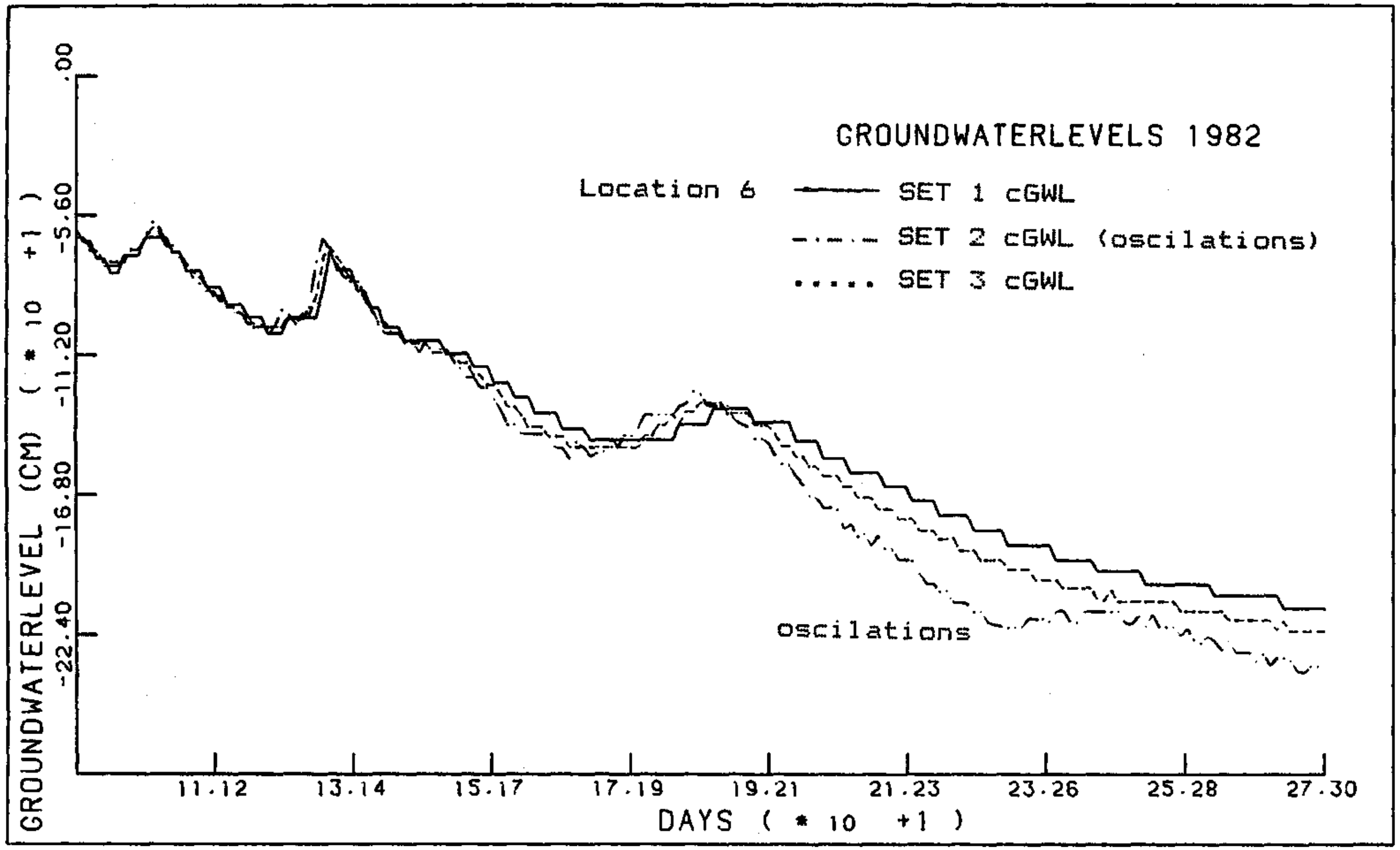


Figure 9. Example of oscilations of calculated GWL

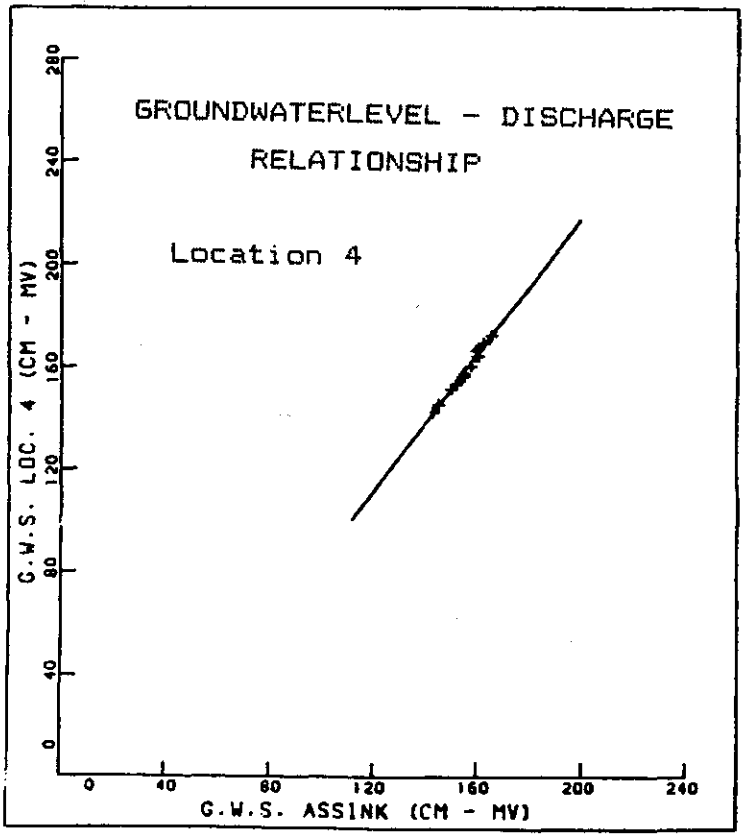
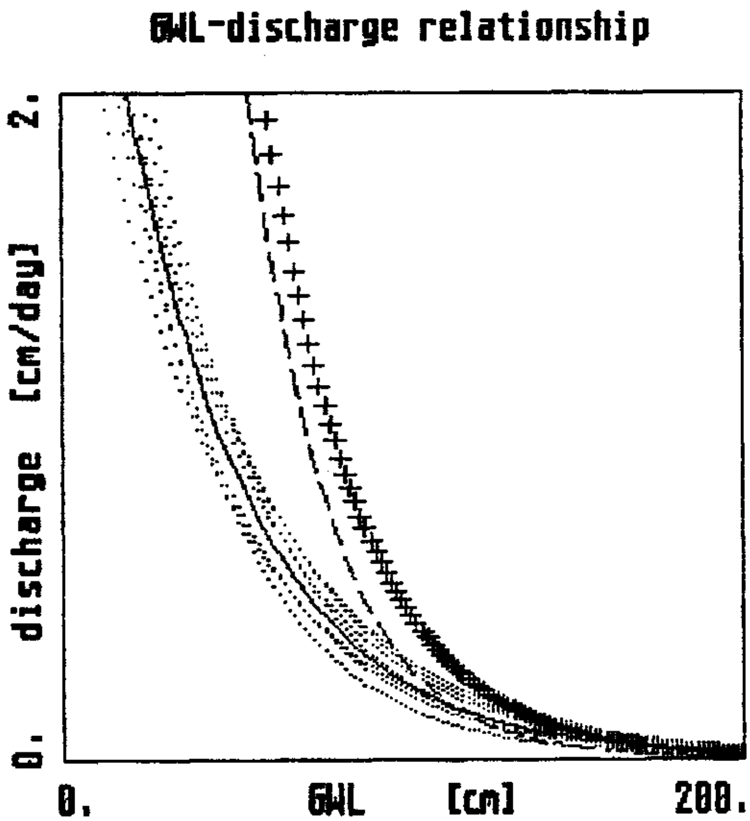
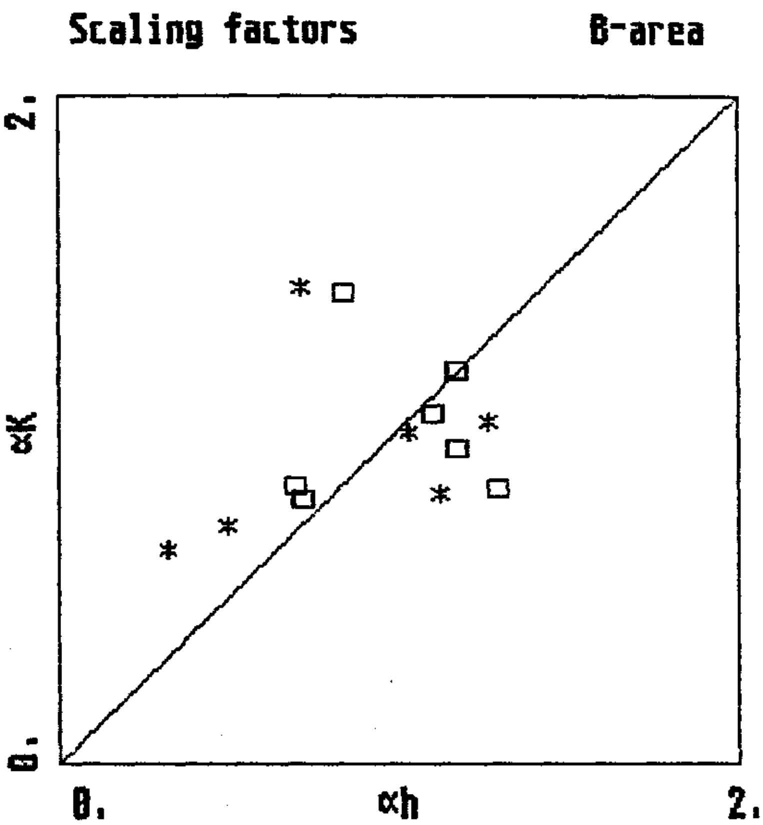


Figure 10. Relation between measured GWL at Assink and Location 4



----- mean GWL-D for B-area
..... GWL-D for particular locations of B-area
\- - - arbitrary extreme
+++++ mean GWL-D for whole Hupselse Beek area

Figure 11. GWL - discharge relationship



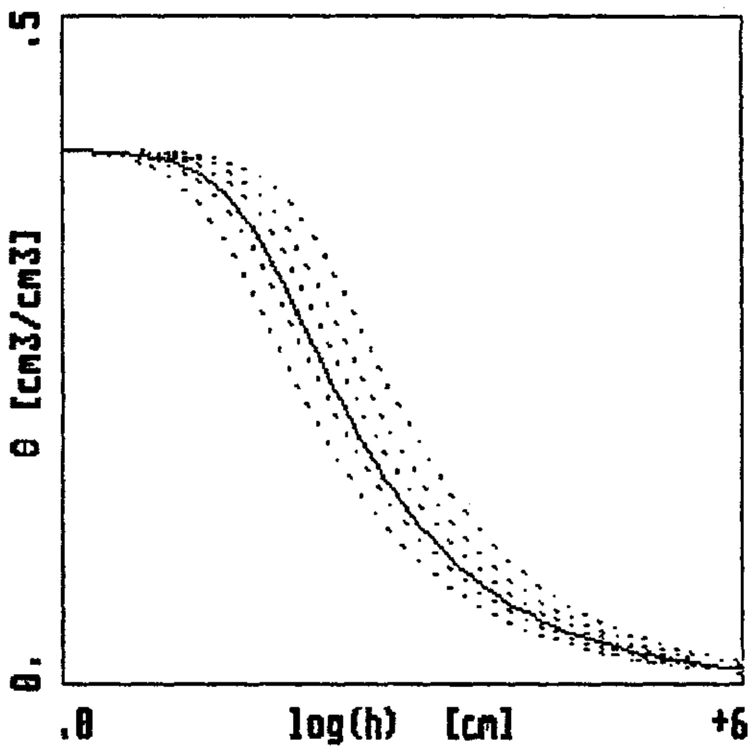
* A-horizon

□ BC-horizon

Figure 12. Relationship of scaling factors for B-area

Figure 13. The influence of scaling factor α_H on the shape of retention curves. The full line is for the mean retention curve

1st layer



2nd layer

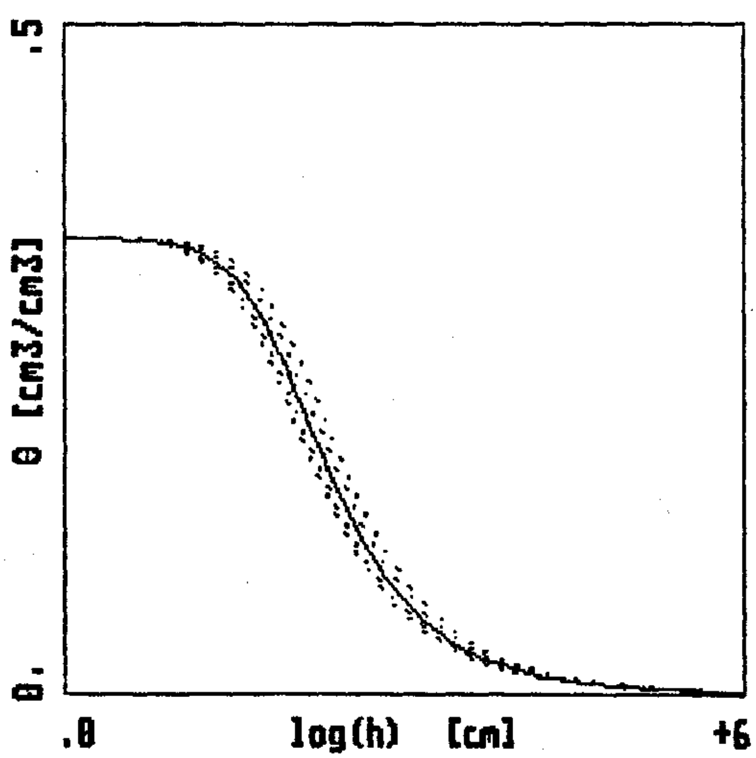
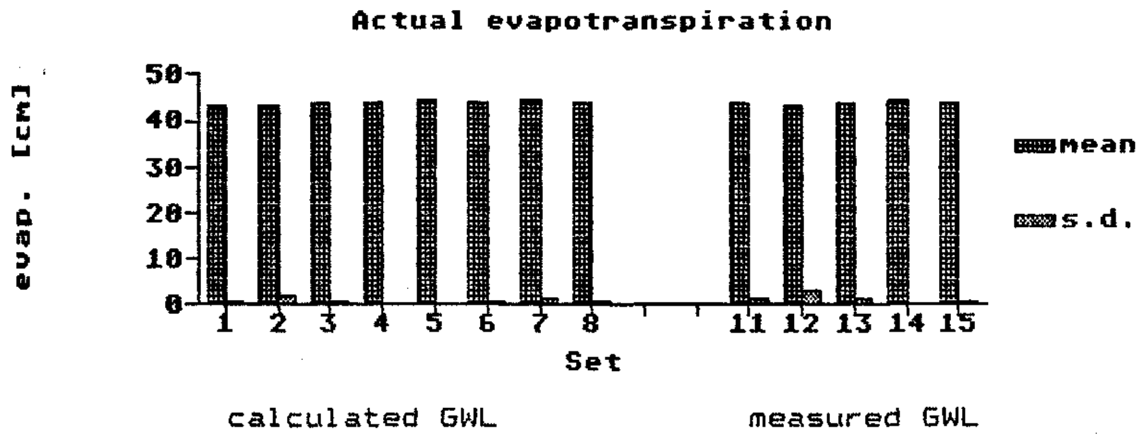
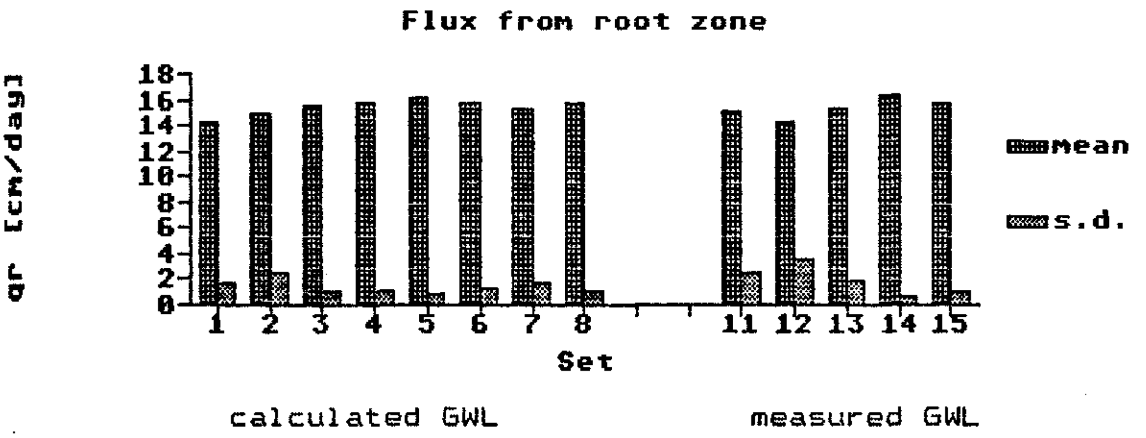
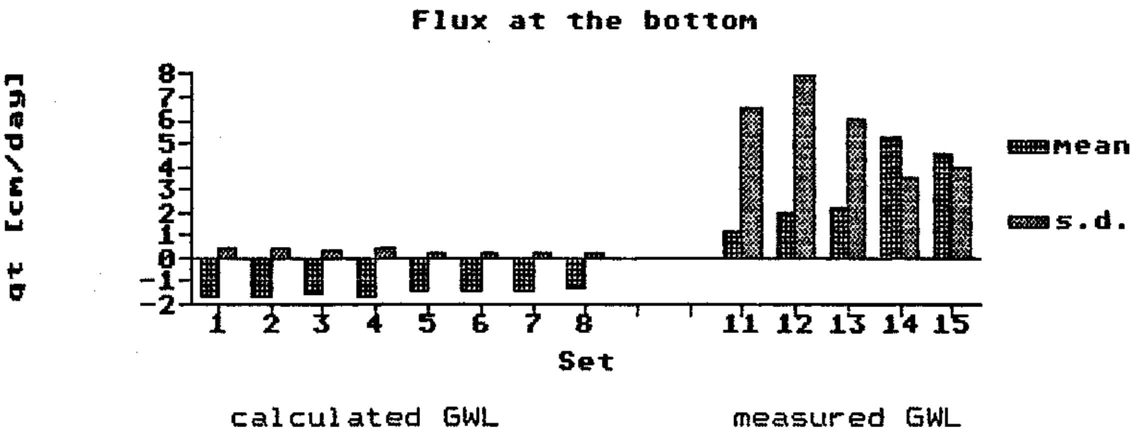


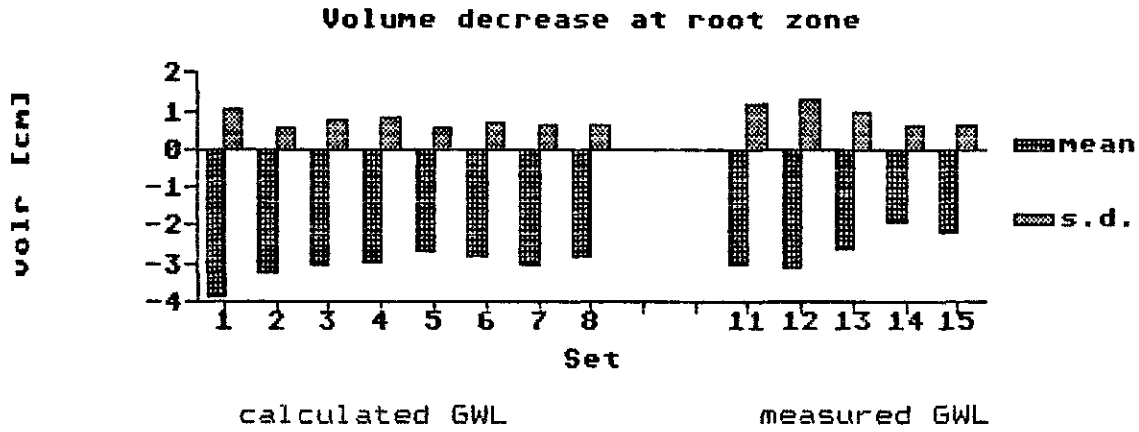
Figure 14. Comparison of mean results and standard deviations of the particular components of water balance for all the soil input sets in combination with both types of the lower boundary condition in order as listed below:

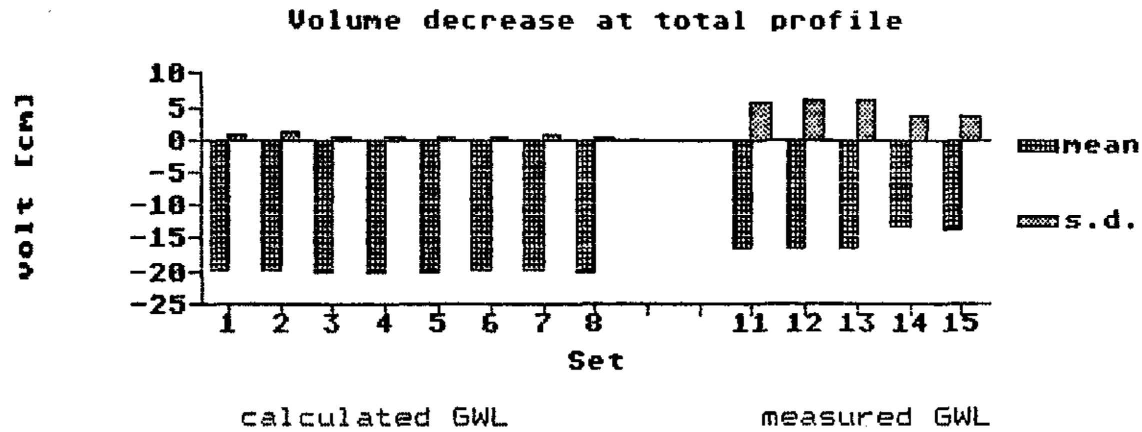
1	SET 1	GWL-D of loc.		11	SET 1	measured GWL
2	SET 2	GWL-D of loc		12	SET 2	measured GWL
3	SET 3	GWL-D of loc		13	SET 3	measured GWL
4	SET 3	mean GWL-D		14	SET α_h	measured GWL
5	SET α_h	mean GWL-D		15	SET $\alpha_h+\alpha_k$	measured GWL
6	SET $\alpha_h+\alpha_k$	mean GWL-D				
7	SET $\alpha_h+\theta_s$	mean GWL-D				
8	SET $\alpha_h+\alpha_k+\theta_s$	mean GWL-D				

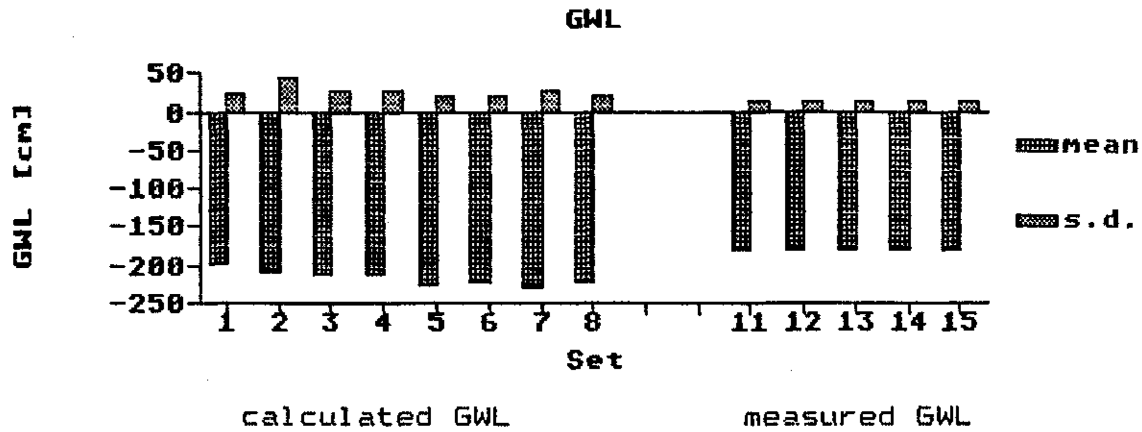

Actual evapotranspiration
evap. [cm]
50
40
30
20
10
0
1 2 3 4 5 6 7 8 11 12 13 14 15
Set
mean
s.d.
calculated GWL
measured GWL


Flux from root zone
qr [cm/day]
18
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 11 12 13 14 15
Set
mean
s.d.
calculated GWL
measured GWL


Flux at the bottom
qt [cm/day]
8
7
6
5
4
3
2
1
0
-1
-2
1 2 3 4 5 6 7 8 11 12 13 14 15
Set
mean
s.d.
calculated GWL
measured GWL

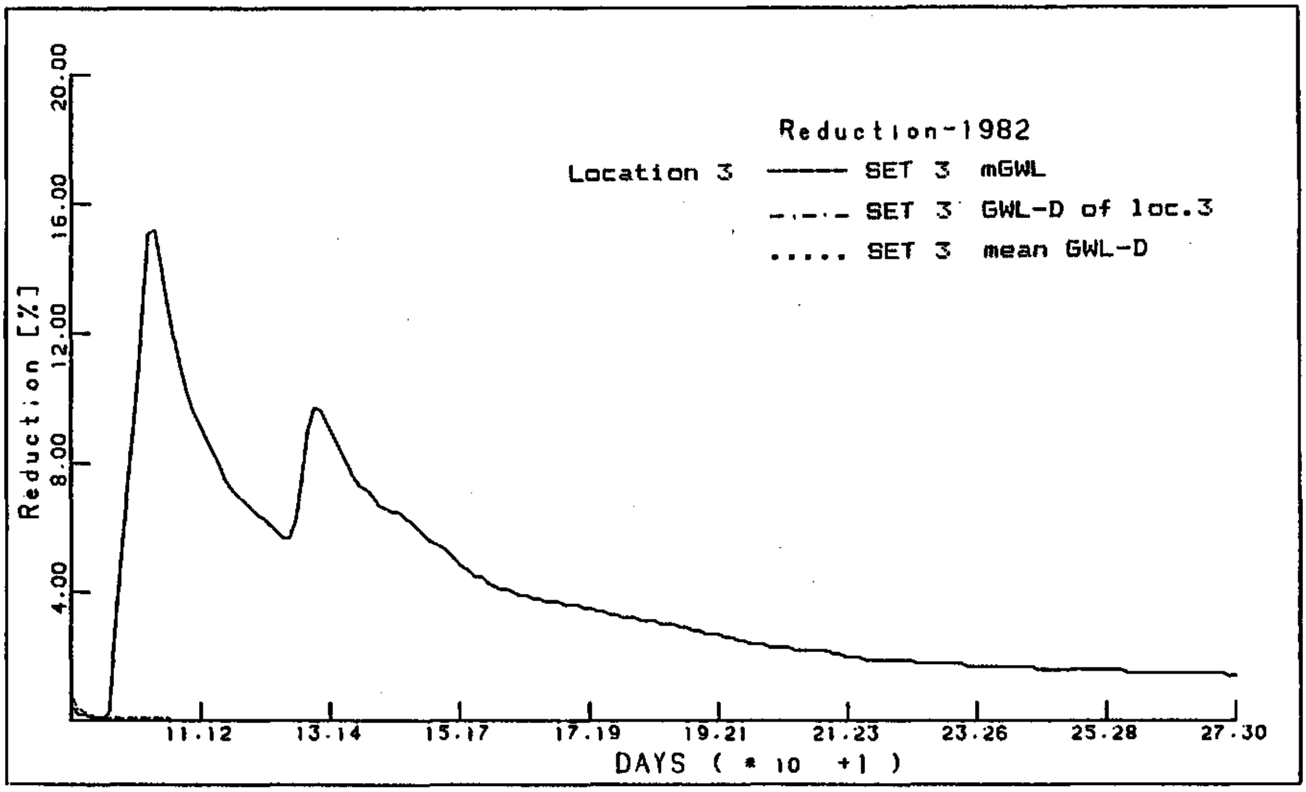

Volume decrease at root zone
volr [cm]
2
1
0
-1
-2
-3
-4
1 2 3 4 5 6 7 8 11 12 13 14 15
Set
mean
s.d.
calculated GWL
measured GWL

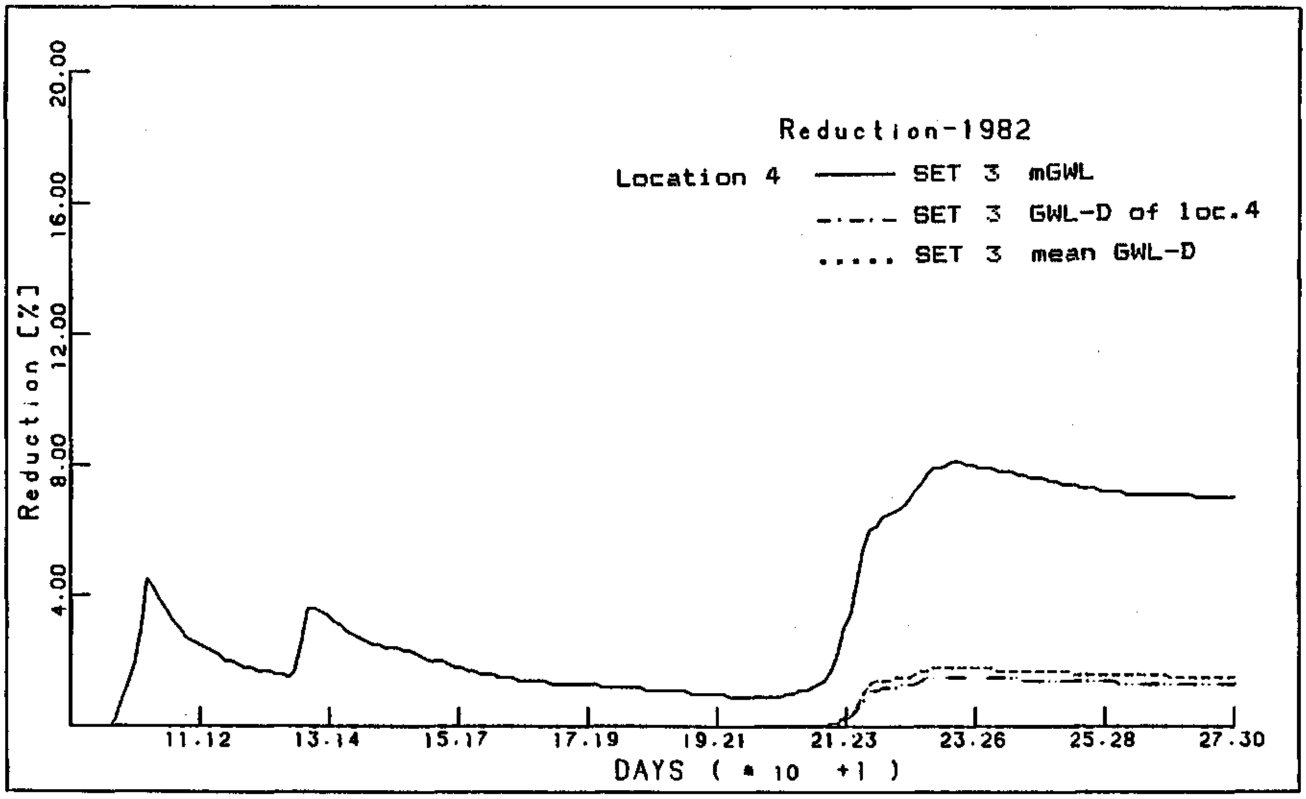

Volume decrease at total profile
volt [cm]
10
5
0
-5
-10
-15
-20
-25
1 2 3 4 5 6 7 8 11 12 13 14 15
Set
mean
s.d.
calculated GWL
measured GWL

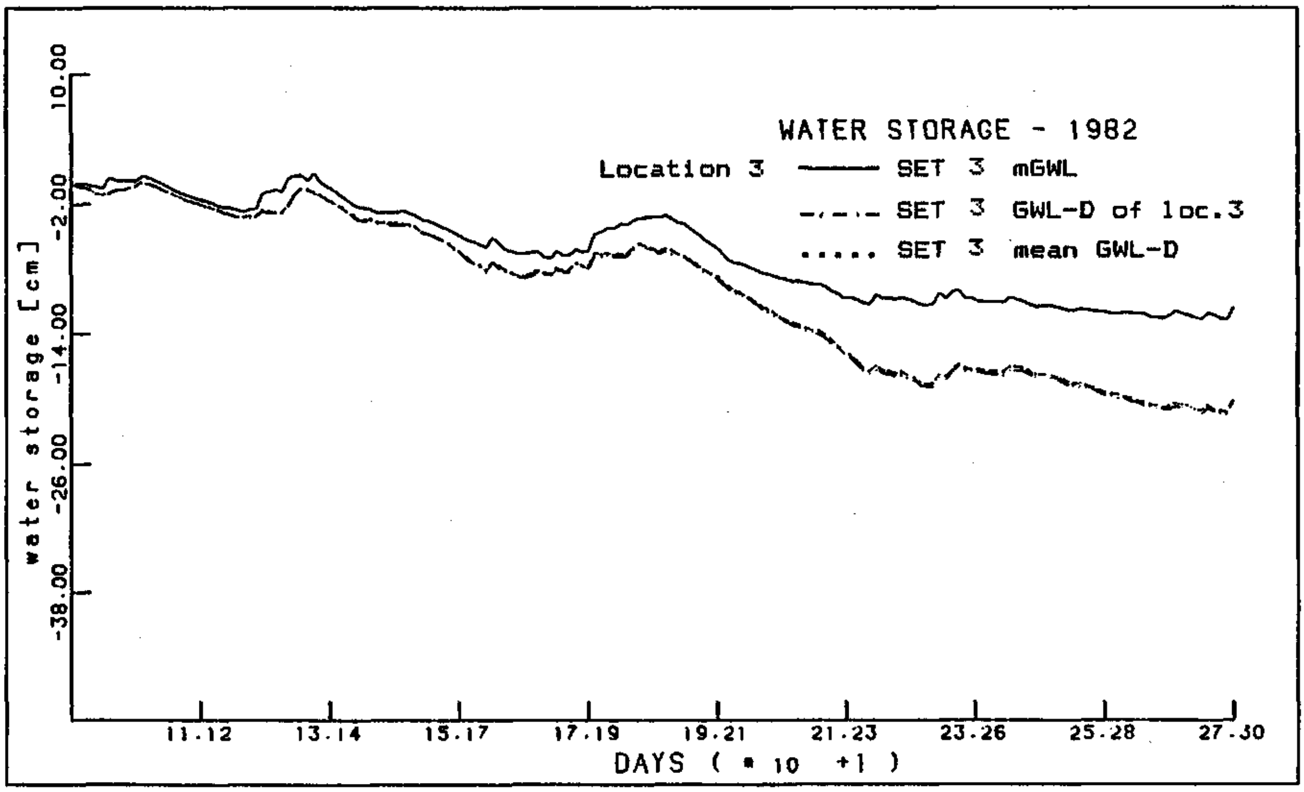

GWL
GWL [cm]
50
0
-50
-100
-150
-200
-250
1 2 3 4 5 6 7 8 11 12 13 14 15
Set
mean
s.d.
calculated GWL
measured GWL

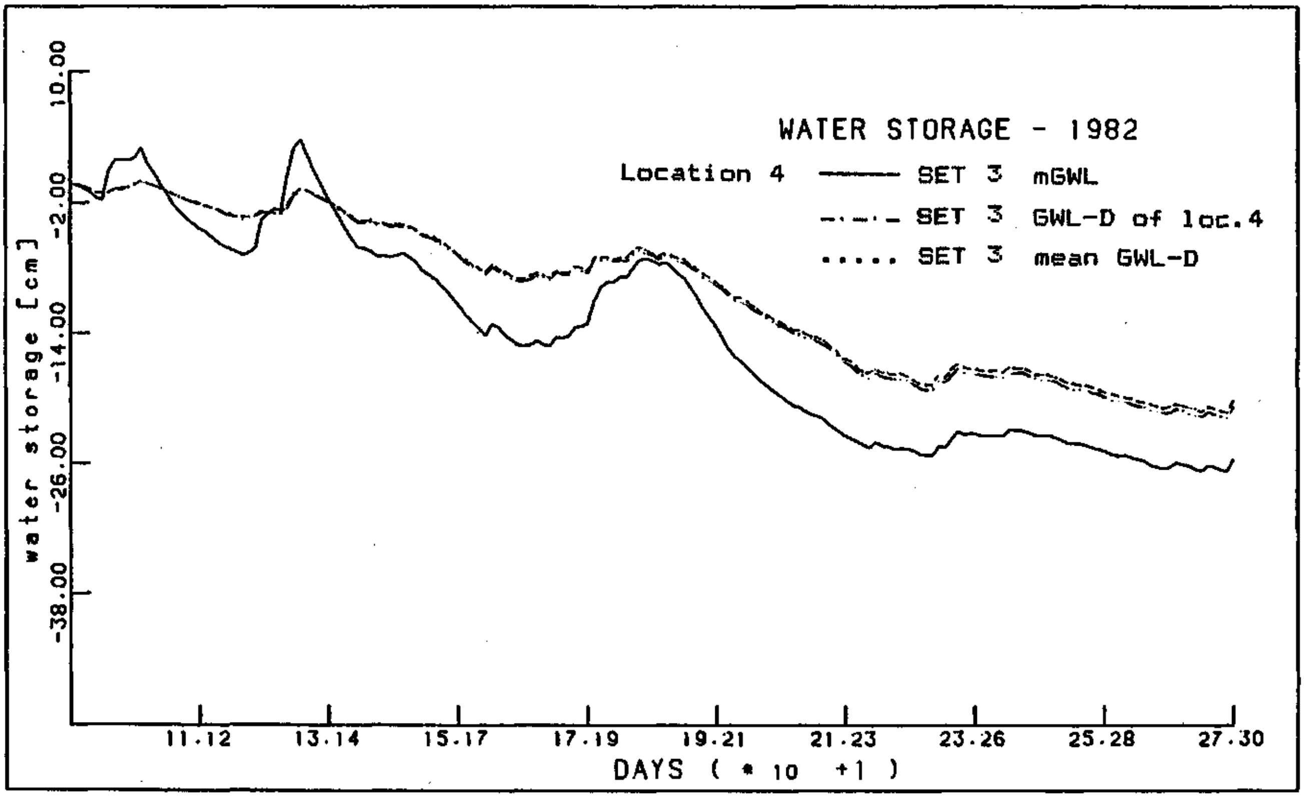
Appendix Examples of seasonal courses of components of water balance for combinations of soil input sets and lower boundary condition

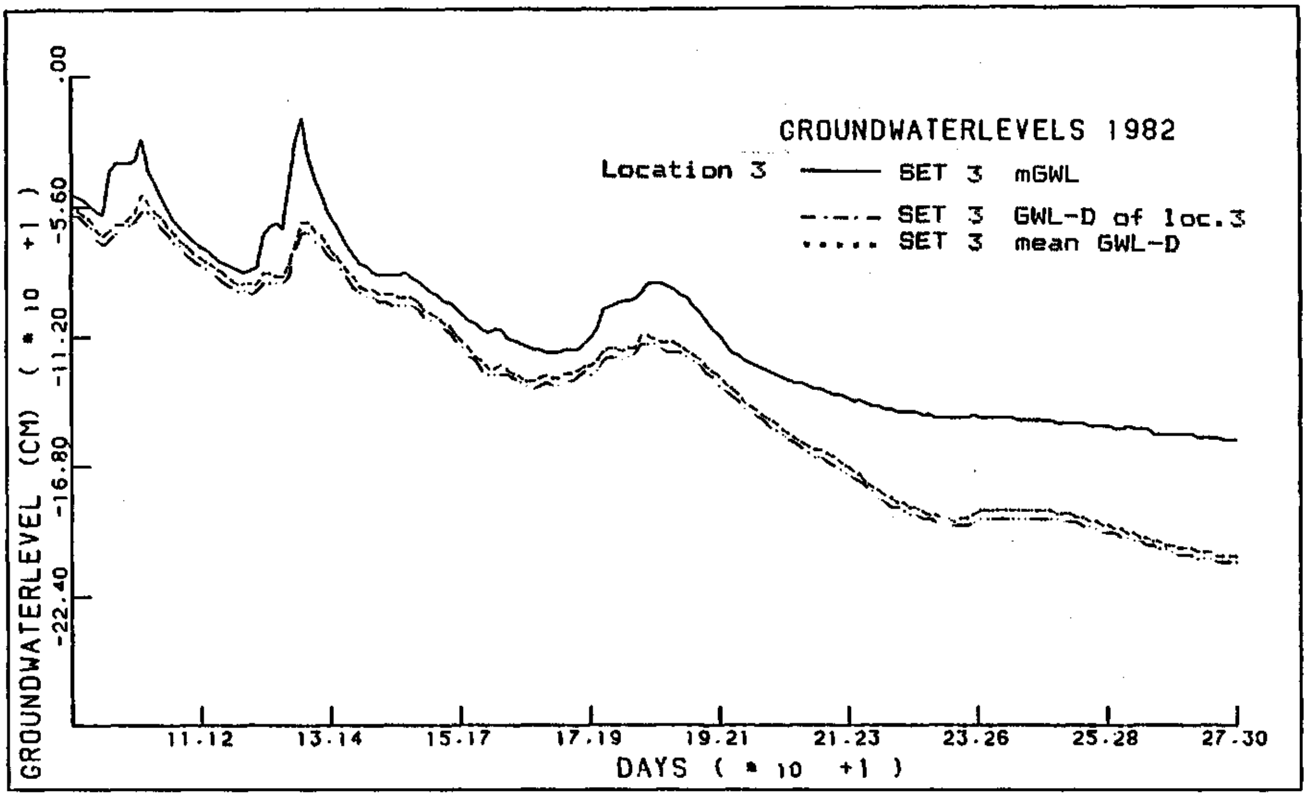
Figure 15. The influence of the lower boundary condition, differences between mGWL as lower boundary condition and two types of GWL-D relationships as lower boundary condition; shown for Location 3 (very wet) and Location 4 (very dry)


Reduction-1982
Location 3
SET 3 mGWL
SET 3 GWL-D of loc.3
SET 3 mean GWL-D
Reduction [%]
20.00
16.00
12.00
8.00
4.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


Reduction-1982
Location 4
SET 3 mGWL
SET 3 GWL-D of loc.4
SET 3 mean GWL-D
Reduction [%]
20.00
16.00
12.00
8.00
4.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER STORAGE - 1982
Location 3
SET 3 mGWL
SET 3 GWL-D of loc.3
SET 3 mean GWL-D
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER STORAGE - 1982
Location 4
SET 3 mGWL
SET 3 GWL-D of loc.4
SET 3 mean GWL-D
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


GROUNDWATERLEVELS 1982
Location 3
SET 3 mGWL
SET 3 GWL-D of loc.3
SET 3 mean GWL-D
GROUNDWATERLEVEL (CM) (* 10 +1)
.00
-5.60
-11.20
-16.80
-22.40
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

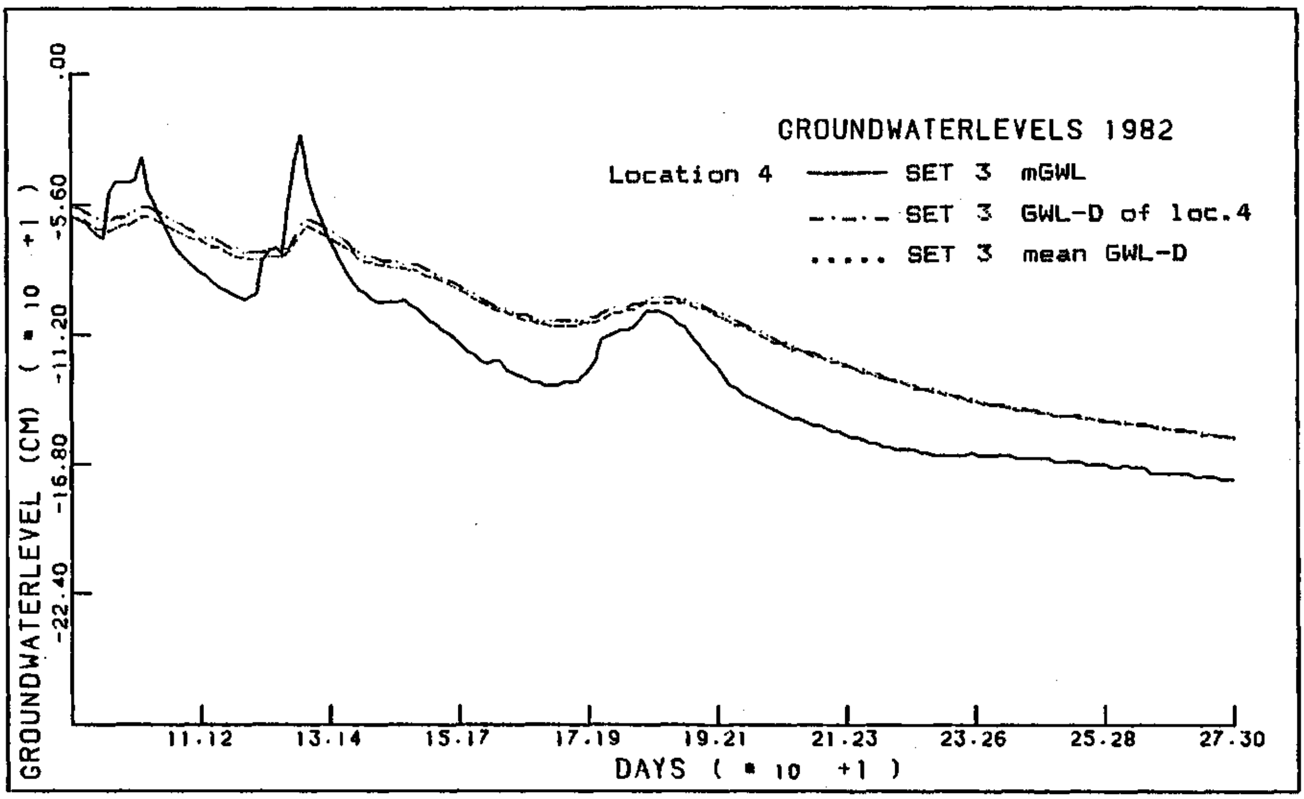
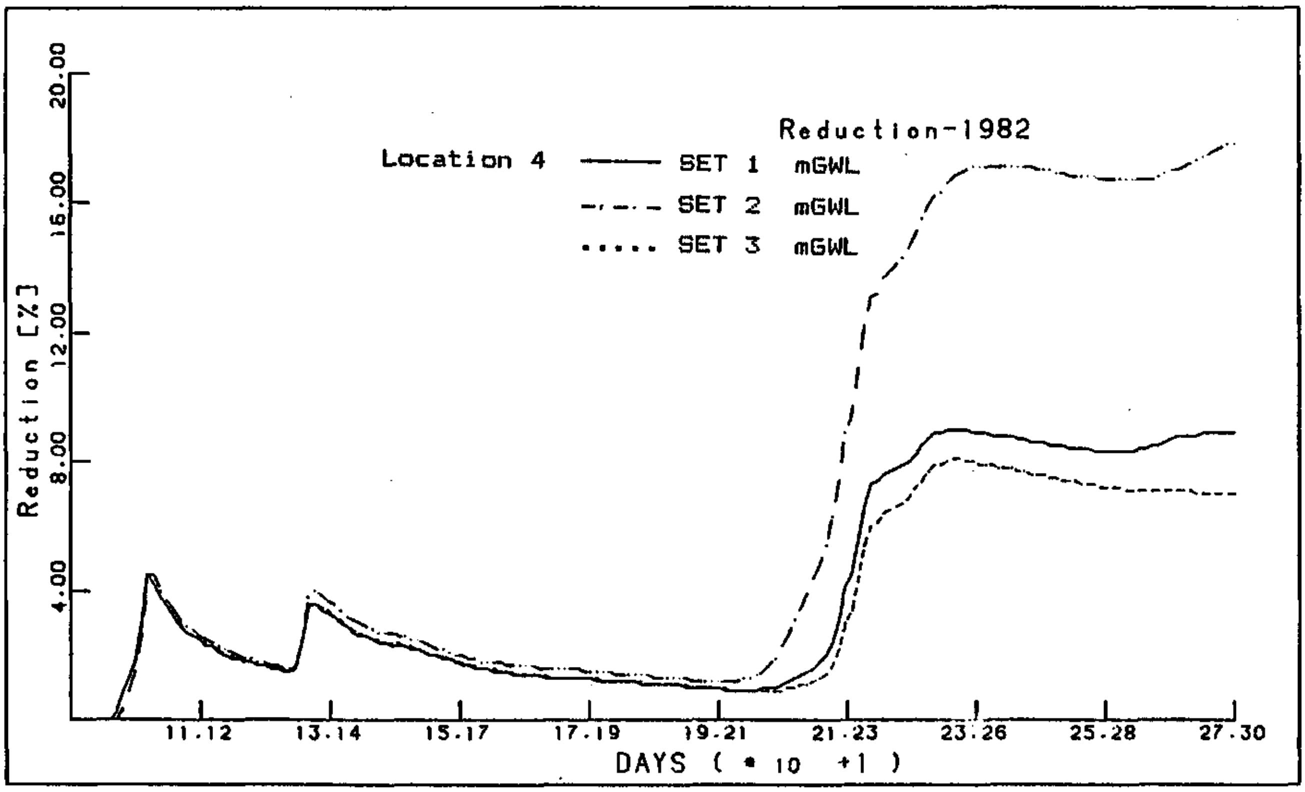
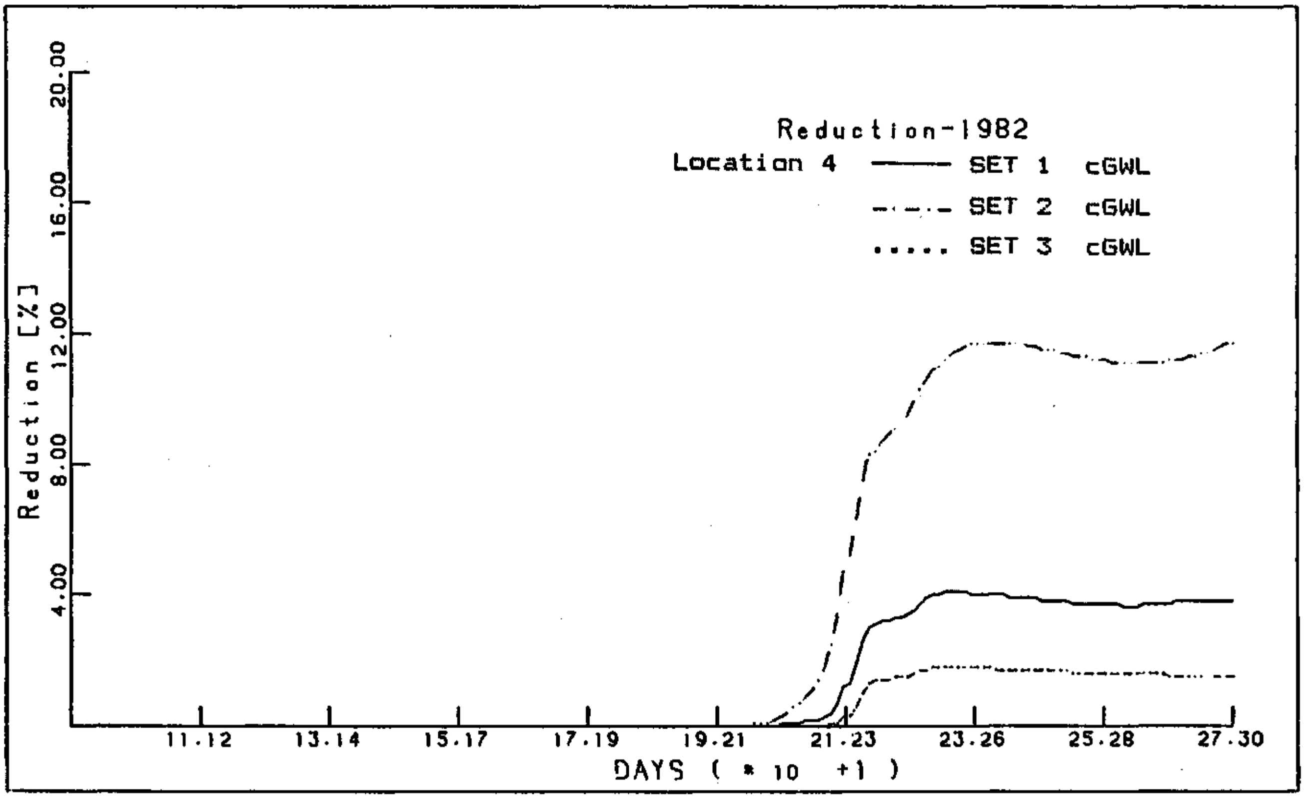
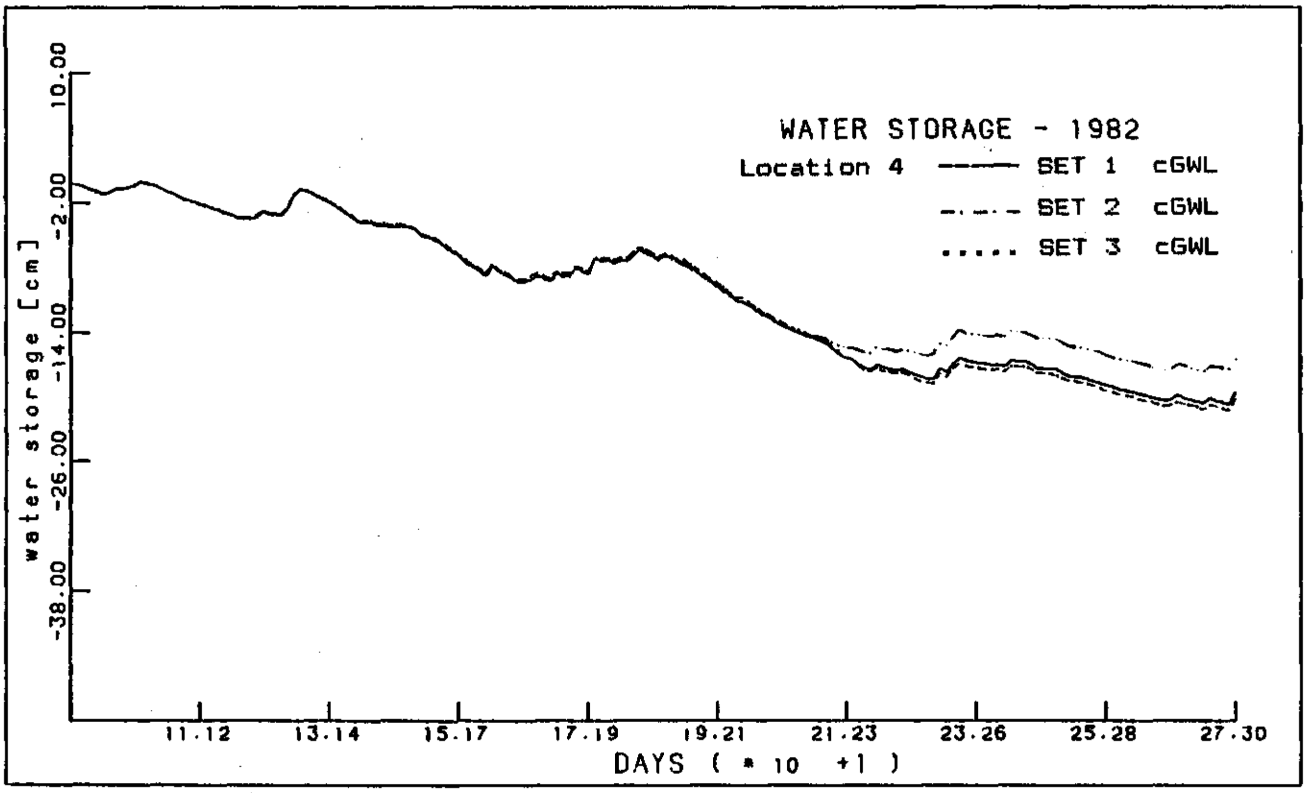

GROUNDWATERLEVELS 1982
Location 4
SET 3 mGWL
SET 3 GWL-D of loc.4
SET 3 mean GWL-D
GROUNDWATERLEVEL (CM) (* 10 +1)
.00
-5.60
-11.20
-16.80
-22.40
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

Figure 16. The influence of three types of hydraulic conductivities in connection with ordinary retention curve; for both lower boundary conditions for Location 4


Reduction-1982
Location 4
SET 1 mGWL
SET 2 mGWL
SET 3 mGWL
Reduction [%]
0.00
4.00
8.00
12.00
16.00
20.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


Reduction-1982
Location 4
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
Reduction [%]
4.00
8.00
12.00
16.00
20.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER STORAGE - 1982
Location 4
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

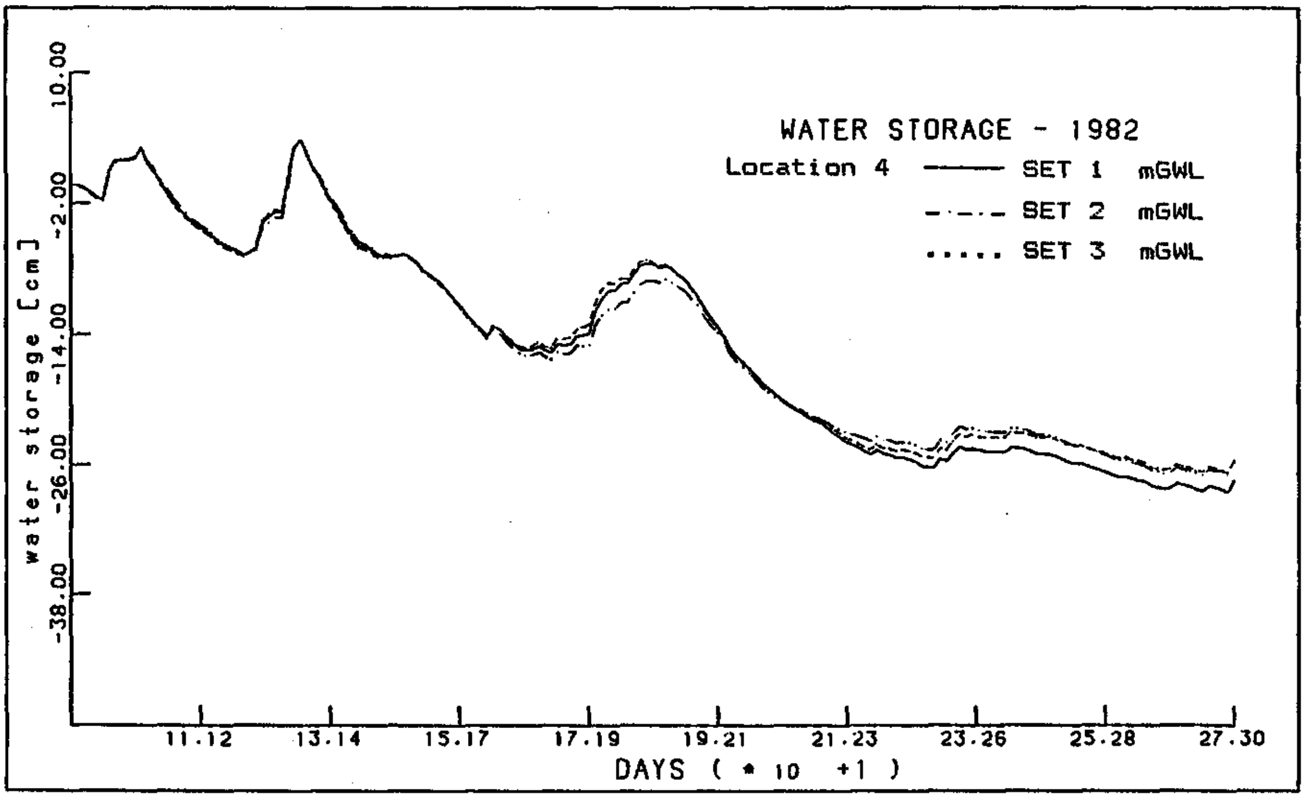
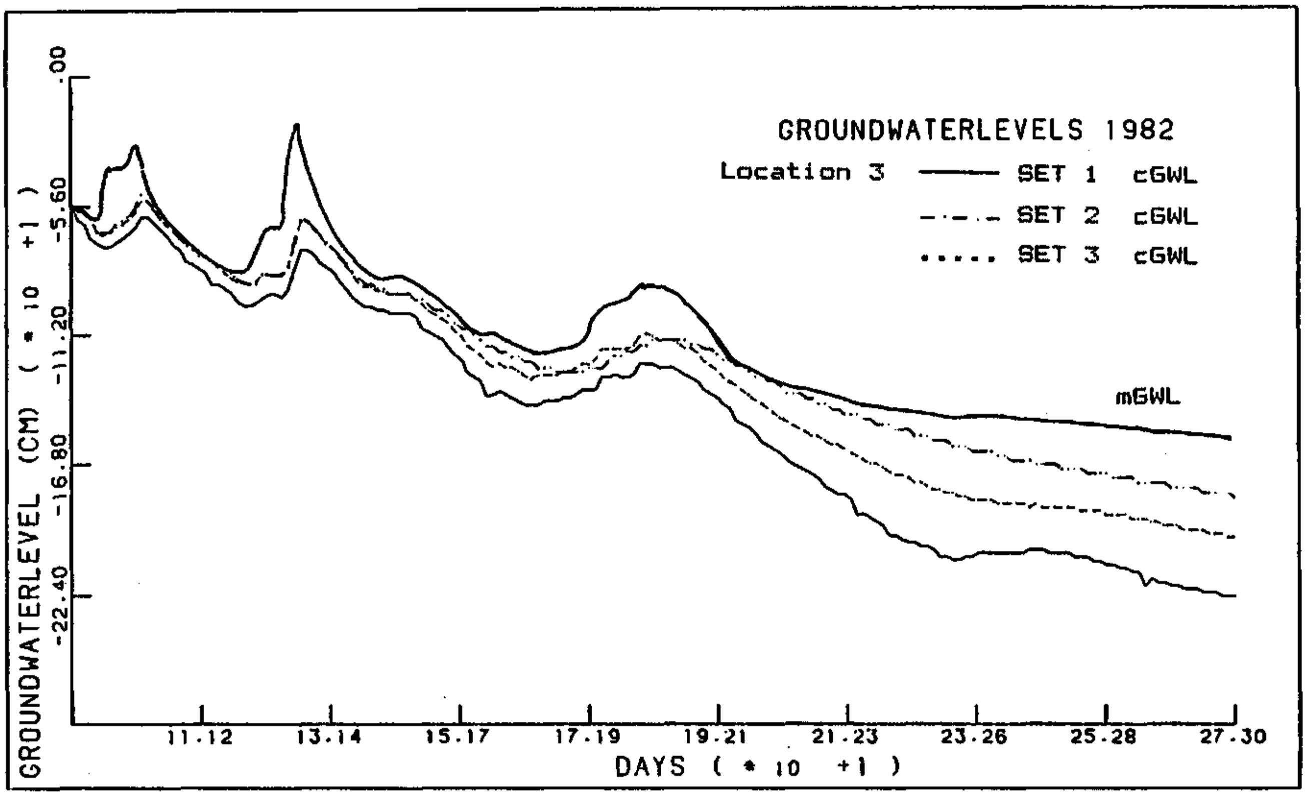
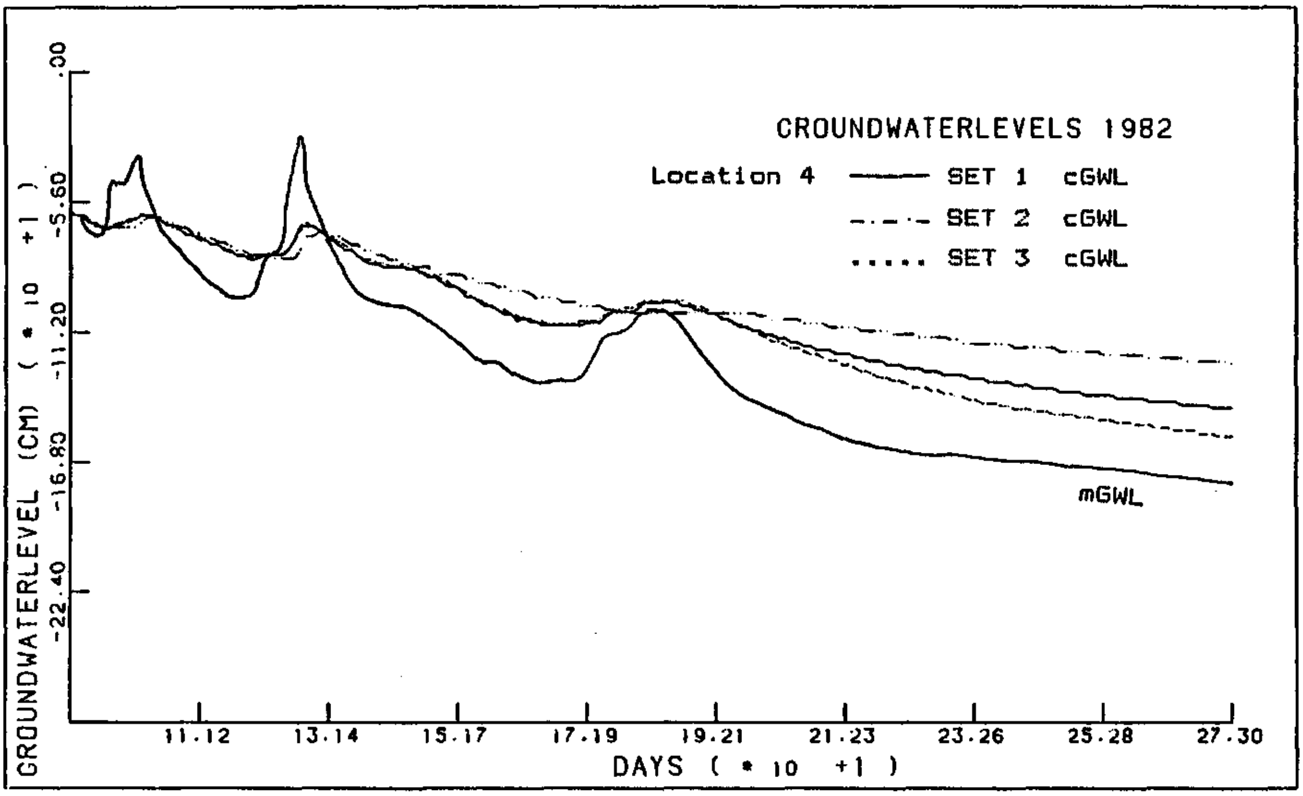
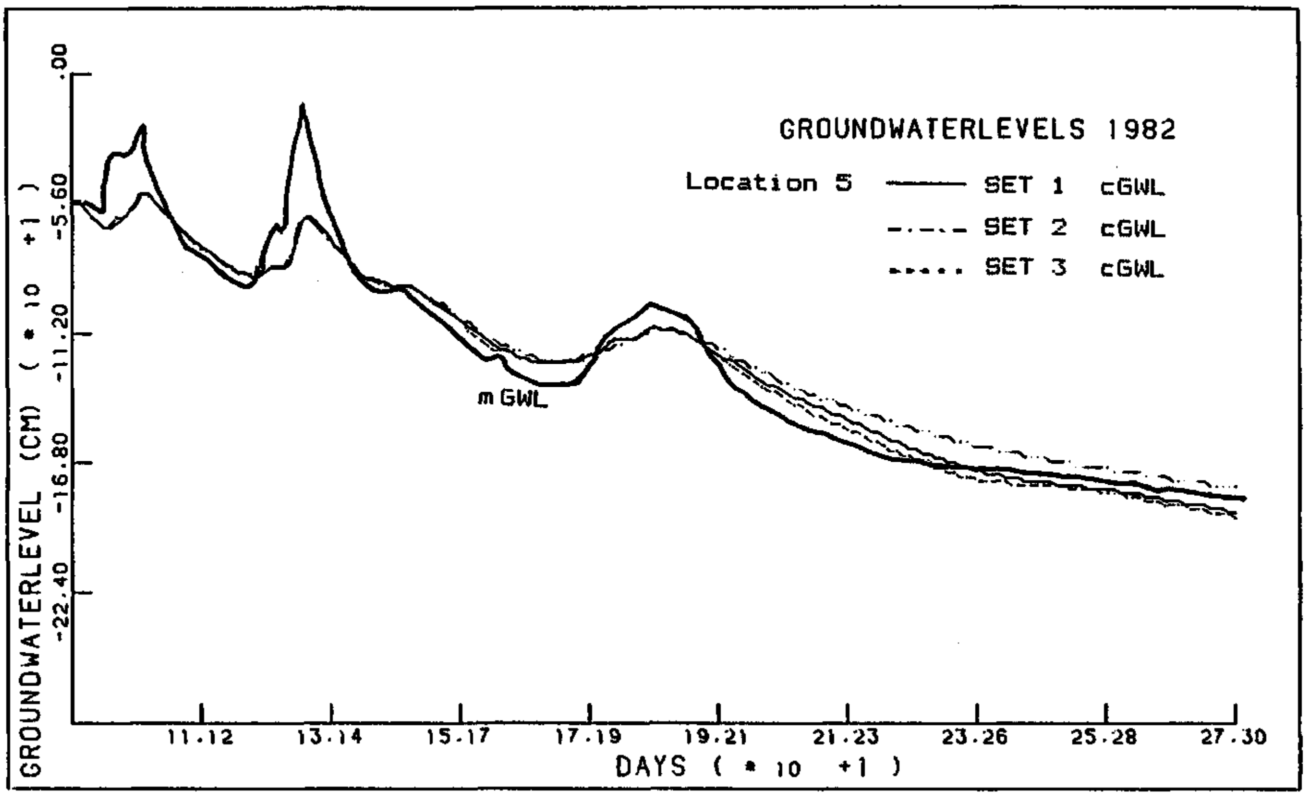

WATER STORAGE - 1982
Location 4
SET 1 mGWL
SET 2 mGWL
SET 3 mGWL
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

Figure 17. The influence of three types of hydraulic conductivities on the calculated GWL for two extreme locations (3+4) and for the "ideal" location (5); compared with measured GWL

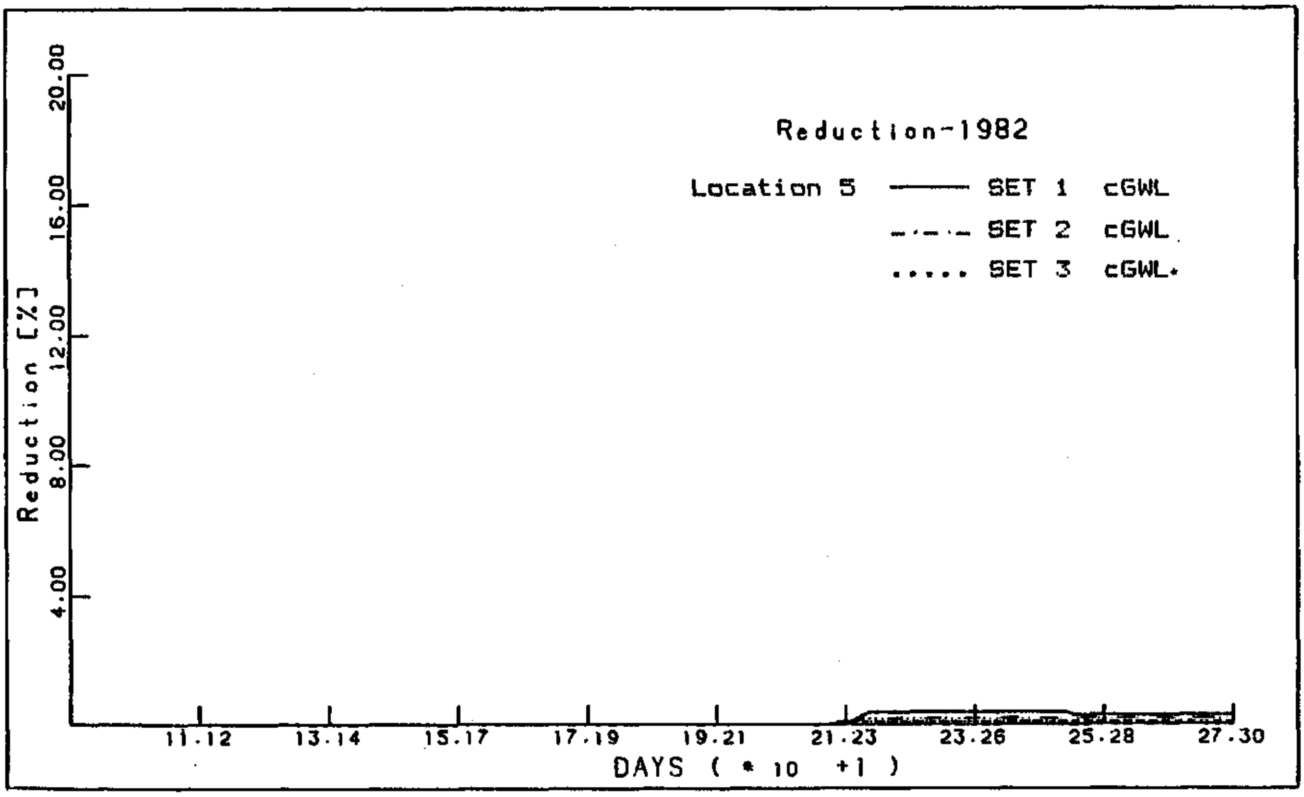

GROUNDWATERLEVELS 1982
Location 3
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
mGWL
.00
-5.60
-11.20
-16.80
-22.40
GROUNDWATERLEVEL (CM) (* 10 +1)
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


GROUNDWATERLEVELS 1982
Location 4
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
mGWL
.00
-5.60
-11.20
-16.80
-22.40
GROUNDWATERLEVEL (CM) (* 10 +1)
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)



GROUNDWATERLEVELS 1982
Location 5
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
mGWL
GROUNDWATERLEVEL (CM) (* 10 +1)
.00
-5.60
-11.20
-16.80
-22.40
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

Figure 18. The influence of three types of hydraulic conductivities in connection with ordinary retention curve for Location 5; calculated GWL


Reduction-1982
Location 5
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
Reduction [%]
20.00
16.00
12.00
8.00
4.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

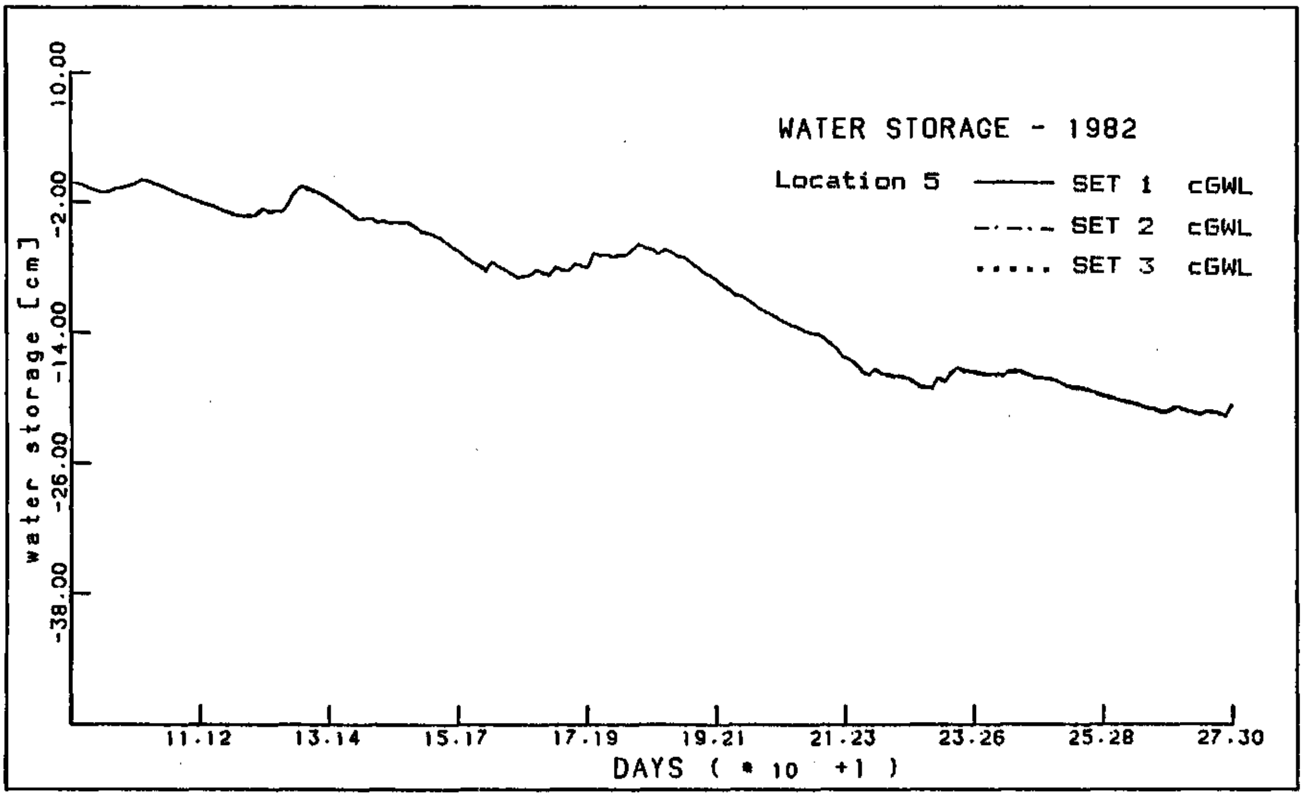
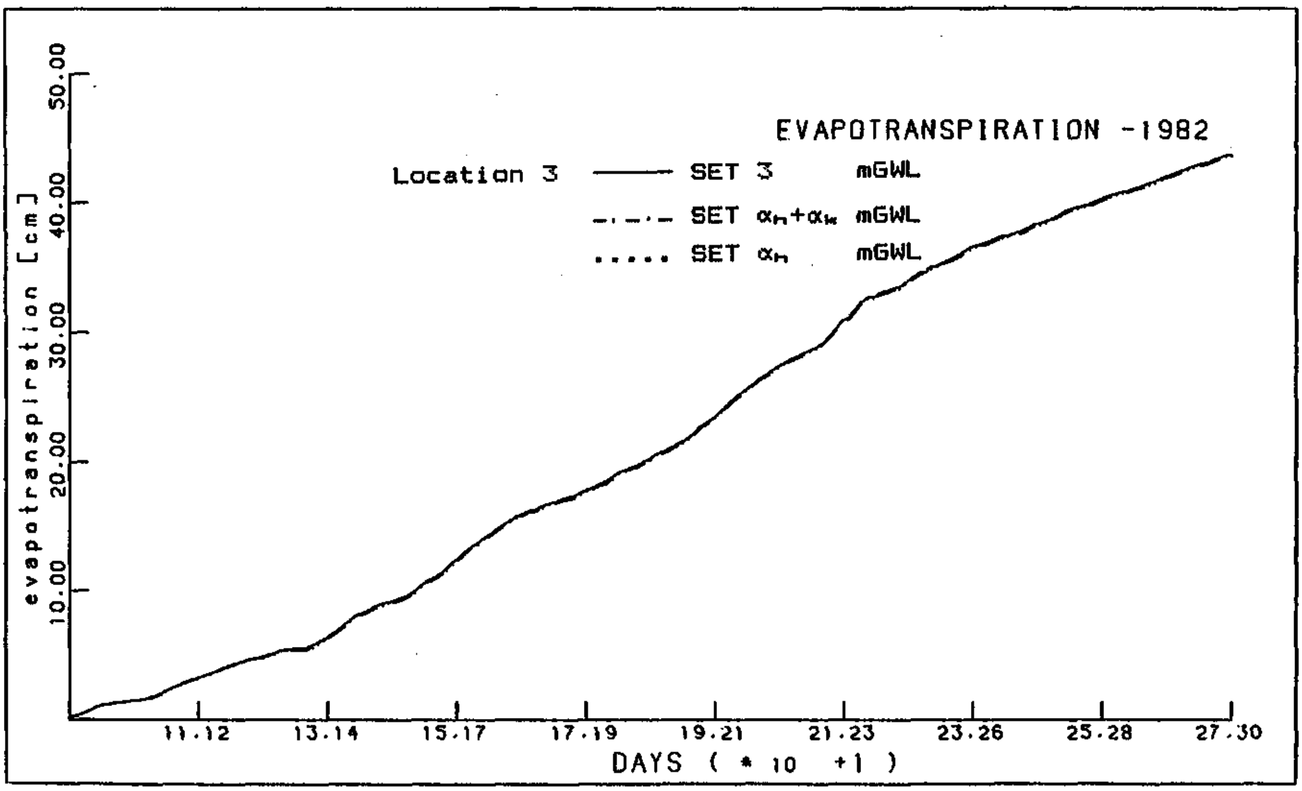
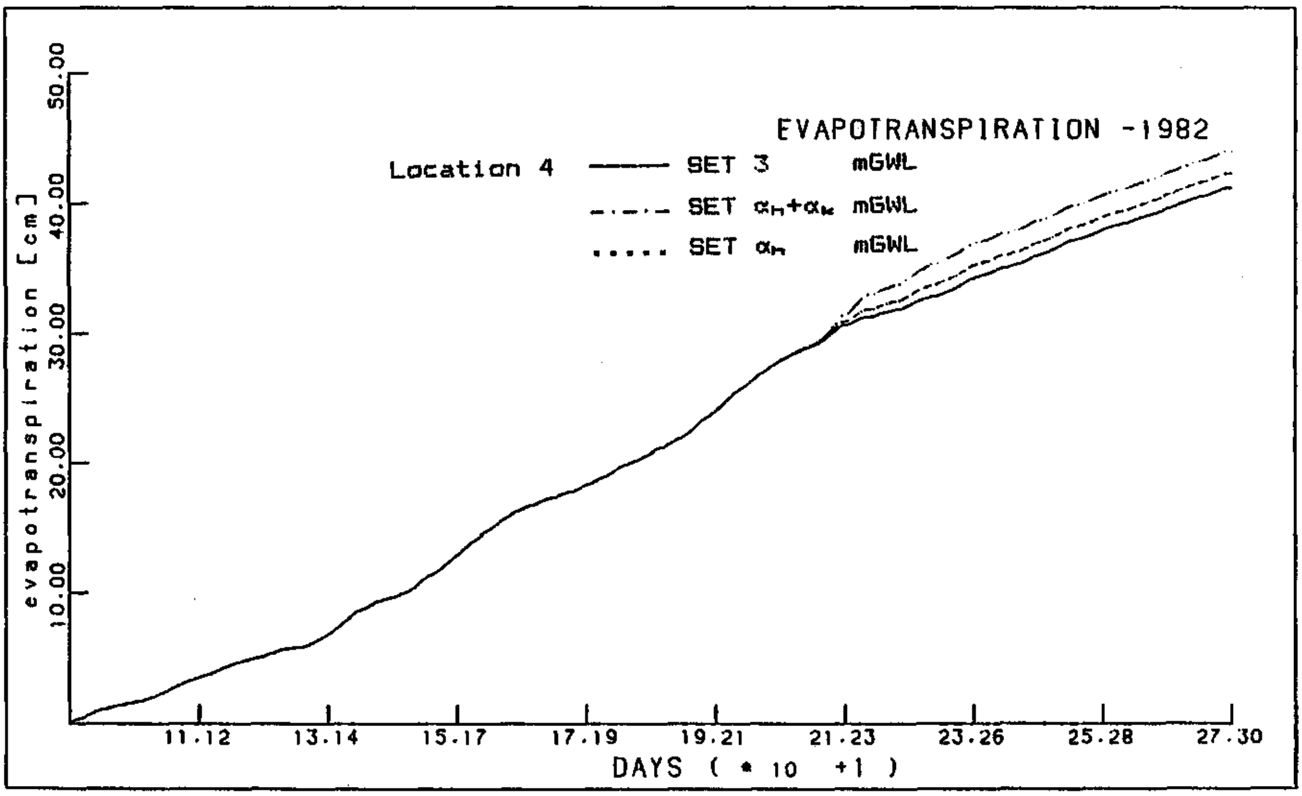
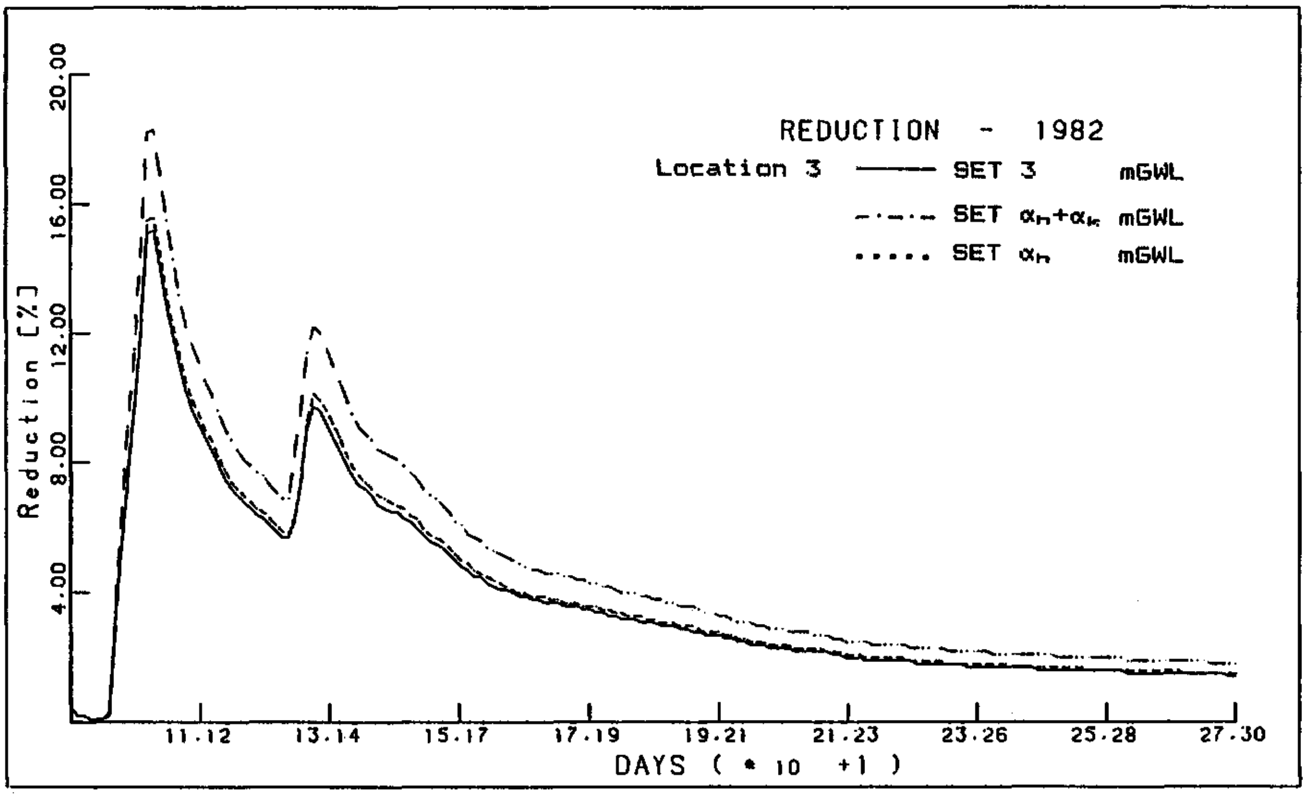
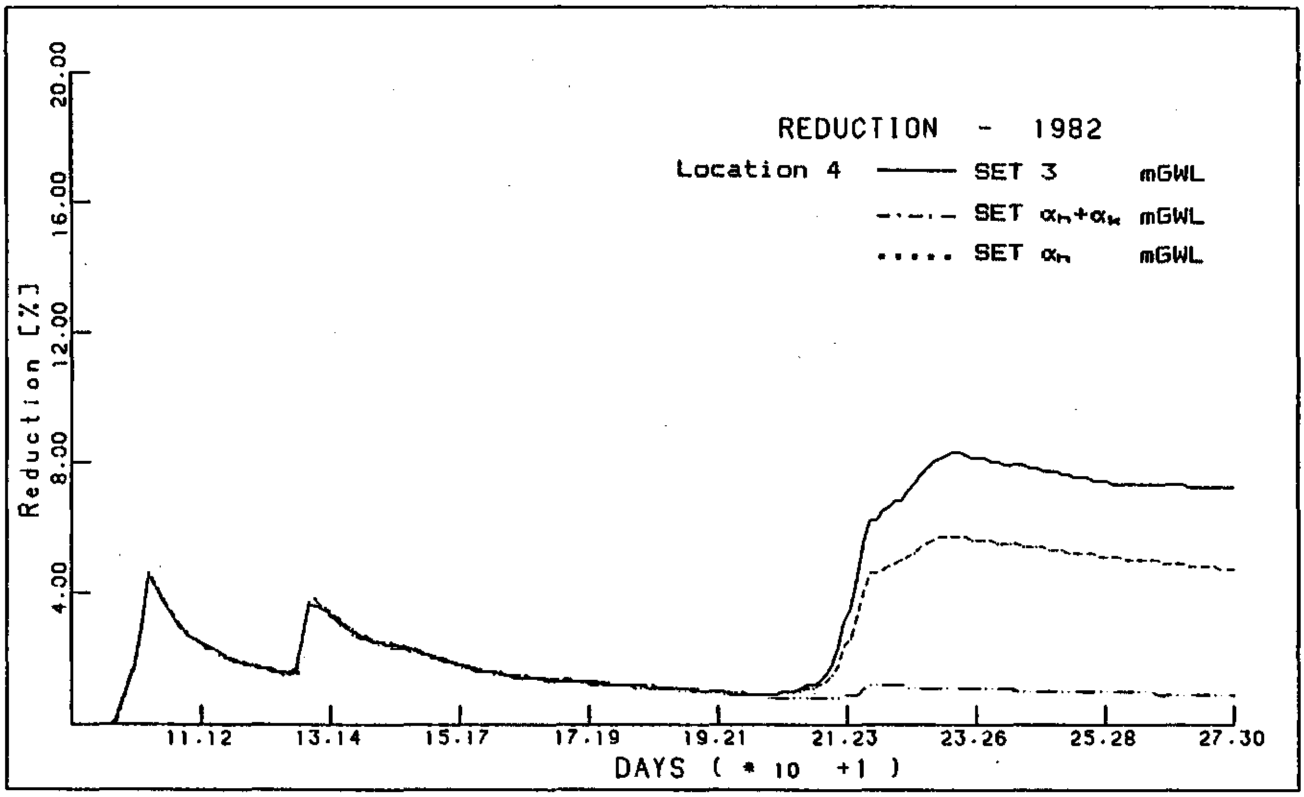

WATER STORAGE - 1982
Location 5
SET 1 cGWL
SET 2 cGWL
SET 3 cGWL
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

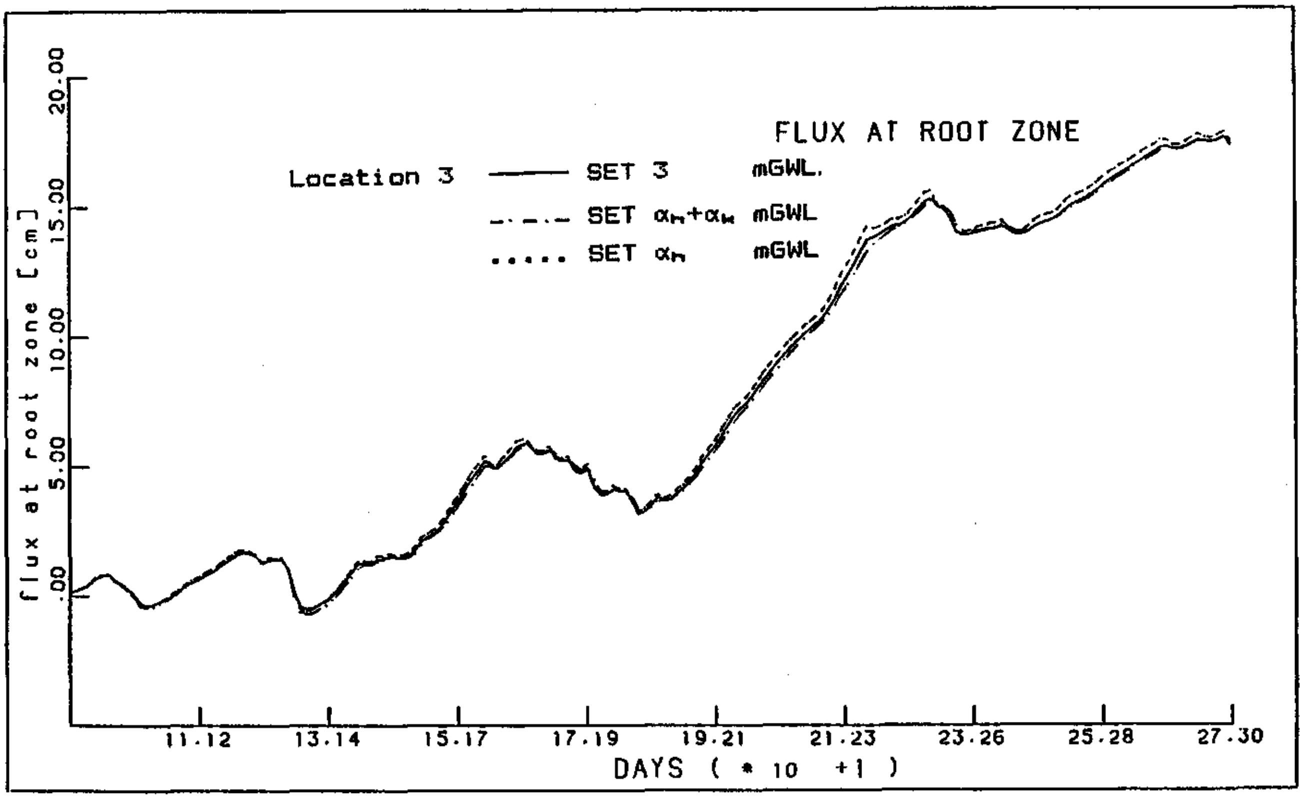
Figure 19. The influence of scaled soil hydraulic functions on the seasonal courses of components of water balance for two extreme locations, compared with results for SET 3; measured GWL

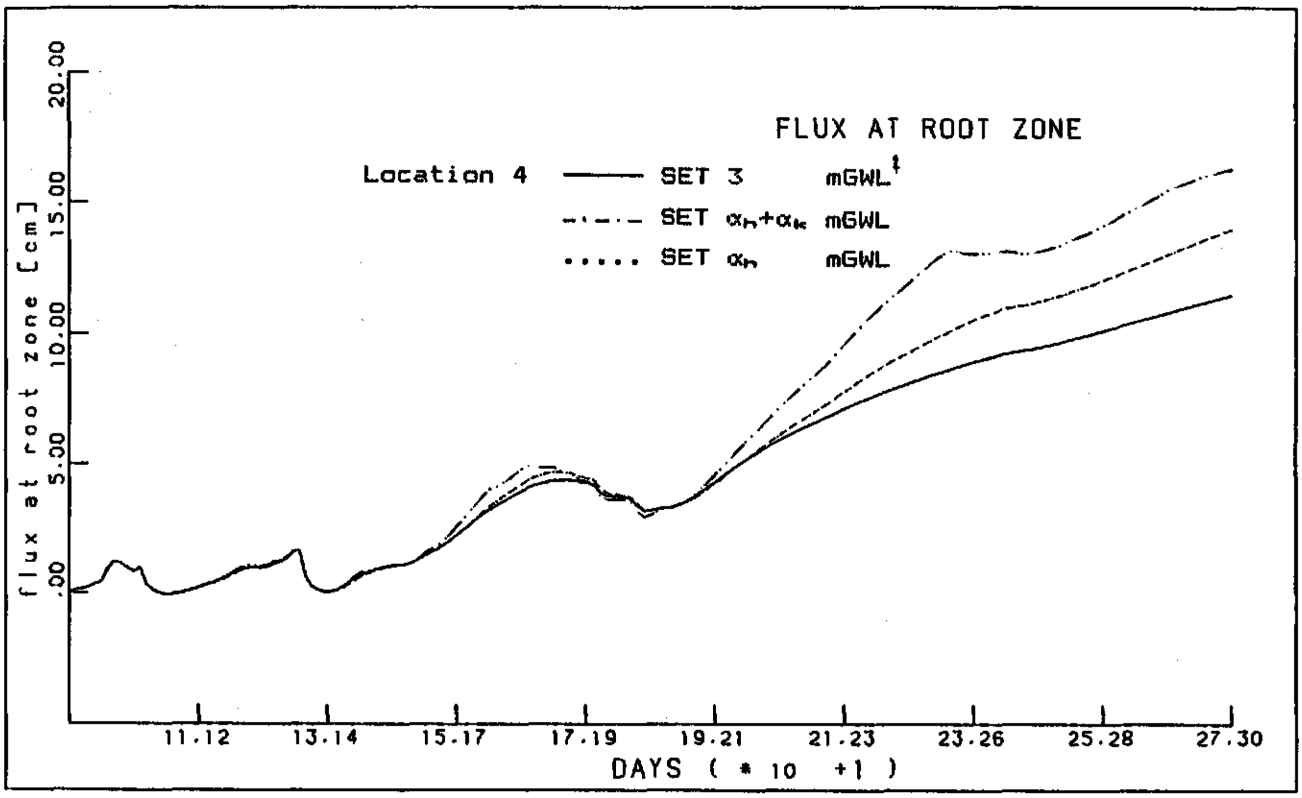

EVAPOTRANSPIRATION -1982
Location 3
SET 3 mGWL
SET αH+αK mGWL
SET αH mGWL
evapotranspiration [cm]
10.00
20.00
30.00
40.00
50.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

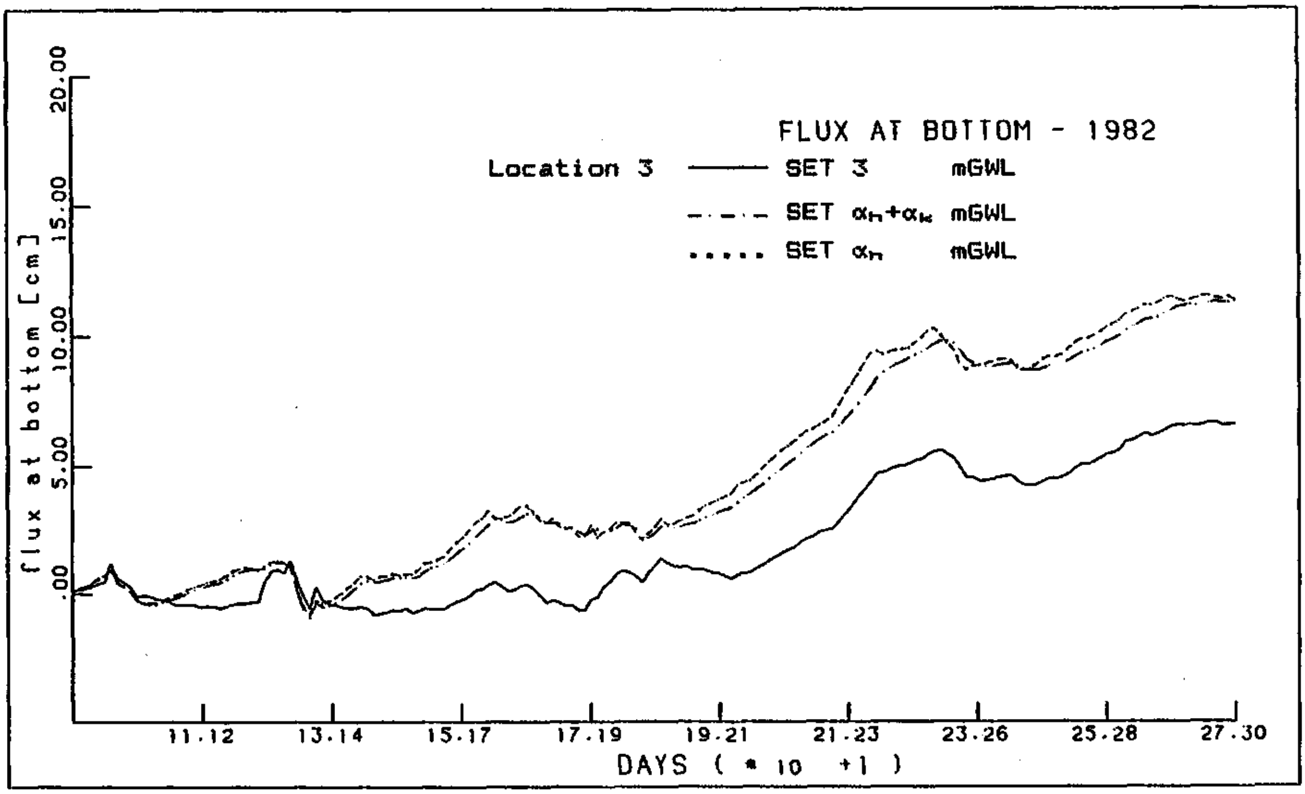

EVAPOTRANSPIRATION -1982
Location 4
SET 3 mGWL
SET αH+αK mGWL
SET αH mGWL
evapotranspiration [cm]
10.00
20.00
30.00
40.00
50.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


REDUCTION - 1982
Location 3 SET 3 mGWL
SET $\alpha_h+\alpha_k$ mGWL
SET α_h mGWL
Reduction [%]
20.00
16.00
12.00
8.00
4.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

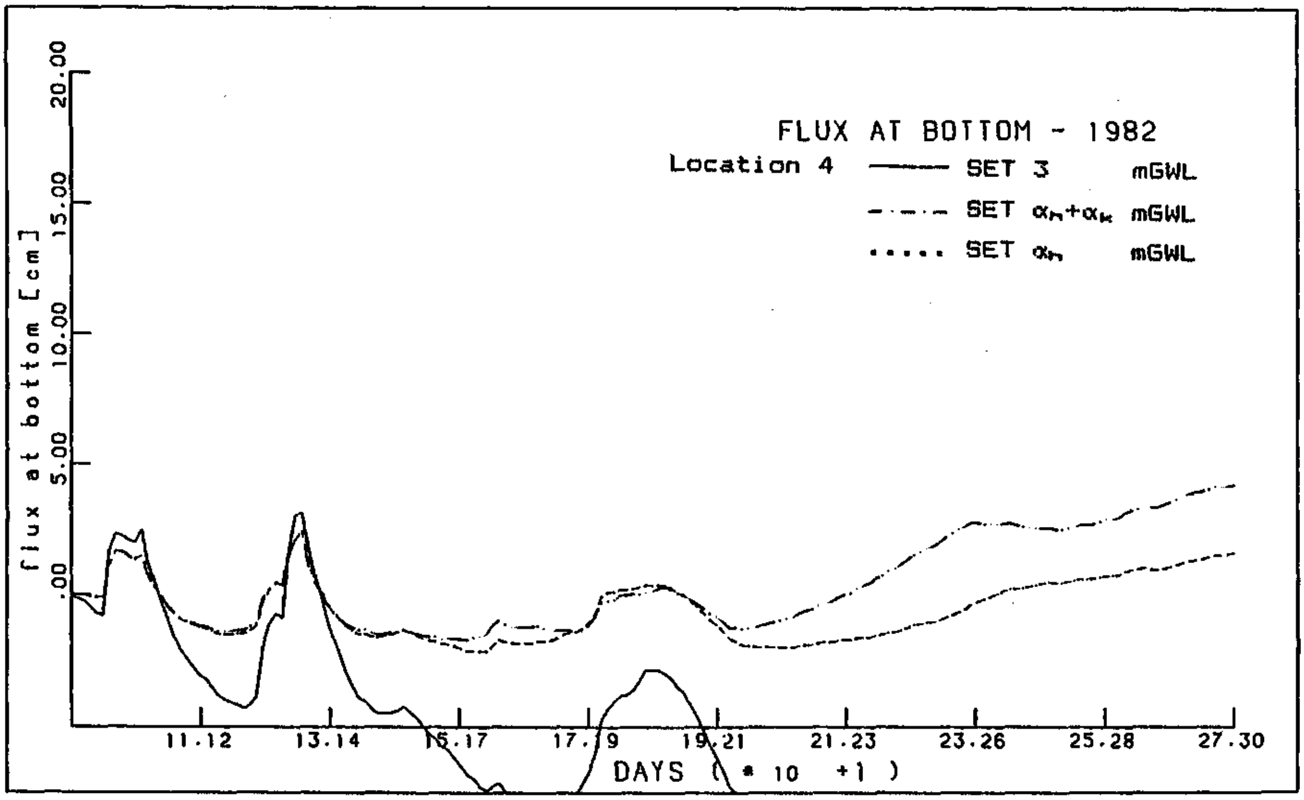

REDUCTION - 1982
Location 4 SET 3 mGWL
SET $\alpha_h+\alpha_k$ mGWL
SET α_h mGWL
Reduction [%]
20.00
16.00
12.00
8.00
4.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


FLUX AT ROOT ZONE
Location 3
SET 3 mGWL
SET αh+αk mGWL
SET αh mGWL
flux at root zone [cm]
.00
5.00
10.00
15.00
20.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

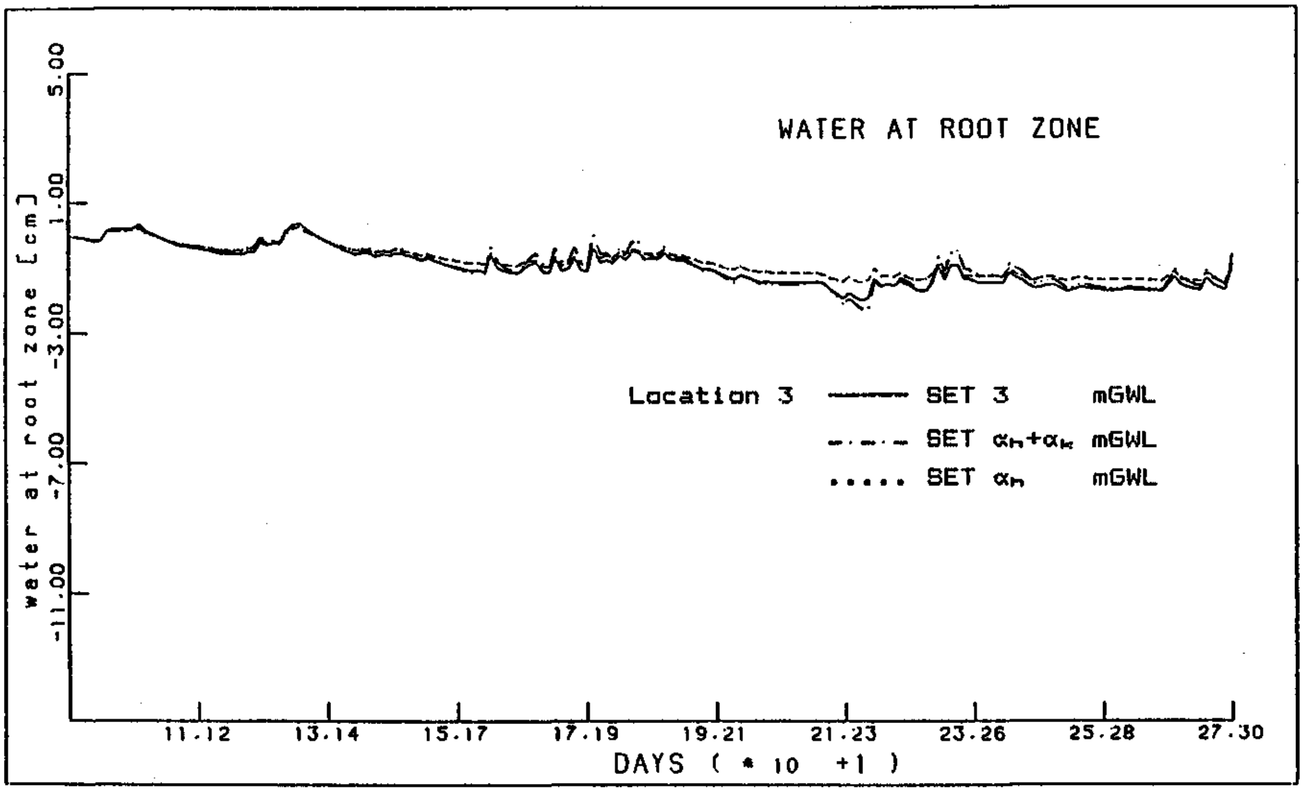

FLUX AT ROOT ZONE
Location 4
SET 3 mGWL
SET αh+αk mGWL
SET αh mGWL
flux at root zone [cm]
.00
5.00
10.00
15.00
20.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

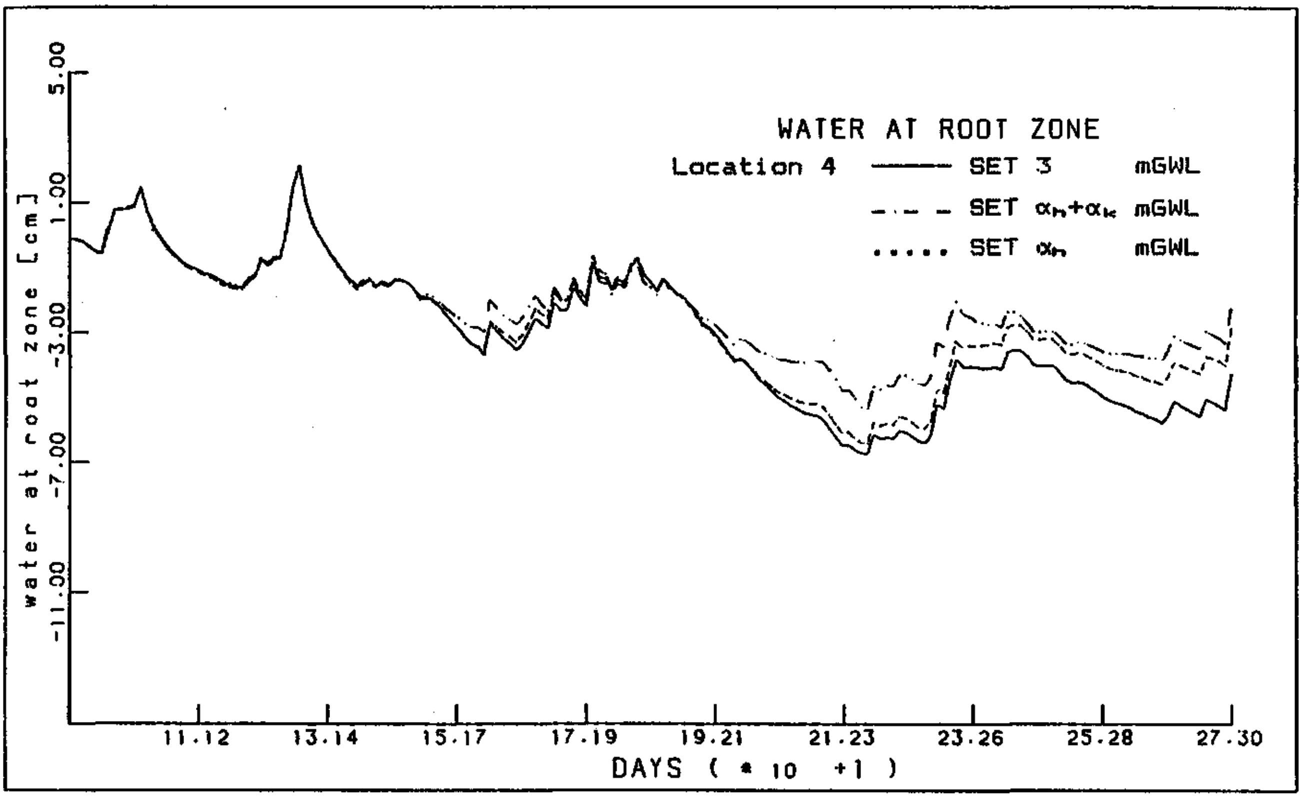


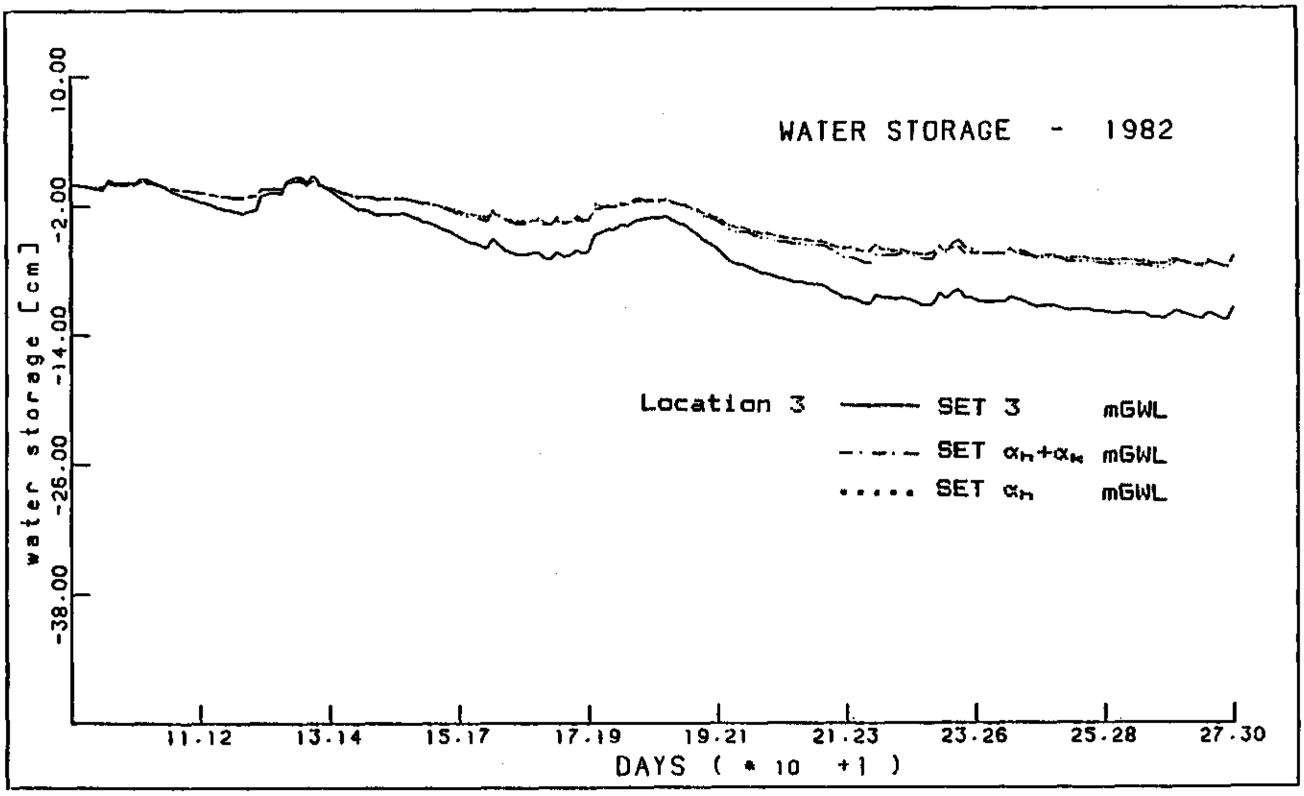
FLUX AT BOTTOM - 1982
Location 3 SET 3 mGWL
SET $\alpha_h+\alpha_k$ mGWL
SET α_h mGWL
flux at bottom [cm]
20.00
15.00
10.00
5.00
.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)

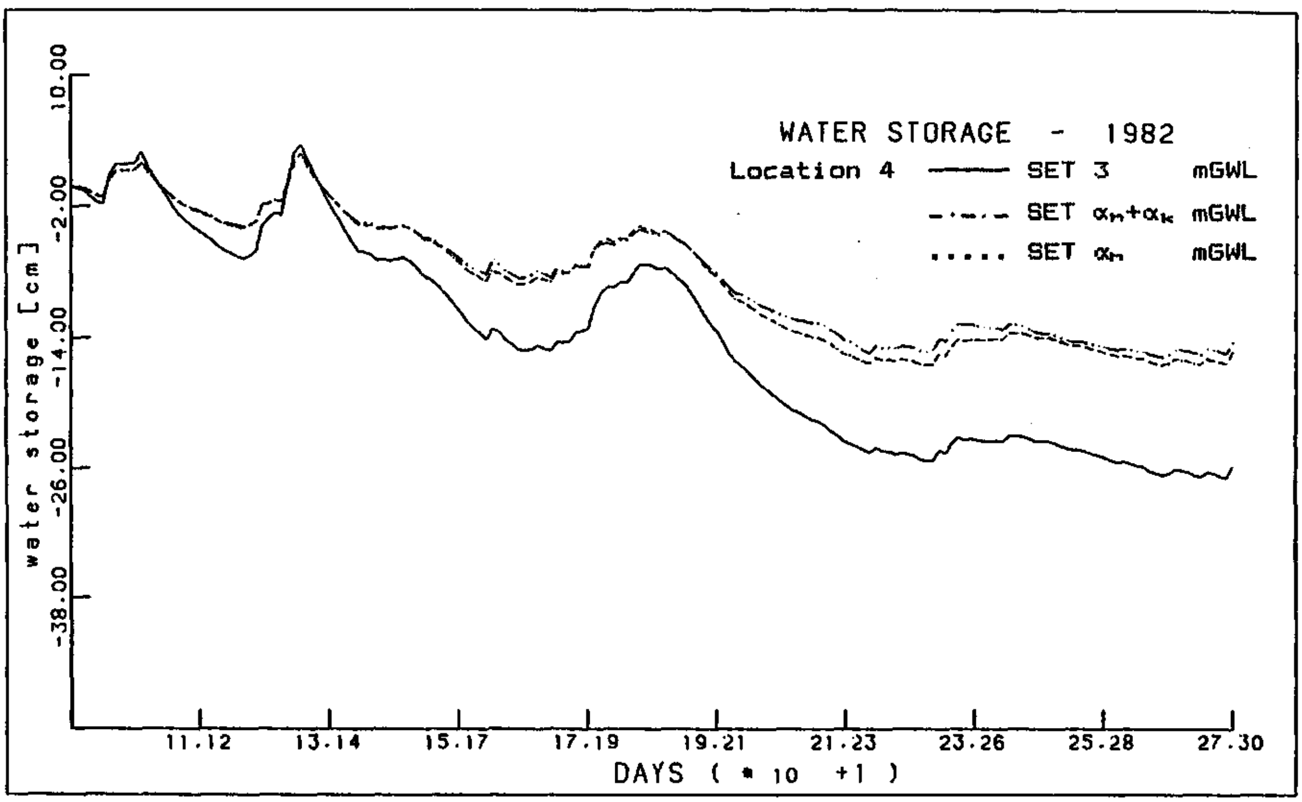


FLUX AT BOTTOM - 1982
Location 4 SET 3 mGWL
SET $\alpha_h+\alpha_k$ mGWL
SET α_h mGWL
flux at bottom [cm]
20.00
15.00
10.00
5.00
.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER AT ROOT ZONE
Location 3
SET 3 mGWL
SET $\alpha_h+\alpha_k$ mGWL
SET α_h mGWL
water at root zone [cm]
5.00
1.00
-3.00
-7.00
-11.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER AT ROOT ZONE
Location 4
SET 3 mGWL
SET $\alpha_h+\alpha_k$ mGWL
SET α_h mGWL
water at root zone [cm]
5.00
1.00
-3.00
-7.00
-11.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER STORAGE - 1982
Location 3
SET 3 mGWL
SET $\alpha_H+\alpha_K$ mGWL
SET α_H mGWL
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)


WATER STORAGE - 1982
Location 4
SET 3 mGWL
SET $\alpha_H+\alpha_K$ mGWL
SET α_H mGWL
water storage [cm]
10.00
-2.00
-14.00
-26.00
-38.00
11.12
13.14
15.17
17.19
19.21
21.23
23.26
25.28
27.30
DAYS (* 10 +1)