# THE USE OF A HYDRAULIC MODEL TO INVESTIGATE THE EFECTS 0F DRAIN DEPTH AND DRAINAGE INTENSITY ON SOIL MOISTURE POTENTIAL AND DEPTH OF GROUNDWATER TABLE

A thesis presented in partial fulfilment of the requirements for the degree of Master of Science

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DRAINAGE (MINOR SUBJECT)

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Wageningen, June, 1975.

TO

FELICIA AKINSANYA

my beloved adopted
mother

## ACKNOWLEDGEMENTS

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Wageningen, June 1975. J. O. Fatokun

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## INTRODUCTION

Wind, (1972) analysed the problems of vertical unsaturated flow as affected by horizontal groundwater flow under natural rainfall regimes. The present effort is an attempt to use the hydraulic model developed by Wind to analyse the effects of drainage intensity and drain depth on the soil moisture and the depth of groundwater table of a particular soil under standardized and natural rainfall sequences as suggested by Wind in the closing paragraph of his article. Since the model simulates conditions very much like the soil would, it is expected that the results presented and discussed here will help in determining acceptable drainage criteria for certain agricultural requirements and in showing how the soil moisture content of the top soil is influenced by the given rainfall patterns.

The soil studied is a homogeneous clay loam with a capillary conductivity at zero moisture tension $k_o$ of 1 cm $dy^{-1}$ and a reaction factor $\alpha$ of 0.025 $cm^{-1}$ described as type 16 in Rijtema (1969). The characteristics of the $k(\psi)$ and $\psi(m)$ relations are given in figures 1 and 2 of Wind (1972).

The theoretical background and detailed description of the model are as in Wind (op cit) and further elaborated in the major thesis (Agrohydrology) of Mokhtaruddin Manan who was my co-worker in the experimental phase of this study. Therefore, only a brief quantitative description of the model is given here as a starting point in understanding my part of the study. The reader who is interested in the theory and details of calibration is referred to the above-mentioned thesis.



Fig. 1: Pictorial side view of the model as used for this study.

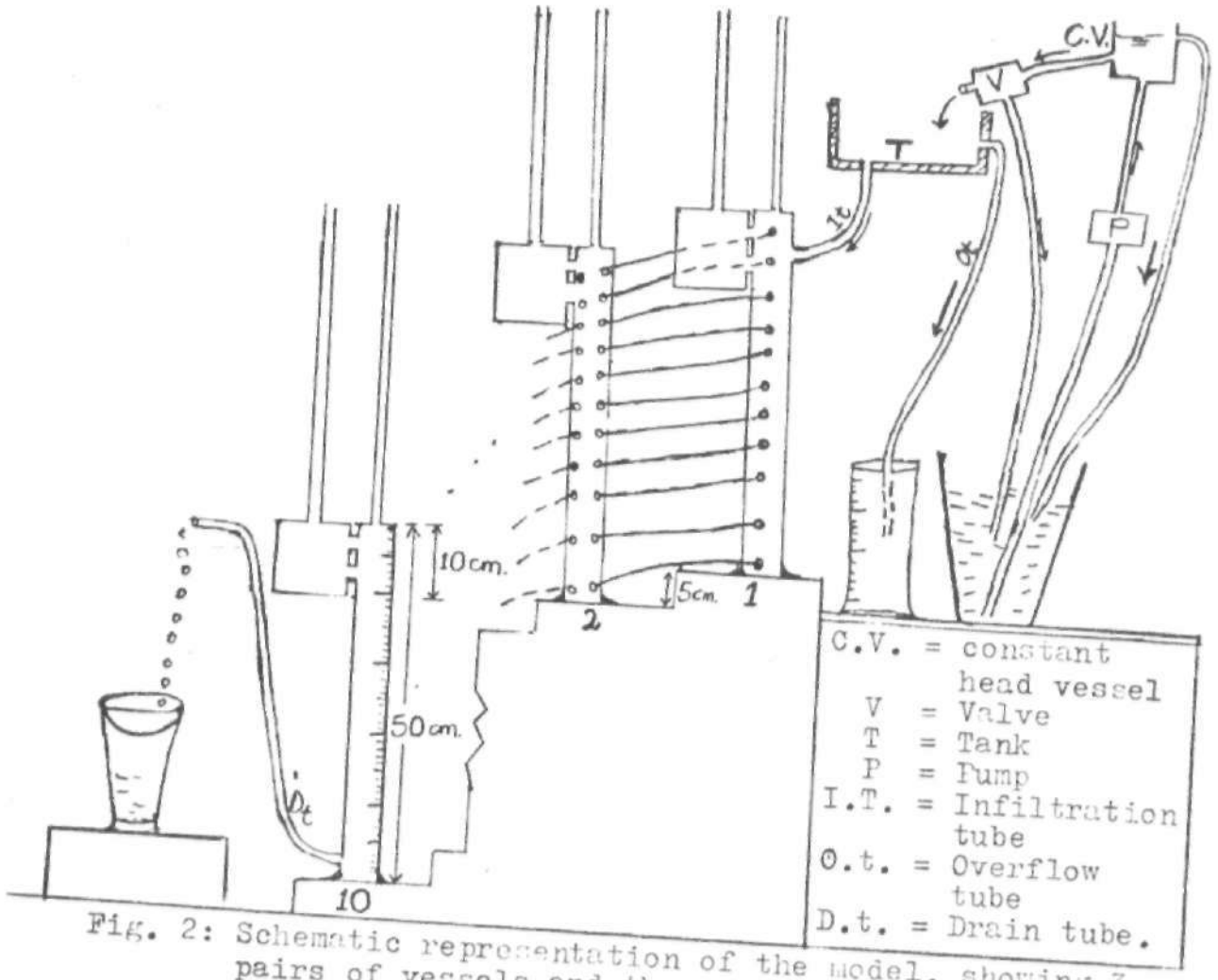



Fig. 2: Schematic representation of the model, showing 3 pairs of vessels and the accessories.

## THE MODEL

Unsaturated vertical flow of moisture is governed by Darcy's law which states:

$$V = -k \left(\frac{d\Psi}{dZ} + 1\right) \qquad (1)$$

with

$$k = k_o e^{-\alpha \Psi w} \quad \text{(Rijtema, 1965)} \qquad (2)$$

where V = flow velocity, positive in upward direction (cm $dy^{-1}$)

k = capillary conductivity (cm $dy^{-1}$)

$\Psi$ = capillary potential (cm)

Z = vertical distance above a reference level (cm)

$k_o$ = capillary conductivity at $\Psi = 0$ (cm $dy^{-1}$)

$\alpha$ = reaction factor ($cm^{-1}$)

e = base of natural logarithm.

The flow of water into the drains is governed by the drainage equation $V_d = -A \Psi d$ (3) which is derived from Hooghoudts equation (1939) of drainage discharge.

where $V_d$ = velocity of drainage discharge (cm $dy^{-1}$)

A = drainage intensity ($dy^{-1}$)

$\Psi d$ = capillary potential at drainage depth (cm).

The model was constructed to simulate these flow processes.

Figures 1 and 2 give a picture and the schematic representation of the model respectively. Each of the ten pairs of vessels represents a layer of 10 cm of soil depth (d) with its moisture characteristic (see fig. 3).

The capillary potential $\Psi$ in equation 1 is simulated by the distance between the top of each vessel and the water level in the vessel. To simulate the influence of the gravity potential (Z) on the total soil moisture potential ($\Phi$), the vessels are placed on steps which differ by 5 cm. Taking the top of the first vessel as the reference level, the distance from the top of any other vessel to the reference level represents Z for that soil layer. Thus, the relation below holds for the model:

$$\Phi = \Psi + Z \qquad (4)$$

Each pair of vessels consists of a small and bigger tube, connected such that free flow exists between them. The long vertical tubes on top of the vessels make it possible to have positive pressure in each soil layer. An empty vessel represents the driest soil condition (i.e. a capillary potential $\psi_e$ of -100 cm) while a full vessel represents the wettest condition of $\psi = 0$. The difference in soil moisture between both conditions is denoted by m(dimensionless). Since the vertical scale ($S_v$) of the model is 0.5 (see Manan ), this $\psi_e$ of -100 cm is represented by a vessel of 50 cm. length.

To simulate the capillary conductivity k of the soil, the vessels are interconnected by means of 9 short and 2 long (twice as long as the short) nylon connecting tubes. In unsaturated flow, k varies with $\psi$ according to equation 2; and as $\psi$ varies with the level of water in the vessels, it is necessary to place the connecting tubes at various heights on the vessels as shown in fig. 3. The determination of the positions of the tubes, their lengths, diameter and number is given by Manan.

Drainage is simulated by removing water by means of a single drainage tube from the vessel which represents the soil layer at drainage depth. The outflow opening of the tube must be placed at the same level as the top of that vessel. Two tubes of diameter 0.30 cm and of different lengths were used, each denoting a certain drainage intensity as shown in the table below:

| Length of drainage tube (cm) | Drainage Intensity A ($dy^{-1}$) |
|---|---|
| 205 | 0.01 |
| 121 | 0.02 |

Rainfall was simulated by supplying water into the model through the first vessel. To simulate ponding, the tank was fitted at a certain height above the top of the first vessel and water was pumped into it. The depth of ponding is limited to 6 mm by an overflow tube. The area of the tank represents the surface area of the soil - 940 $cm^2$ which is also the area scale ($S_a$) of the model- (see

M. Manan). Infiltration into the soil is simulated by means of an infiltration tube (of length 40 cm and diameter 0.4 cm) from the tank to the first vessel. The infiltration rate of the soil is 2.66 cm $dy^{-1}$ when the tube is flowing full.

## EXPERIMENTAL PROCEDURES

To simulate a certain amount of rainfall (mm $dy^{-1}$), the calibration curve of the pump was used, running the pump for the appropriate length of time to obtain the desired rainfall. The model time being 5 minutes - i.e. 5 mins. representing 1 day (see model factors in Mokhtar)- it was not possible to simulate day rainfalls in excess of about 60 mm with the valve used. To make reading easy, the water used was coloured (fig. 1) and the long vessels calibrated in mm.

The starting point of each experiment was an equilibrium condition for a particular drain depth and drainage intensity. This equilibrium was assumed as a basis for comparison among the different combinations of depth and intensity since one had no definite idea of the soil moisture condition prior to infiltration (see "some deviations from field situation" in Wind, 1972). Equilibrium exists when the absolute value of the soil moisture tension in each vessel corresponds with the height of water level (in the vessel) above the groundwater table. The soil moisture at that time is the equilibrium moisture content. The time during equilibrium at which rainfall begins is called zero time.

At zero time, the desired amount of rainfall was given and the readings of the water level in each vessel were recorded at predetermined time intervals. The difference (in cm.) between the top of and the water level in each vessel, multiplied by 2(model factors in Menan) gives the value of the capillary potential at the middle of the soil layer represented by that vessel at the time of reading.

The depth of the groundwater table (Dgw) was calculated from the solution of equations 1 and 3 which is:

$$\Delta Z = \frac{\Psi_d}{1 - \frac{q}{k_o}\Psi_d} \qquad (5)$$

from which $Dgw = D - \Delta Z$

where D = drain depth (cm)

$\Delta Z$ = distance between the groundwater table mid-way between two parallel drains and the level of water in the drains (cm)- see fig. 4 ,

and other terms are as previously defined.

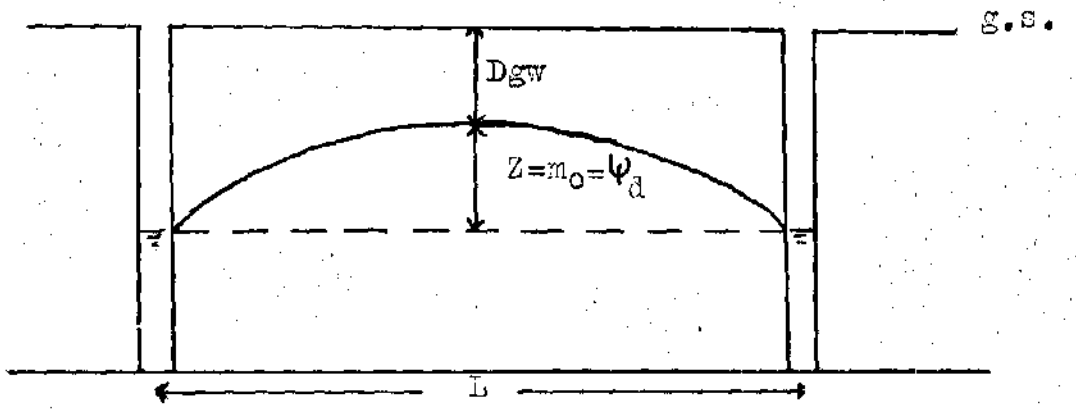



Fig. 4: Drainage Parameters.

Drainage Intensity Defined:

Hooghoudt's (1936) equation of saturated horizontal flow is:

$$S = \frac{8kdm}{L^2} \qquad (6)$$

where S = discharge velocity (m dy$^{-1}$)
k = saturated permeability of the soil (m dy$^{-1}$)
d = equivalent depth of aquifer (m)
m = Z in fig. 4
L = drain spacing (m)

This equation, expressed in terms of Darcy's law (eq.1) gives equation 3 ($V_d = - A\psi d$).
From both equations (3 and 6) it follows that

$$A = \frac{8\ kd}{L^2}\ dy^{-1} \qquad (7)$$

Thus A indicates the intensity with which the soil is drained.

It is not usual for drainage intensities to exceed 0.02 dy$^{-1}$; under Dutch circumstances, most tile drainage systems were designed with A = 0.014 dy$^{-1}$. Given a hydraulic head (or capillary potential at Drain depth) of 50 cm, this intensity results in a drain discharge of 0.7 cm dy$^{-1}$.

Parameters used for the experiments

Drain depths of 80 and 100 cm and drainage intensities of 0.01 and 0.02 $dy^{-1}$ were used under five arbitrarily chosen standardized and one natural rainfall sequence. The standardized rainfall had the same total of 110 mm in ten consecutive days and the sequences are shown in table 1.

Table 1: Standardized Rainfall Sequences (mm)

| Sequence No. \ Days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 110 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 110 |
| 3 | 20 | 18 | 16 | 14 | 12 | 10 | 8 | 6 | 4 | 2 | 110 |
| 4 | 3 | 7 | 11 | 15 | 19 | 20 | 16 | 11 | 6 | 2 | 110 |
| 5 | 19 | 15 | 11 | 7 | 3 | 2 | 6 | 11 | 16 | 20 | 110 |

The natural rainfall sequence used was that of December 1938 in Jakarta (Indonesia). The choice of place was based on what was available and that of month on what was nearest to the assumed equilibrium condition. The last rainfall in November of that year was on the 21st and the first in December was on the 2nd, meaning a gap of some ten days (see table 2). Thus it was assumed that the soil might not be too far from the assumed equilibrium condition at the beginning of the December rains. The rainfall sequences are presented along with the results.

Objective:

The objective of the present experiments was to analyse the effects of drainage depth and intensity on the moisture potential of the top soil and groundwater depth with time as a result of the different rainfall sequences on the mentioned clay loam soil.

Table 2: Jakarta rainfall in November - December, 1938

| Month and days | | amount (mm) | Month & days | | amount(mm) |
|---|---|---|---|---|---|
| November | 21 | 7.7 | December | 16 | nil |
| December | 1 | nil | | 17 | 2.6 |
| | 2 | 0.6 | | 18 | nil |
| | 3 | 2.0 | | 19 | " |
| | 4 | 46.5 | | 20 | " |
| | 5 | nil | | 21 | " |
| | 6 | 10.0 | | 22 | " |
| | 7 | 3.5 | | 23 | 27.8 |
| | 8 | nil | | 24 | 7.3 |
| | 9 | 8.1 | | 25 | 0.7 |
| | 10 | 0.6 | | 26 | nil |
| | 11 | nil | | 27 | 5.4 |
| | 12 | 2.0 | | 28 | 1.5 |
| | 13 | 0.4 | | 29 | 18.6 |
| | 14 | 4.8 | | 30 | 12.6 |
| | 15 | 1.5 | | 31 | 36.7 |

## RESULTS AND DISCUSSION

The results are presented in two parts-standardized and natural rainfall sequences each-of which is separated into:

(a) Capillary potential in the top soil layer i.e. at a depth of 5 cm (figs. 5a - 5e).

(b) The groundwater table (figs. 6a - 6e).

Each of a and b is presented for three combinations of drain depth and drainage intensity hereafter referred to as drainage conditions A,B, and C, viz:

A : D=100 cm, $A = 0.01\ dy^{-1}$

B : D= 80 cm, $A = 0.01\ dy^{-1}$

C : D= 80 cm, $A = 0.02\ dy^{-1}$

Thus it is possible to compare the effects of different depths and intensities. The standardized rainfall sequences are hereafter referred to as sequences 1, 2, 3, 4 and 5 as presented in table 1.

The time (in days) needed for the soil moisture potential to get back to the initial equilibrium condition after the rainfall stopped is shown for drainage conditions A, B and C only for the rainfall sequence 1 since the recession part of the curves is exponential in all cases.

### A. Standardized Rainfall Sequences

#### 1. Capillary potential

The results are shown in figs. 5a-e. In all cases, the effects of drain depth and drainage intensity are not much during the rainy days but more pronounced during the rainless days as can be seen from the recession curves.

The effect of depth (i.e. comparing drainage conditions A & B) is clearer if one considers the length of complete saturation of the top soil layer under both conditions. For example, in rainfall sequence 4, there are 4 days of complete saturation for drainage condition B but only 2 days for condition A. For the same rainfall sequence, the effect of intensity (comparing conditions B and C) appears less than that of depth - i.e. complete saturation for 3 days. This trend appears true for the other rainfall

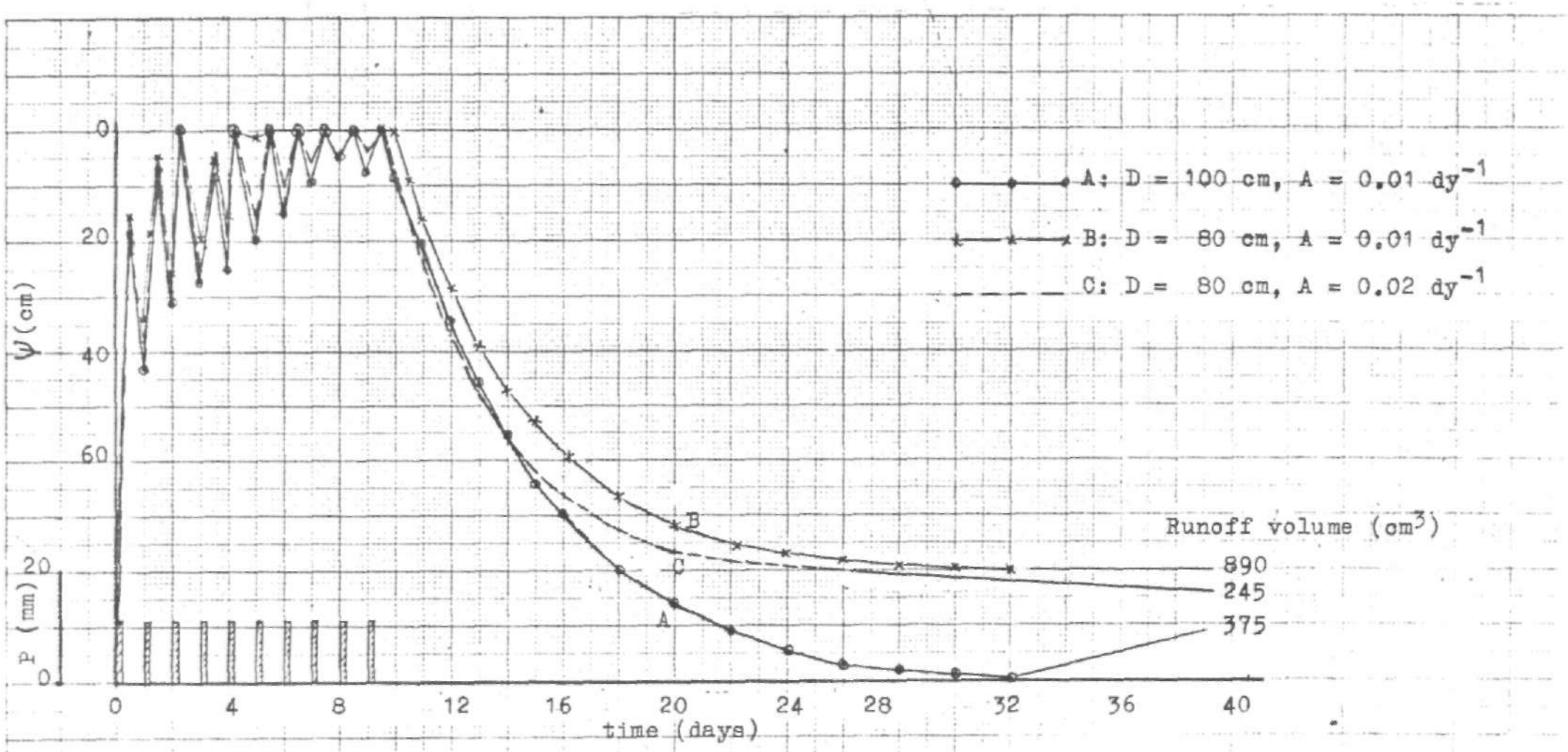



Fig. 5a: Soil, moisture potential ($\psi$) at 5 cm depth for rainfall sequence 1.

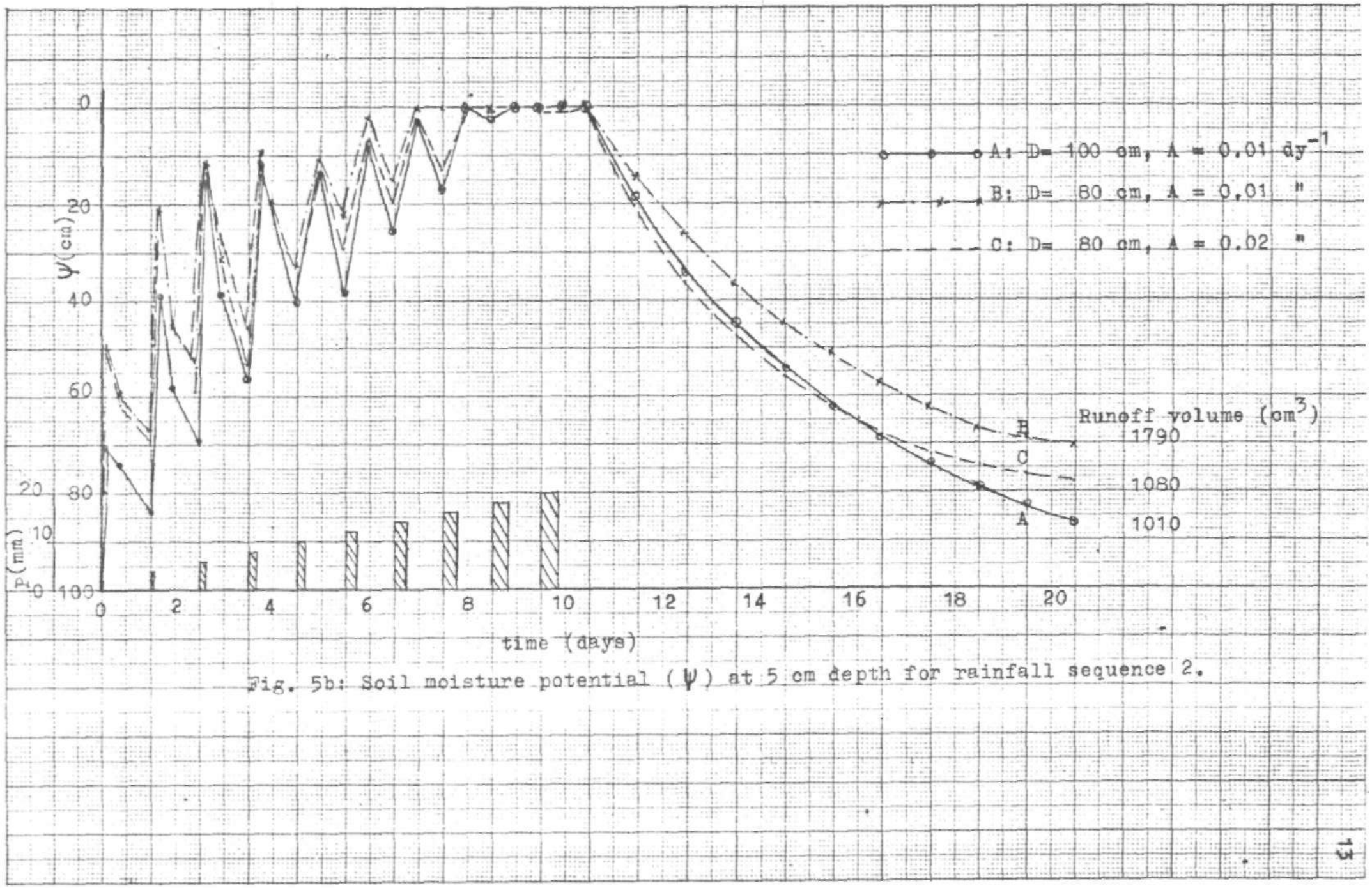



Fig. 5b: Soil moisture potential ( $\psi$ ) at 5 cm depth for rainfall sequence 2.

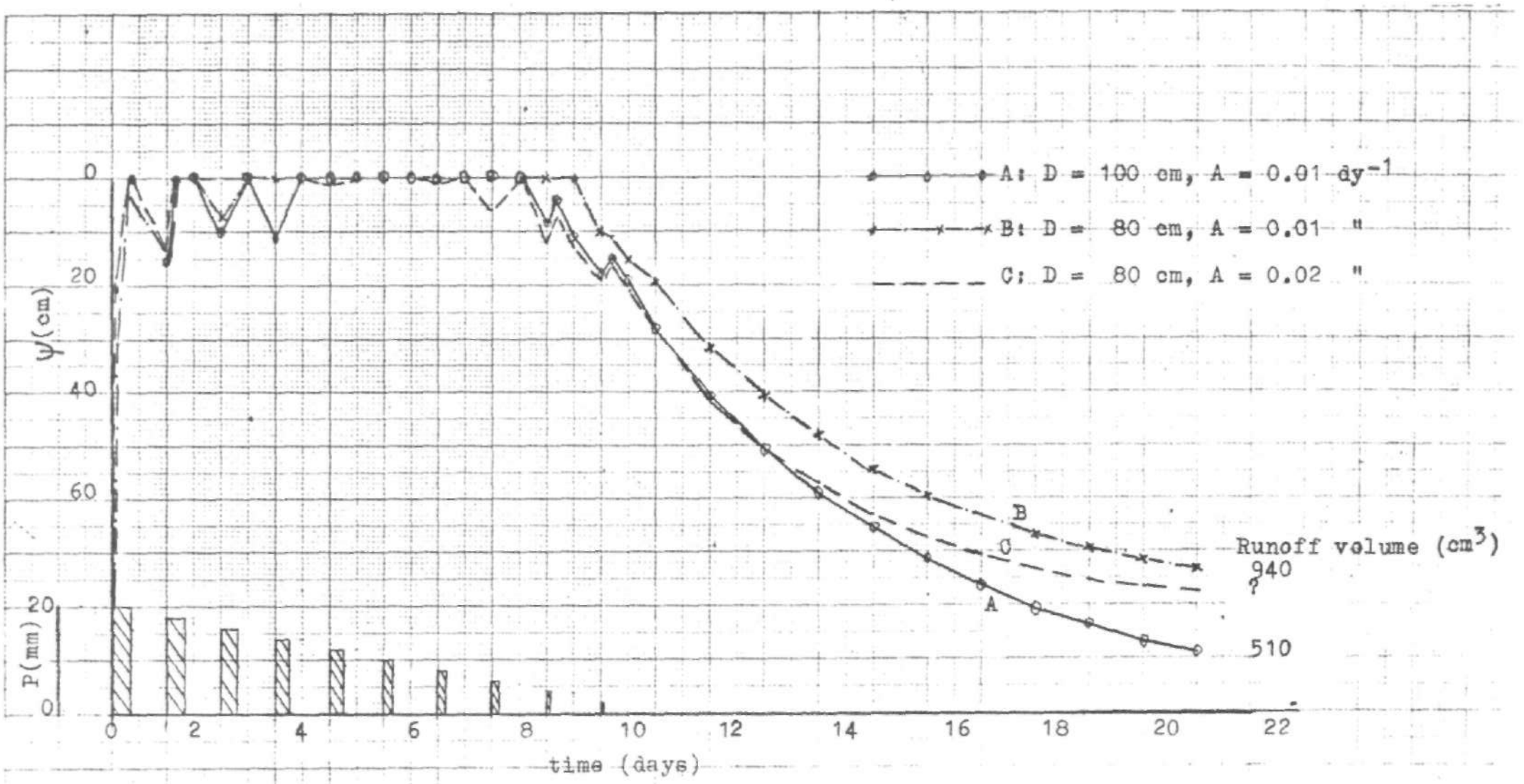



Fig. 5c: Soil moisture potential ($\psi$) at 5 cm depth for rainfall sequence 4.

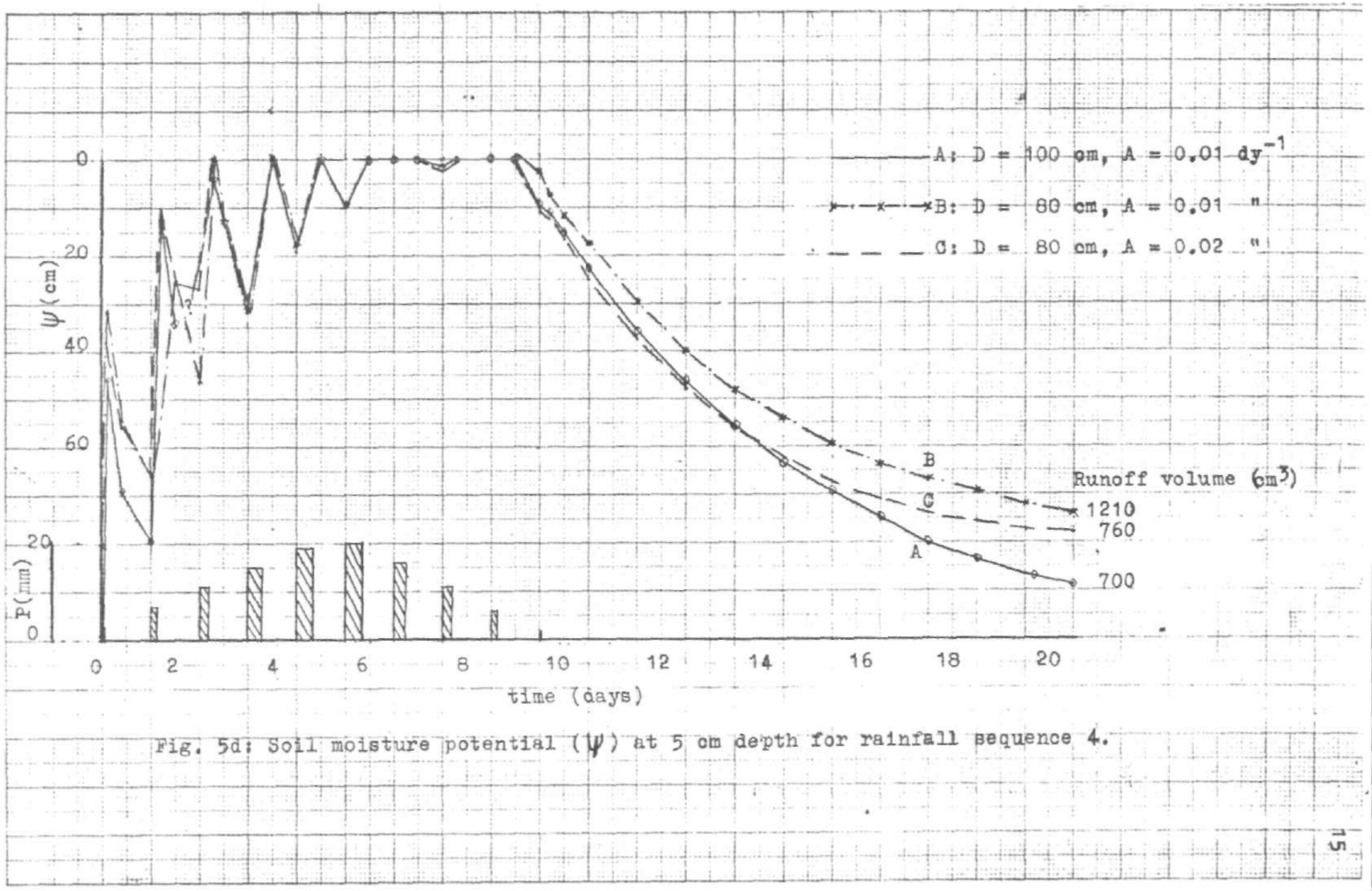



Fig. 5d: Soil moisture potential ($\psi$) at 5 cm depth for rainfall sequence 4.

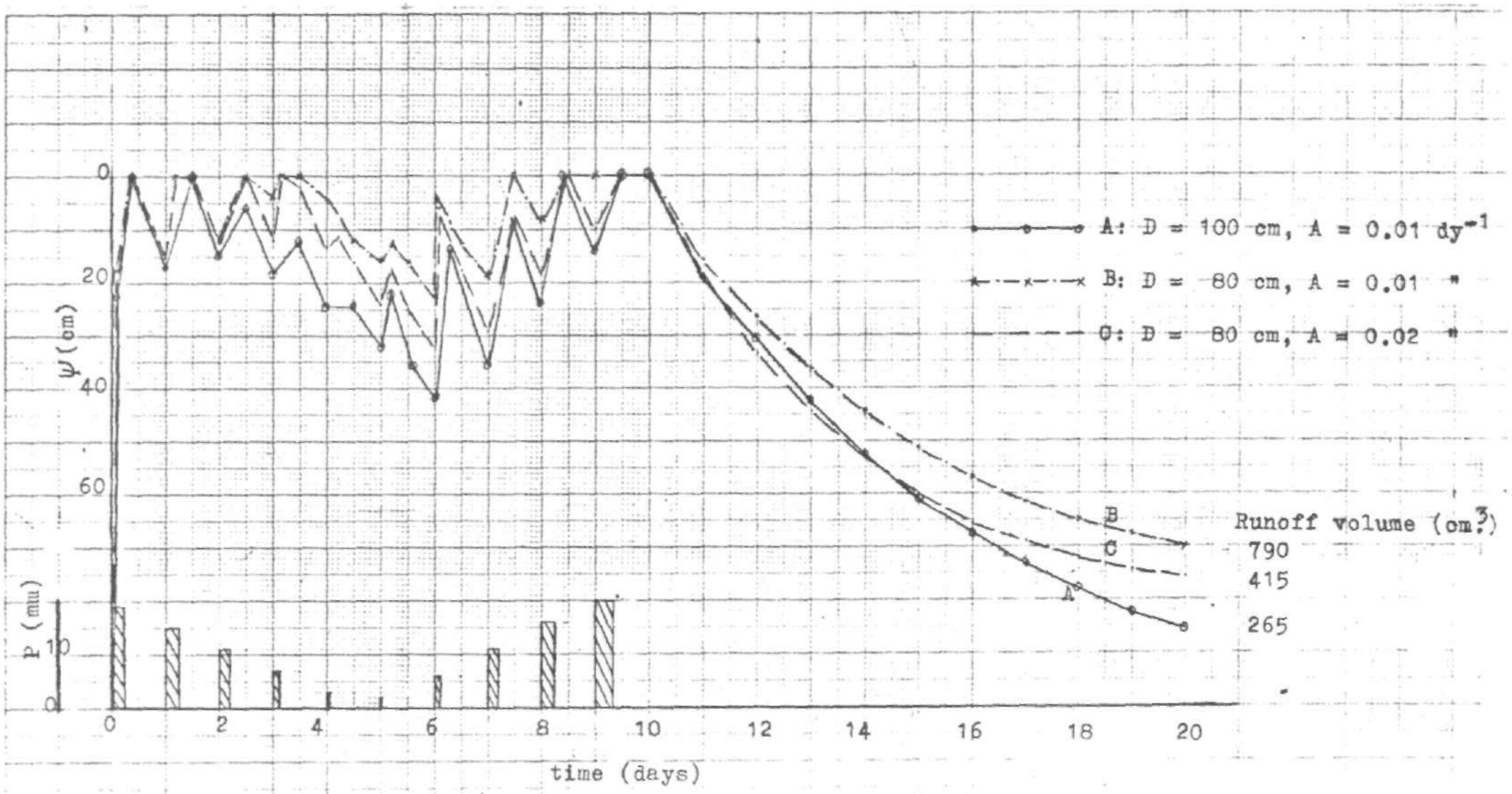



Fig. 5e: Soil moisture potential ($\psi$) at 5 cm depth for rainfall sequence 5.

sequences.

Considering the different rainfall sequences, it appears that sequence 3 keeps the soil saturated for the longest period whereas sequence 5 keeps the top soil saturated only for short periods and that ocassionally. For example, with drainage condition B, sequence 3 keeps the top soil continuously saturated for 7.5 days, whereas sequence 5 does that for only 1.5 days and for 0.5 day at two other times. In the same way, the time of occurrence of complete saturation after the beginning of the rainfall sequence is only 1.5 days for sequence 3 and about 8.5 days for sequence 5. The remaining three sequences appear intermediate between these two extremes.

The effect of evapotranspiration on the top soil layer may have considerable influence on the soil moisture potential as presented in figures 5a-e and the foregoing treatise. This, coupled with the fact that most agricultural crops have their roots at depths greater than 5 cm. (see table 4 ), makes it necessary to extend the results and discussions of this study to deeper soil layers. Hence figures similar to 5a-e are shown in appendix I for 25 cm. depth.( (For the same reasons, appendix II is included).

Generally, the trend is the same as for 5 cm depth except that there is less fluctuation of the soil moisture potential. In addition, it appears that rainfall sequence 2 in this case, keeps the soil continuously saturated for the shortest period (c.f. sequence 3 at 5 cm depth), even for drainage condition B.

With regard to the runoff resulting from each rainfall sequence, it appears that the total volume ($cm^3$) and the time of occurrence depend on the soil moisture condition before high rainfalls occur. For example, sequence 2 gives the highest amount for all the drainage conditions, all occurring from the last three rainfalls of the sequence.

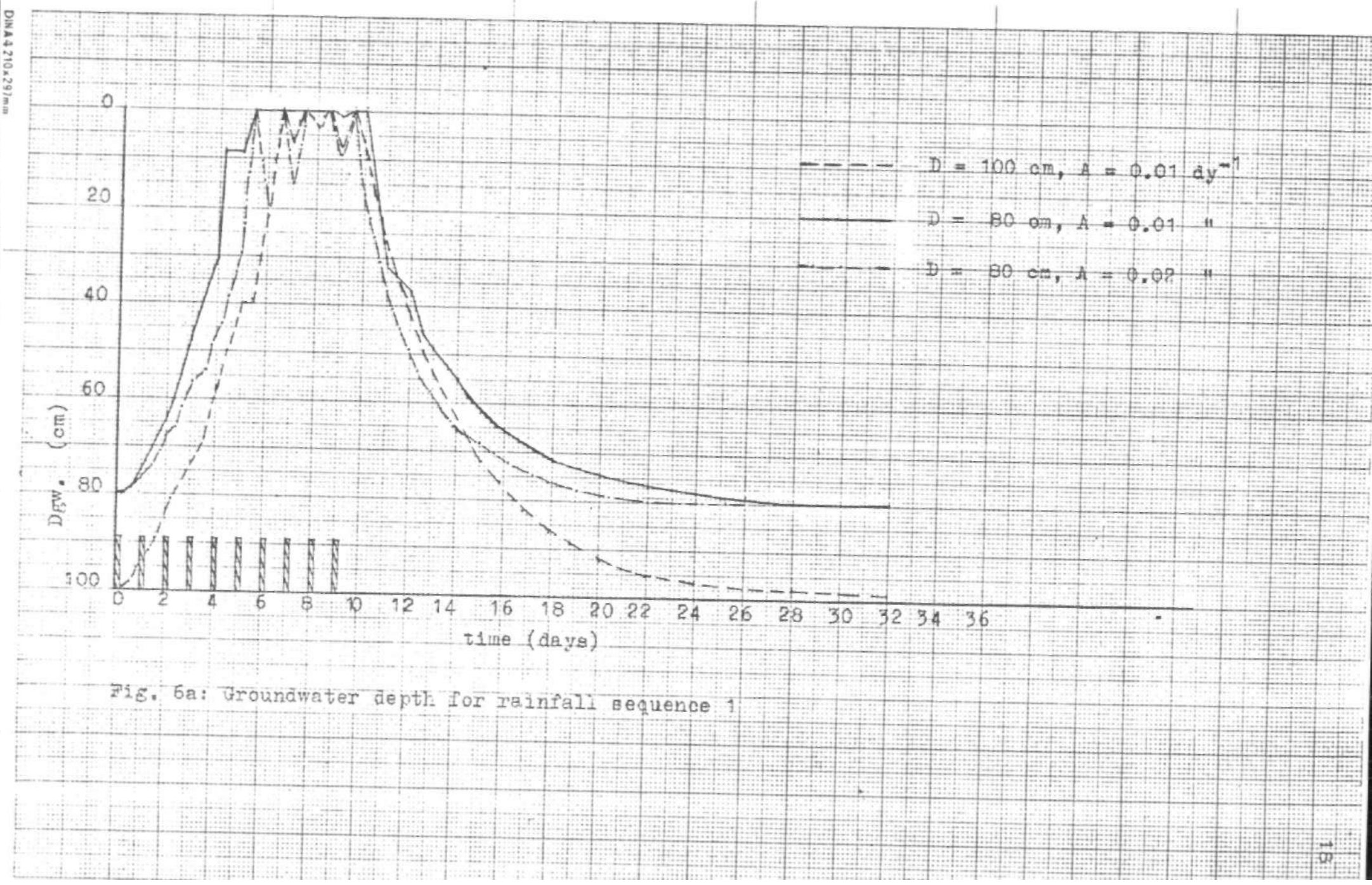



Fig. 6a: Groundwater depth for rainfall sequence 1

DIN A 210 x 297 mm

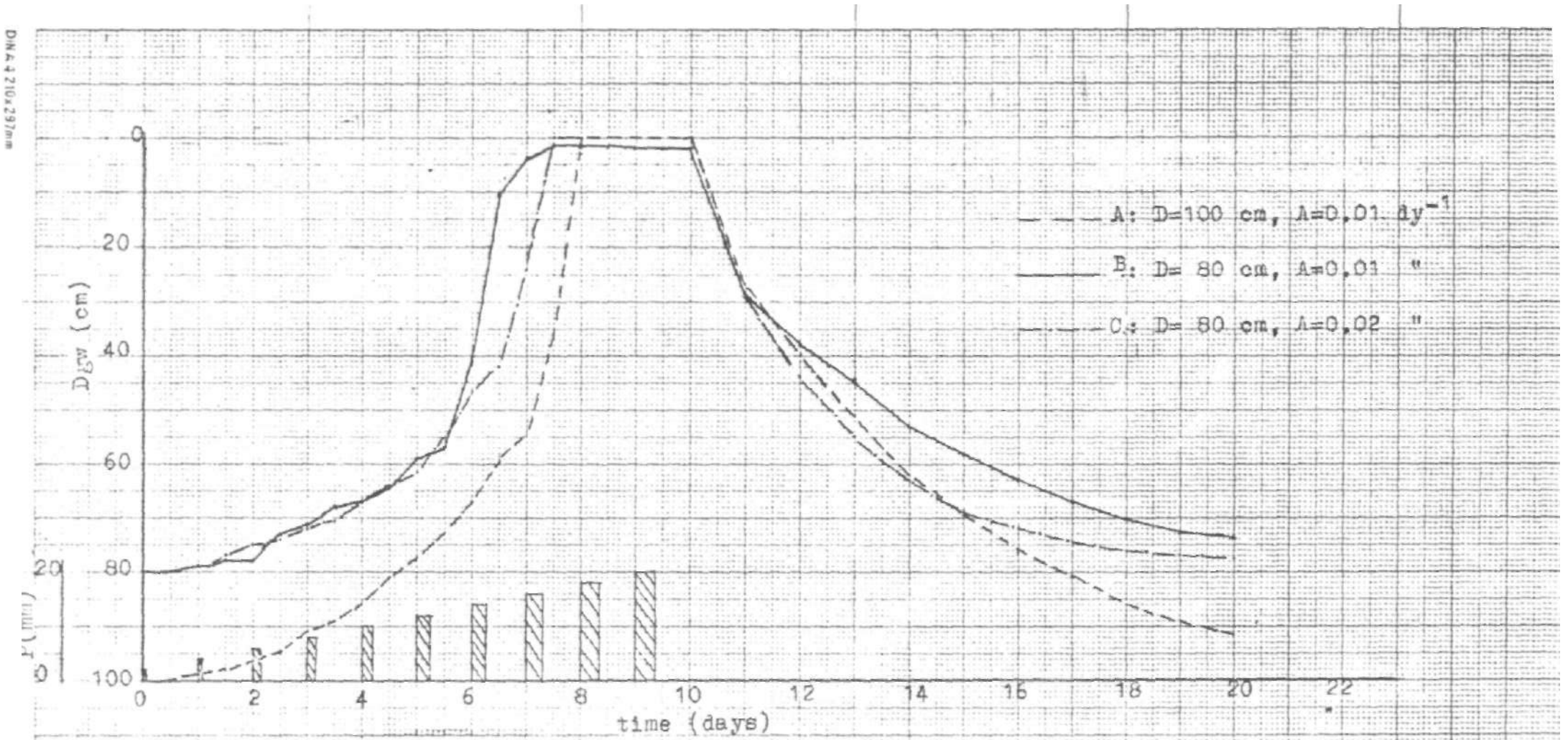



Fig. 6b: Groundwater depth for rainfall sequence 2

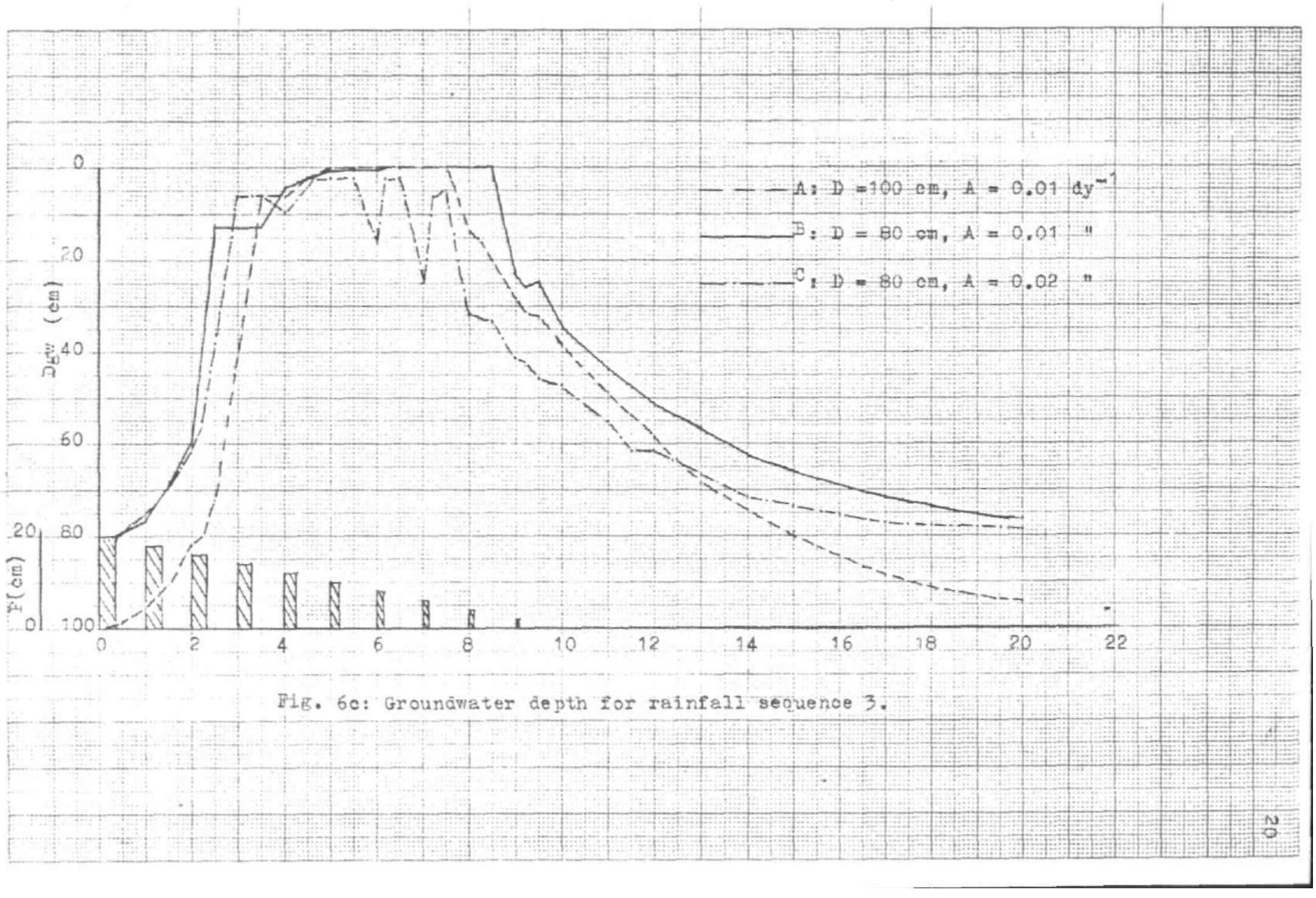



Fig. 6c: Groundwater depth for rainfall sequence 3.

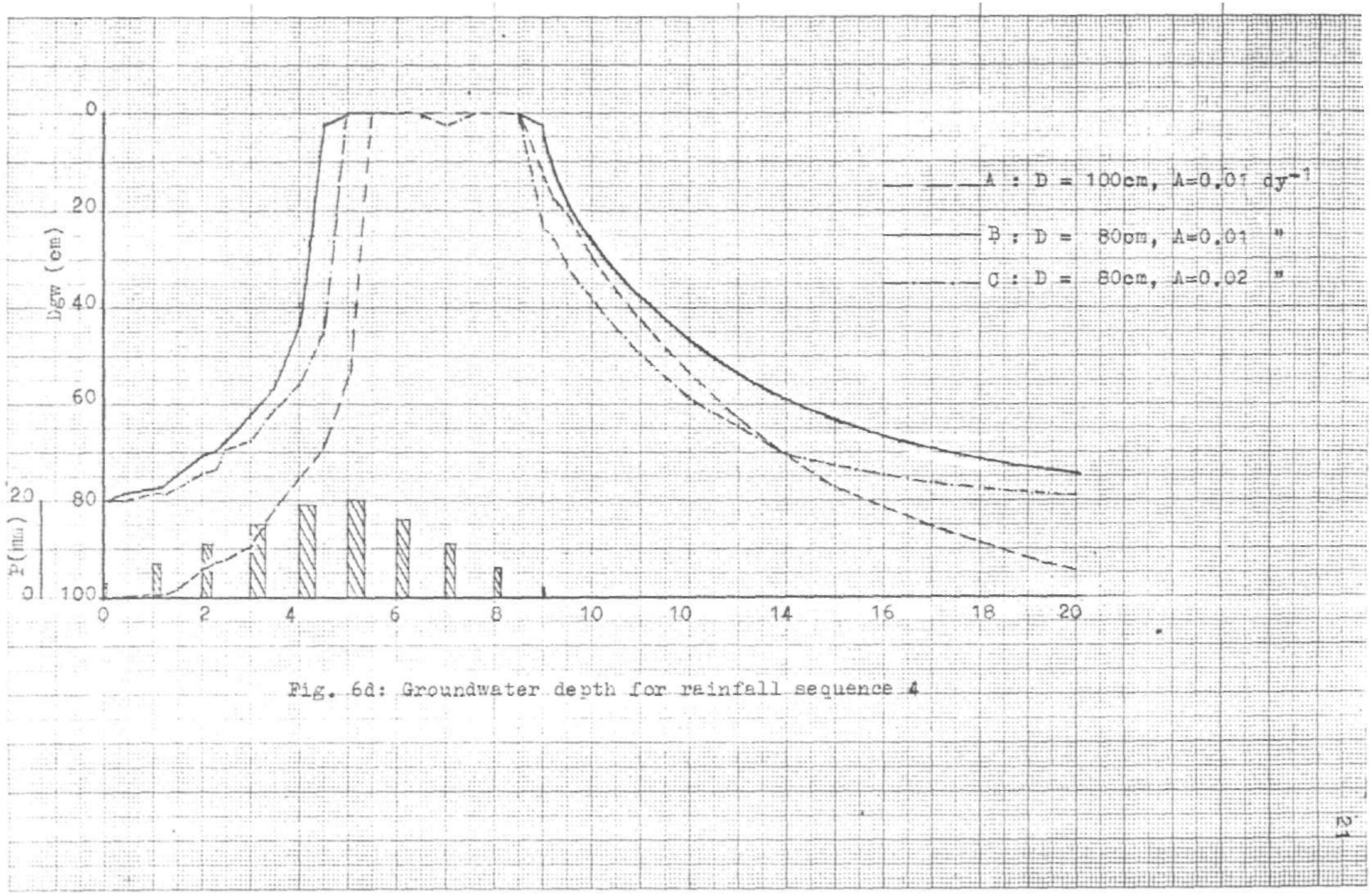



Fig. 6d: Groundwater depth for rainfall sequence 4

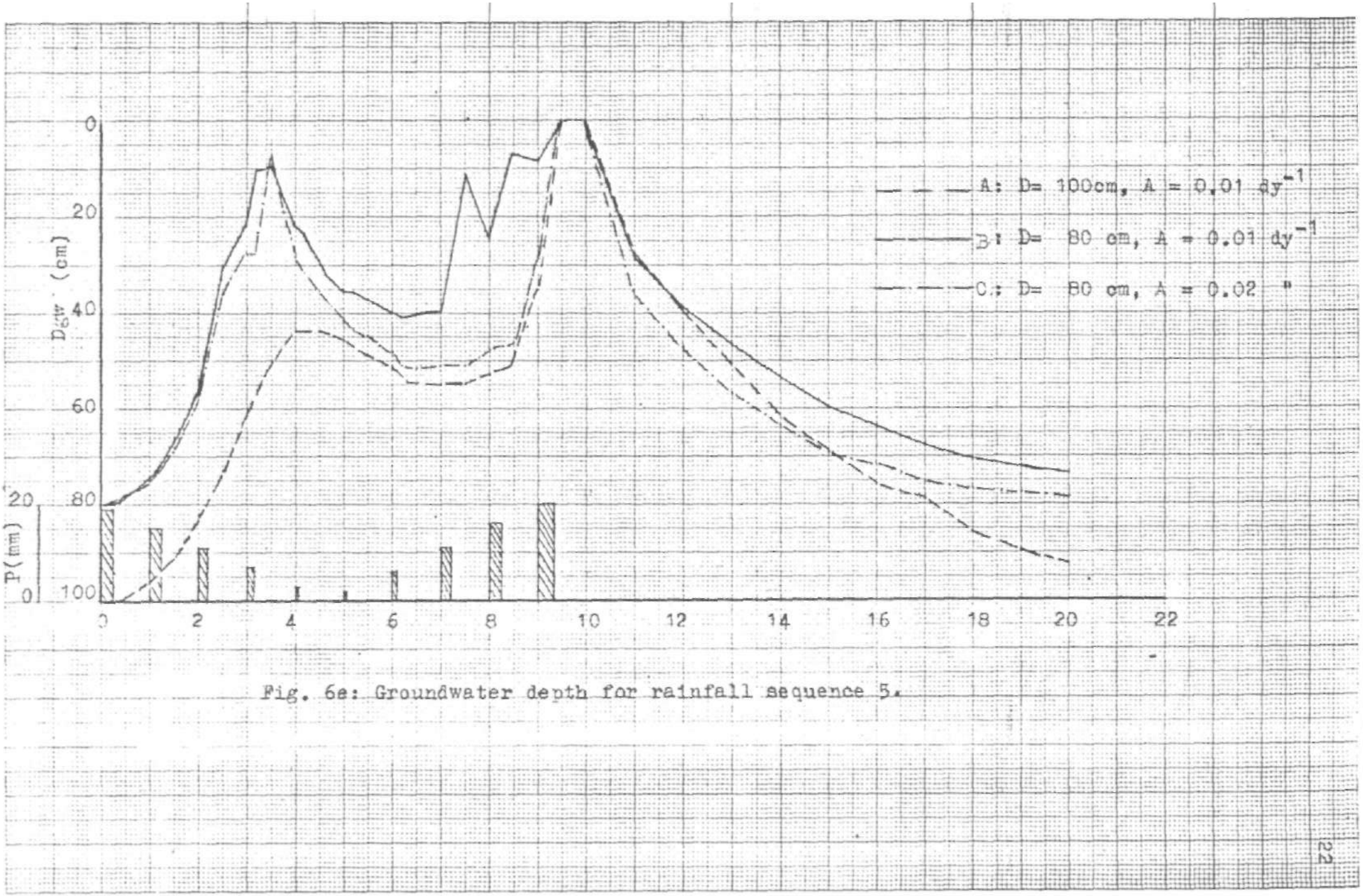



Fig. 6e: Groundwater depth for rainfall sequence 5.

2. Depth of groundwater table

The effect of drain depth on the depth of the groundwater table appears greater along the rising and tail end of the recession part of the curves than that of intensity. On the other hand, the effect of intensity is greater immediately after the end of the rainy period.

On the whole, the rising and falling of the groundwater table seems to follow the rainfall sequences for all drainage conditions.

In terms of keeping the water table below a certain depth, it appears that the effect of drain depth is more important for all the drainage conditions and rainfall sequences. The length of time for which the groundwater table reaches and remains on the ground surface appears shortest for rainfall sequence 5 under all the drainage conditions considered.

A. December 1938 rainfall for Jakarta

1. Capillary potential

With high values of rainfall, the effects of drain depth and drainage intensity seem negligible. However, as the rainfall gets lower and the absolute values of $\psi$ increase, they become clearer. In this regard, the pattern is exactly the same as for the standardized rainfall sequences. But unlike the case of standardized sequences, it appears the period of complete saturation of the top soil is the same for all the three drainage conditions.

Table 3 shows the amount ($cm^3$) of runoff associated with each drainage condition, resulting from the same rainfall and day. The first time of occurrence of runoff is the same for A, B and C. The comparative amount of runoff resulting from each drainage condition with the same rainfall does not appear consistent (see table 3), but the total shows a much higher value for condition B. This suggests that the drainage condition (B) keeps the top soil wettest during this period as can be seen from fig. 7. i.e. it keeps the top soil saturated for half a day longer than the other two.

Table 3: Comparative amounts of Runoff*($cm^3$)

| Drainage condition / Rainfall(mm) | A | B | C |
|---|---|---|---|
| 47 | 860 | 980 | 940 |
| 10 | 0 | 50 | 0 |
| 27.5 | 450 | 320 | 380 |
| 18.5 | 190 | 210 | 190 |
| 12.5 | 85 | 70 | 100 |
| 37 | 750 | 1270 | 950 |
| TOTAL | 2335 | 2900 | 2560 |

* Runoff means the part of the simulated rainfall which flowed out through the overflow tube and therefore did not enter the model.

2. Depth of groundwater table (fig. 8)

The effect of the drain depth on the depth of the groundwater tabel appears consistently greater than that of drainage intensity all through the period considered, except for the first three days after the last rainfall when the effects of both appear equal. Consequently, the length of time for which any point is below the groundwater table seems least for drainage condition A, greatest for B and in-between for condition C. This trend also agrees with that of the standardized rainfall sequences.

In terms of agricultural requirements, this point may be viewed in the light of table 4 which is reproduced from Rijtema (1969). For any of these rooting systems, the period of the rootzone coming under the water table -partly or wholly- is least for drainage condition A. If we take a cereal crop for instance, the rootzone will be under water for about 7 days occurring in two parts of 2 and 5 days, whereas it will be for about 22 days (8 and 14 days) under condition B and about 15 days (6 and 9 days) under condition C.

Depending on the crop tolerance for anaerobic conditions, it appears that the drainage condition A is the best for the soil (clay loam) and crop considered under the December 1938 rainfall in Jakarta.

Table 4: Type of root system and corresponding effective rootzone.

| Type of rooting | Effective rootzone (cm) - g.s. | Example of crop |
|---|---|---|
| Shallow root system | 25 | permanent grass |
| medium shallow root system | 40 | potatoes |
| medium deep root system | 60 | cereals (e.g. maize) |
| deep root system | 80 | alfalfa. |

## SUMMARY

Wind's hydraulic model (1972) was used to investigate the effects of drain depth and drainage intensity on the unsaturated flow of moisture in a clay loam soil and on the depth of groundwater table as initiated by a series of five standardized and one natural rainfall sequences. It was shown that the drainage condition B (D = 80 cm, A = 0.01 $dy^{-1}$) keeps the soil saturated for a longer time than A and C for all the rainfall sequences. The soil was kept driest by drainage condition A (D = 100 cm, A = 0.01 $dy^{-1}$) while condition C (D = 80 cm, A = 0.02 $dy^{-1}$) appears intermediate. The purpose and cost of installing the drainage system will determine which condition to adopt.

Similarly, it was shown that the groundwater table is lowest for condition A, highest for B and in-between for C. For most agricultural purposes, it appears that condition A is the most suitable.

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# APPENDIX I

Soil moisture potential ($\psi$) at 25 cm. depth for the five standardized rainfall sequences.

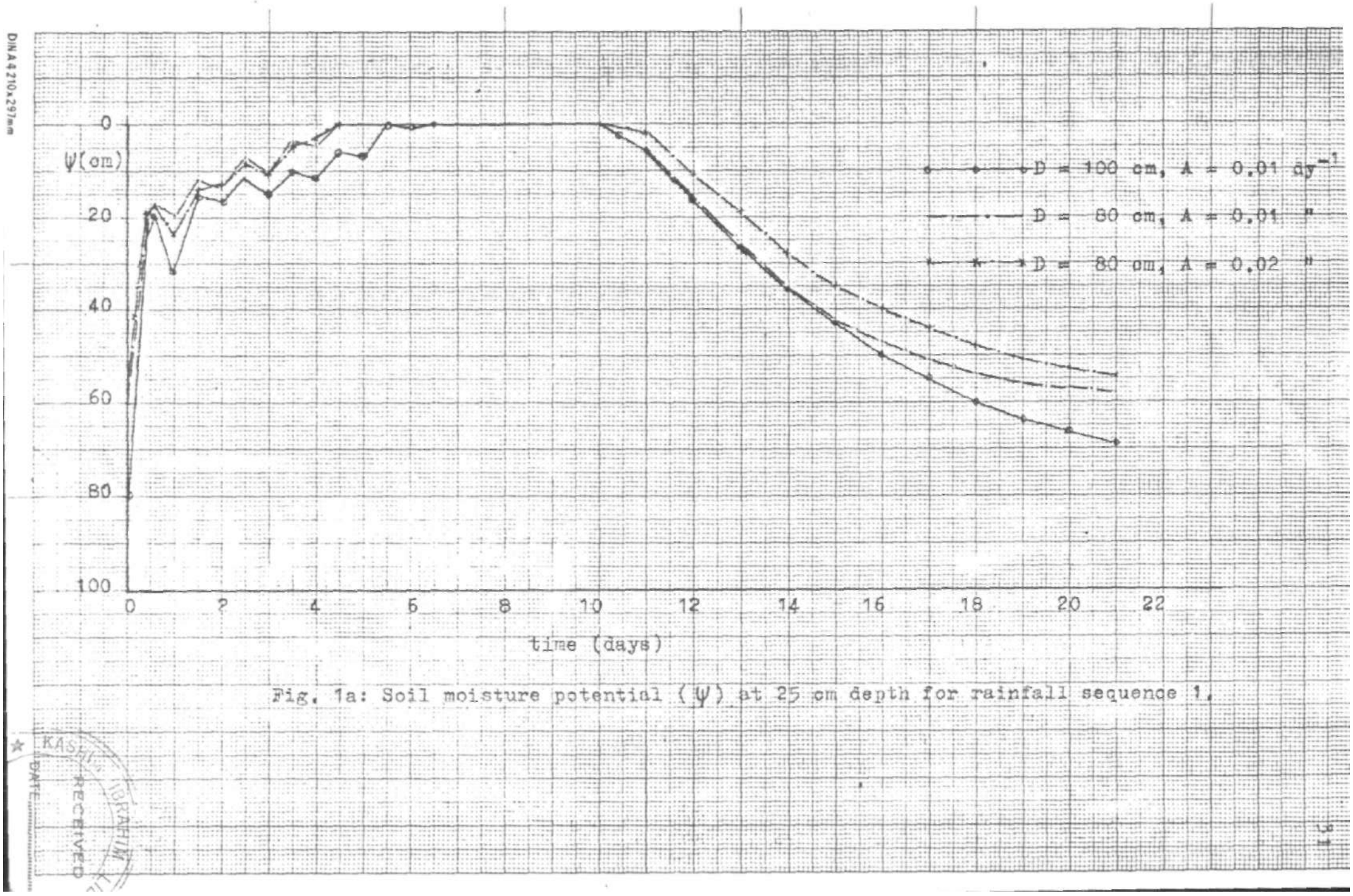



Fig. 1a: Soil moisture potential ($\psi$) at 25 cm depth for rainfall sequence 1.

DIN A4 210 x 297 mm
KASHI RECEIVED DATE

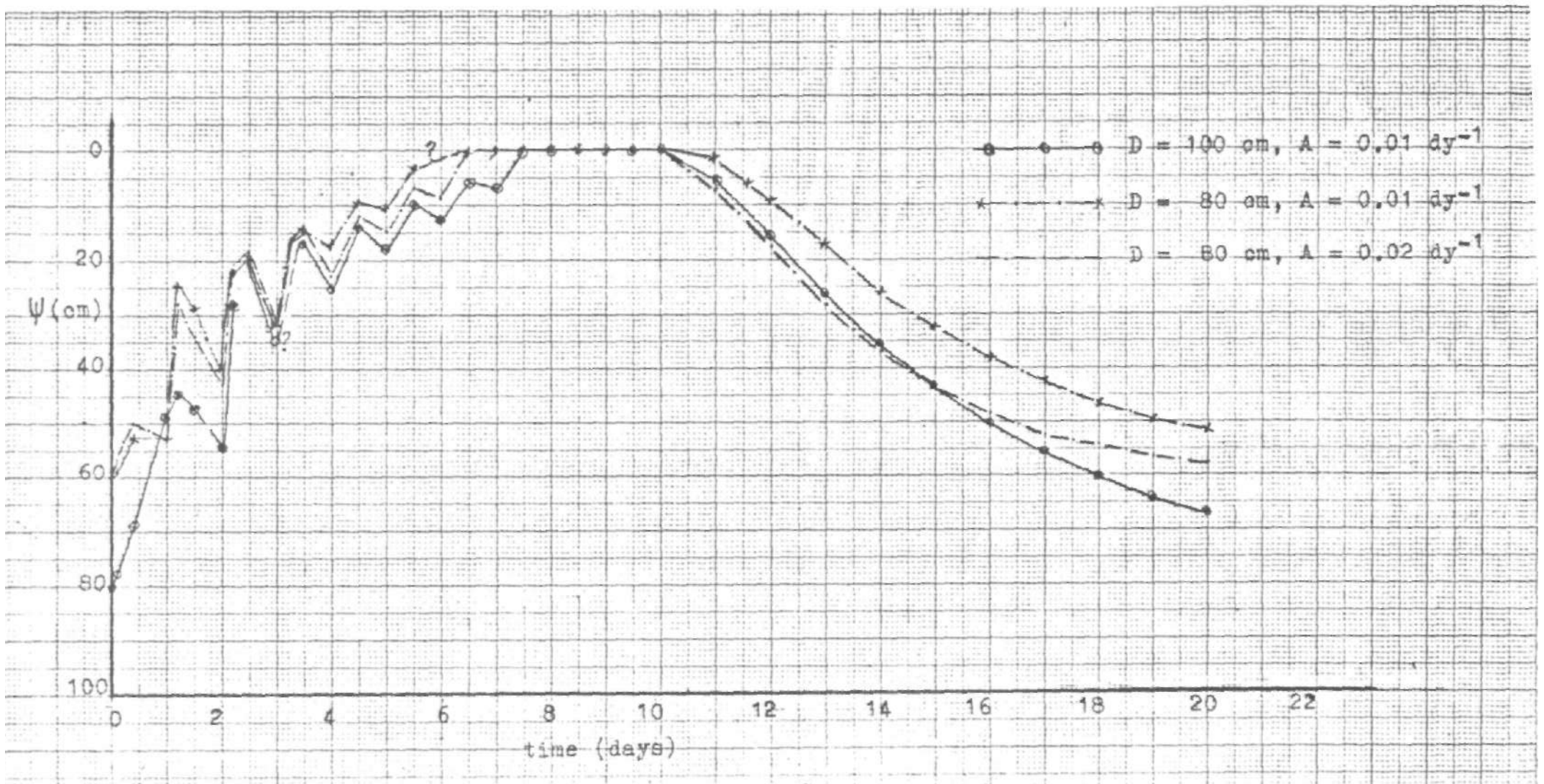



Fig. 1b: Soil moisture potential ( $\psi$ ) at 25 cm depth for rainfall sequence 2.

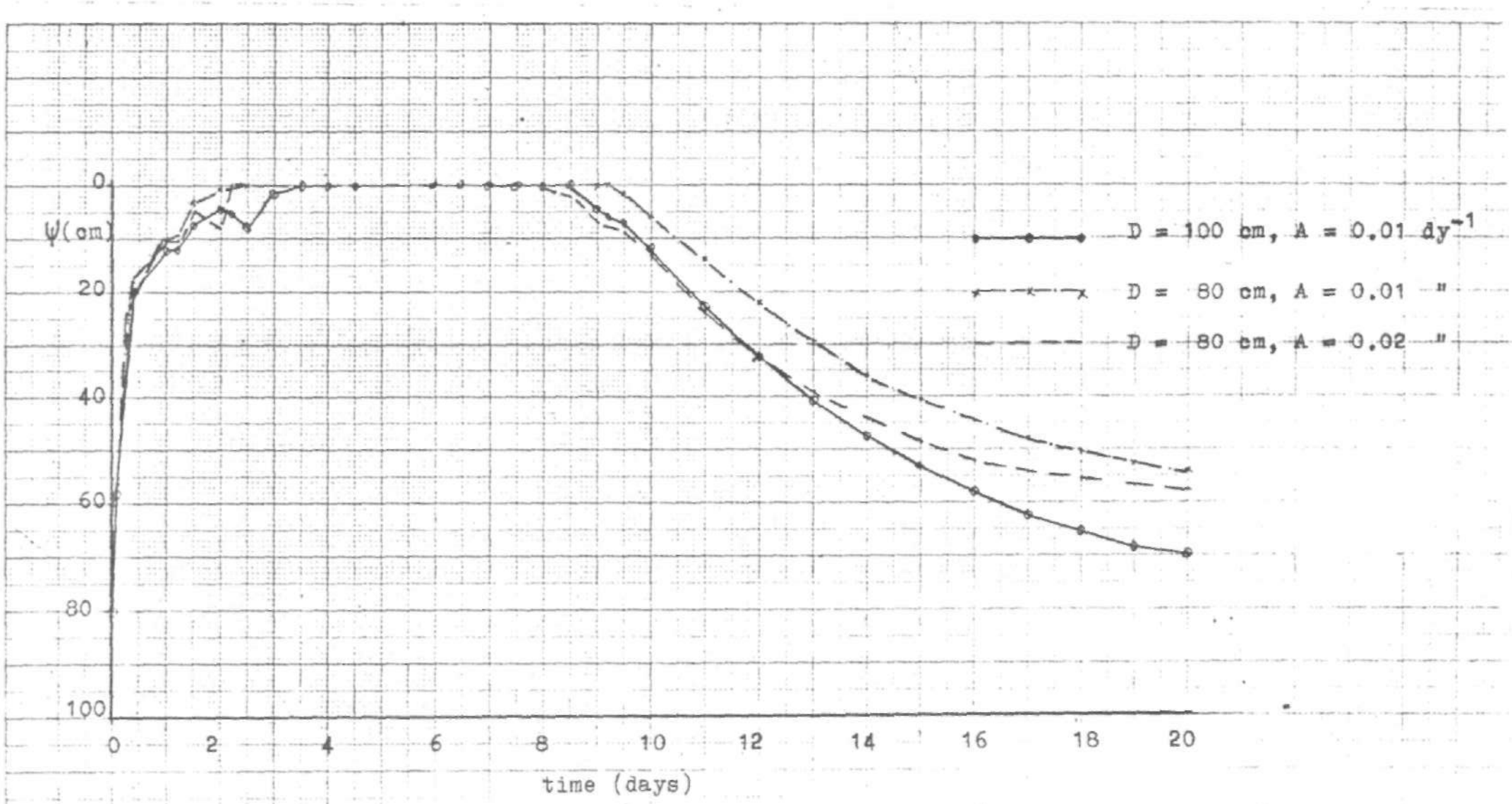



Fig. 1c: Soil moisture potential ( $\psi$ ) at 25 cm depth for rainfall sequence 3.

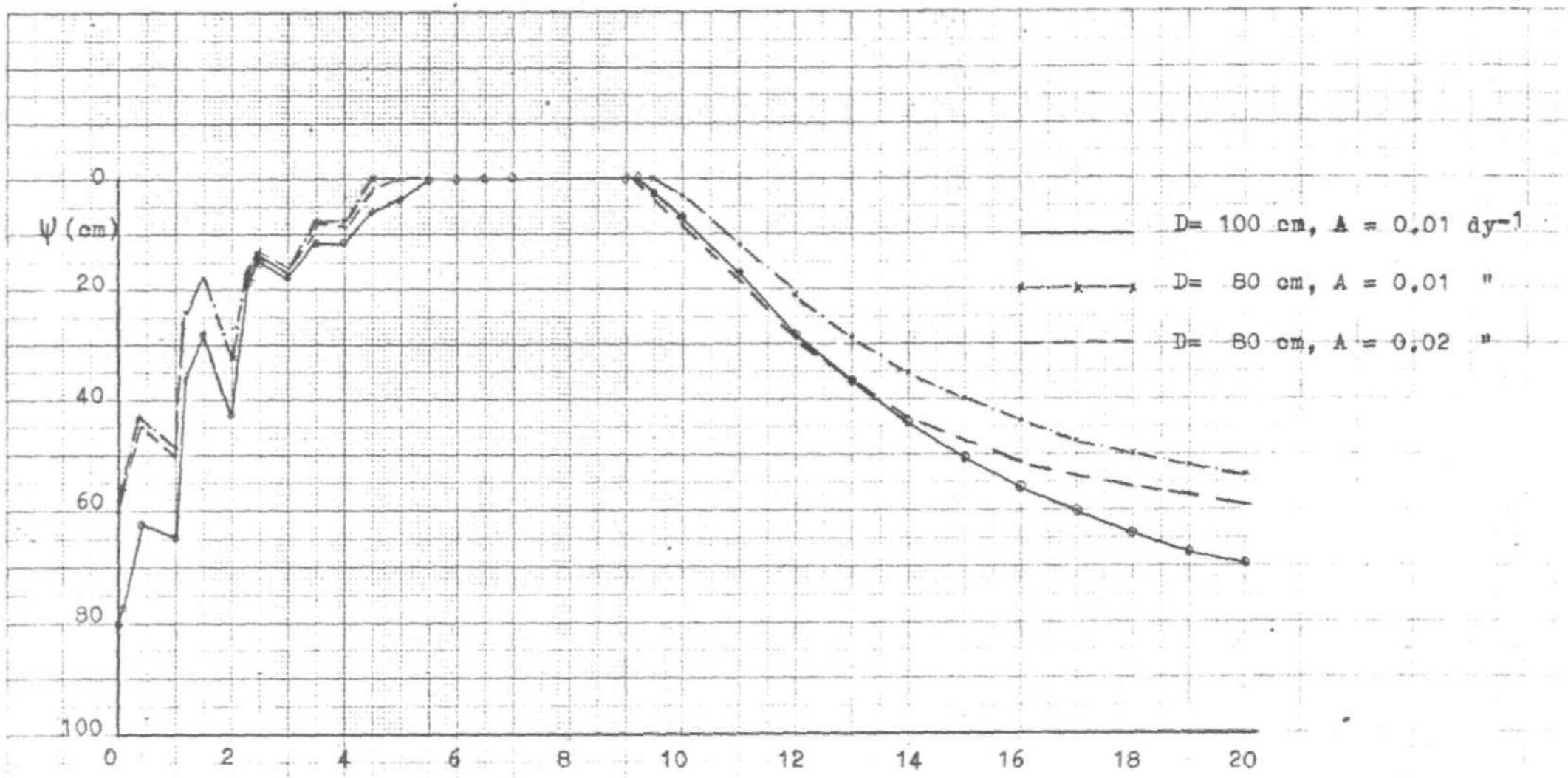



Fig. 1d: Soil moisture potential ($\psi$) at 25 cm depth for rainfall sequence 4 .

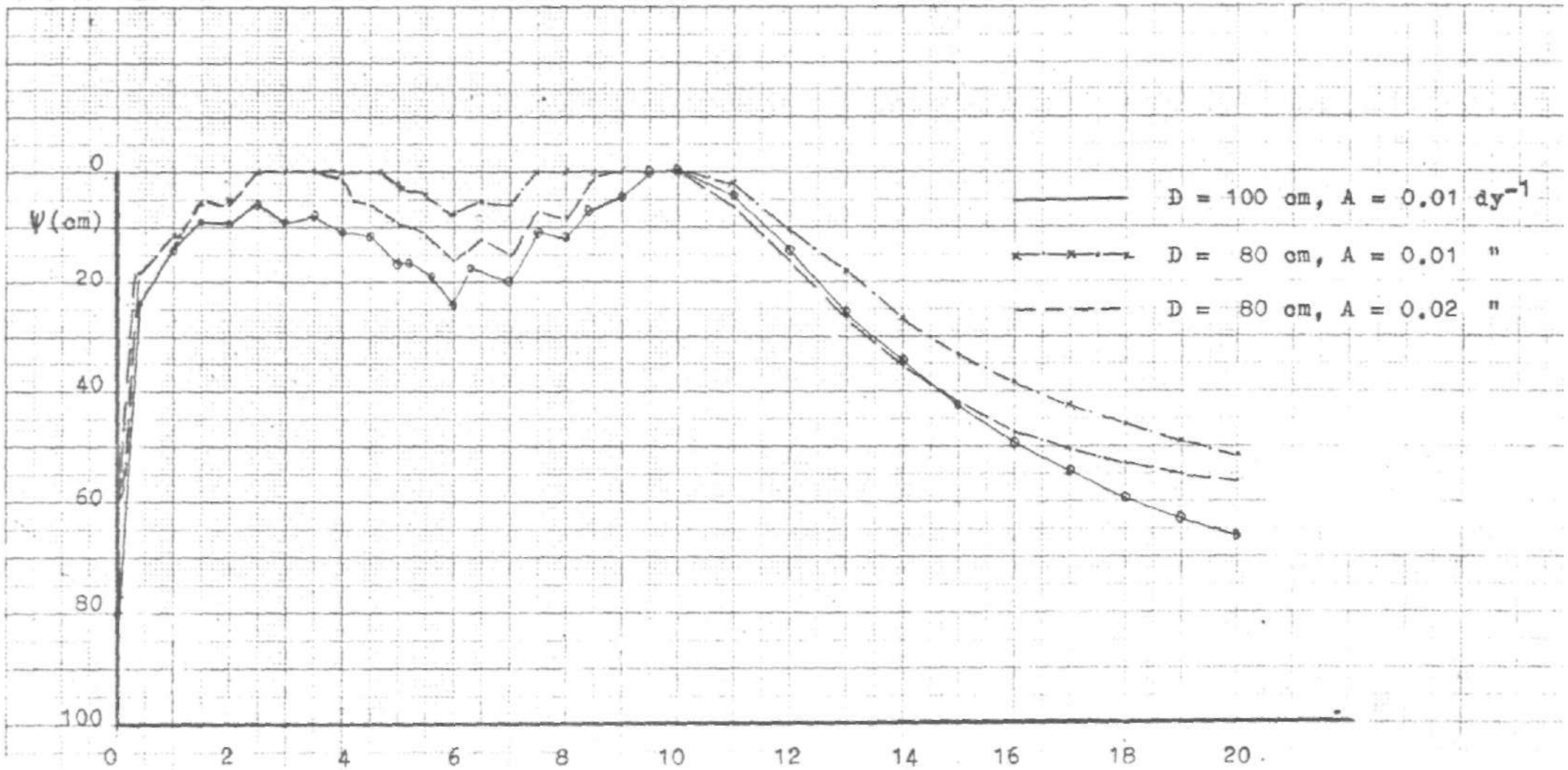



Fig. 1e: Soil moisture potential ($\psi$) at 25 cm depth for rainfall sequence 5.

## Appendix II

Soil moisture potentials as recorded in the laboratory for soil layers 1, 3, 6 and layer at drain depth, including the depth of groundwater table Dgw.

The following explanations apply to all tables .

Soil layer = Vessel no., hence, soil layer 1 = 0-10 cm, 2 = 20-30 cm, etc.

* means that the figures in the row are + (positive) unless otherwise stated.

\+ means that the soil layer has a positive potential (i.e. below groundwater).

Dgw = depth of groundwater table (cm) below the ground surface.

? = the reading was not taken.

Drainage Condition A = Drain depth D = 100 cm
Drainage intensity A = 0.01 $day^{-1}$

B = D = 80 cm, A = 0.01 $day^{-1}$

C = D = 80 cm, A = 0.02 $day^{-1}$

Rainfall sequences 1, 2, 3, 4 and 5 are as defined in table 1 of the main text.

Table 1 a Drainage condition A with rainfall sequence 1

| Soil layer | Time (mins.) 0 | 2.0 | 3.0 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 | 35.0 | 37. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 5.0 | 9.5 | 22.2 | 3.3 | 14.0 | 4.5 | 13.7 | 4.5 | 12.0 | 3.3 | 8.7 | 1.0 | 6.7 | + 3.9 | 1.7 | + 3. |
| 3 | 39.6 | 12.5 | 9.7 | 15.8 | 7.5 | 8.2 | 5.8 | 7.5 | 5.0 | 5.8 | 3.0 | 3.6 | 0 | 0.3 | + 7.7 | + 2.8 | + 7. |
| 6 | 24.5 | 19.0 | 12.5 | 11.5 | 9.0 | 7.5 | 6.3 | 4.7 | 3.2 | 1.7 | 0 | + 2.2 | + 4.3 | + 7.1 | +13.8 | +10.0 | +13. |
| 10* | 0 | 0 | 0.3 | 2.7 | 3.3 | 4.5 | 6.9 | 10.0 | 12.2 | 14.8 | 16.4 | 18.2 | 19.5 | 21.9 | 26.5 | 24.5 | 26. |
| Dgw. | 100 | 100 | 99.4 | 96.5 | 92.9 | 90.1 | 85.3 | 76.5 | 69.5 | 59.9 | 53.4 | 45.2 | 38.7 | 25.2 | 0 | 7.7 | 0 |

| | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 | 105.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14.0 | + 4.3 | + 4.1 | + 4.1 | 0.7 | 9.6 | 17.3 | 22.7 | 27.1 | 31.3 | 34.3 | 37.0 | 39.3 | 41.3 | 43.0 | 44.3 |
| 3 | + 7.4 | + 7.4 | + 6.5 | + 7.5 | + 3.7 | 2.7 | 8.0 | 13.2 | 17.8 | 21.5 | 25.0 | 27.5 | 30.0 | 32.0 | 33.3 | 34.5 |
| 6 | +13.6 | +13.9 | +13.7 | +13.7 | +10.9 | + 5.3 | + 2.2 | 1.2 | 5.0 | 8.4 | 11.4 | 13.8 | 16.2 | 18.0 | 19.3 | 20.4 |
| 10 | 26.4 | 26.6 | 26.6 | 26.6 | 25.1 | 20.7 | 18.6 | 16.1 | 13.8 | 11.6 | 9.4 | 7.9 | 6.2 | 4.5 | 3.5 | 2.7 |
| Dgw. | 0 | 0 | 0 | 0 | 3.2 | 32.2 | 43.3 | 54.7 | 63.8 | 71.5 | 75.3 | 82.6 | 87.1 | 90.1 | 92.5 | 94.3 |

Runoff started after 45 mins. 45 secs.
total volume = 320 ml.

Table 1 b Drainage condition B with rainfall sequence 1

Time (mins.)

| Soil layer | 0 | 2.0 | 3.0 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 | 35.0 | 37.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40.3 | 4.8 | 9.1 | 18.7 | 2.2 | 12.1 | 4.0 | 12.0 | 2.3 | 8.0 | + 3.9 | + 3.9 | + 4.3 | + 4.3 | + 4.3 | + 4.1 | + 4.1 |
| 3 | 30.1 | 9.6 | 8.8 | 11.8 | 7.0 | 6.6 | 4.3 | 5.3 | 2.3 | 1.6 | + 8.8 | + 8.8 | + 8.9 | + 8.8 | + 9.0 | + 9.1 | + 9.1 |
| 6 | 15.3 | 11.0 | 9.8 | 8.2 | 7.0 | 4.4 | 1.8 | + 2.4 | + 4.7 | + 7.4 | +15.4 | +15.8 | +16.1 | +16.1 | +16.2 | +16.0 | +16.0 |
| 9* | 0 | 0.5 | 1.2 | 2.5 | 3.8 | 5.9 | 9.0 | 12.1 | 13.8 | 16.1 | 22.2 | 22.7 | 23.1 | 23.1 | 23.3 | 22.9 | 23.2 |
| Dgw. | 80 | 79.0 | 77.5 | 74.7 | 71.8 | 66.6 | 58.0 | 48.1 | 41.9 | 32.0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 | 105.0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | + 4.1 | + 4.1 | + ? | + 4.9 | + 4.9 | 8.1 | 14.3 | 19.3 | 23.6 | 27.0 | 29.5 | 31.8 | 33.5 | 35.0 | 36.1 | 37.1 | |
| 3 | + 9.1 | + 9.1 | + 2.6 | + 9.7 | + 8.3 | 1.0 | 5.5 | 9.6 | 14.0 | 17.5 | 20.0 | 22.0 | 24.0 | 25.4 | 26.4 | 27.2 | |
| 6 | +16.0 | +16.0 | +11.1 | +16.0 | +14.3 | +8.4 | + 4.6 | + 1.8 | 1.0 | 4.0 | 6.0 | 8.1 | 9.1 | 11.0 | 11.8 | 12.5 | |
| 9 | 23.2 | 23.2 | 19.9 | 23.1 | 22.9 | 17.5 | 14.7 | 12.6 | 10.7 | 8.3 | 7.1 | 5.4 | 4.4 | 3.6 | 3.0 | 2.3 | |
| Dgw. | 0 | 0 | 13.9 | 0 | 0 | 26.2 | 38.4 | 45.9 | 52.8 | 60.1 | 63.5 | 67.9 | 70.4 | 72.2 | 73.6 | 75.2 | |

Runoff started after 36 mins.
Total volume = 650 ml.

Table 1 c Drainage condition C with rainfall sequence 1

| Soil layer | Time (mins.) 0 | 2.0 | 3.0 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 | 35.0 | 37.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40.8 | 1.7 | 7.5 | 17.0 | 4.6 | 13.4 | 3.7 | 11.0 | 2.4 | 8.6 | + 3.6 | 5.1 | + 3.9 | 2.2 | + 3.9 | + 3.9 | + 4.0 |
| 3 | 30.4 | 10.0 | 8.4 | 9.7 | 6.0 | 6.9 | 4.4 | 5.0 | 1.8 | 2.2 | + 6.8 | 0 | + 6.7 | + 1.5 | + 6.4 | + 6.3 | + 6.3 |
| 6 | 15.3 | 11.2 | 9.2 | 7.3 | 5.6 | 3.0 | ? | + 1.7 | + 2.7 | + 5.1 | +11.6 | + 7.1 | +11.7 | + 8.0 | +11.4 | +11.2 | +11.2 |
| 9* | 0 | 0 | 1.0 | 2.9 | 3.1 | 6.4 | 8.7 | 10.5 | 11.1 | 13.0 | 17.3 | 14.4 | 17.2 | 15.2 | 17.1 | 17.1 | 17.1 |
| Dgw. | 80 | 80 | 77.9 | 73.4 | 72.9 | 62.8 | 53.3 | 43.8 | 40.1 | 25.8 | 0 | 12.1 | 0 | 2.5 | 0 | 0 | 0 |

| | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 91.0 | 96.0 | 100.0 | 105.0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.0 | + 4.1 | + 4.1 | + 4.2 | + 3.9 | 9.0 | 16.7 | 22.4 | 27.0 | 30.4 | 33.0 | 35.1 | 37.0 | 38.0 | 38.6 | 39.2 | |
| 3 | + 1.5 | + 6.8 | + 6.6 | + 6.8 | + 6.7 | 2.3 | ? | 13.1 | 17.5 | 21.0 | 23.5 | 25.4 | 27.0 | 28.0 | 28.5 | 29.0 | |
| 6 | + 6.7 | +11.6 | +11.5 | +11.7 | +11.6 | + 5.0 | + 2.4 | 1.0 | 4.3 | 7.4 | 9.2 | 11.2 | 12.6 | 13.3 | 13.8 | 14.1 | |
| 9 | 14.9 | 17.1 | 17.1 | 17.1 | 17.1 | 13.2 | 11.2 | 9.2 | 7.3 | 5.3 | 4.1 | 3.0 | 1.9 | 1.5 | 1.2 | 0.4 | |
| Dgw. | 6.2 | 0 | 0 | 0 | 0 | 24.1 | 39.4 | 50.9 | 59.4 | 66.6 | 70.2 | 73.0 | 75.9 | 76.8 | 77.5 | 79.2 | |

Runoff started after 35 mins. 30 secs.
Total volume = 220 ml.

Table 2.a Drainage Condition A with rainfall sequence 2

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0. | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.0 | 12.5 | 15.0 | 16.5 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 |
| 1 | 50.0 | 35.3 | 37.0 | 41.9 | 19.2 | 29.1 | 34.5 | 7.1 | 19.1 | 28.3 | 5.6 | 9.5 | 20.2 | 6.9 | 19.2 | 4.3 | 12.7 |
| 3 | 39.8 | 39.2 | 34.5 | 24.3 | 22.2 | 23.5 | 27.2 | 14.0 | 13.8 | 21.4 | 9.1 | 8.1 | 12.7 | 7.0 | 9.0 | 5.0 | 6.2 |
| 6 | 24.6 | 24.6 | 23.8 | 22.1 | 21.4 | 18.2 | 18.2 | 17.4 | 11.8 | 13.5 | 11.2 | 10.0 | 9.3 | 8.5 | 6.7 | 5.5 | 3.9 |
| 10x | 0 | 0 | 0 | 0.3 | 0.5 | 0.7 | 1.5 | 1.7 | 2.2 | 3.5 | 4.0 | 4.7 | 6.2 | 7.9 | 9.2 | 10.7 | 12.4 |
| Dgw. | 100 | 100 | 100 | 98.8 | 98.9 | 98.0 | 96.3 | 95.8 | 94.7 | 91.8 | 89.9 | 88.9 | 85.8 | 81.2 | 77.5 | 72.8 | 67.0 |

| | 32.5 | 35.0 | 37.5 | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.2 | 8.5 | +3.2 | 1.1 | +4.2 | +3.9 | +3.9 | +4.1 | 9.3 | 17.0 | 22.3 | 27.0 | 31.0 | 34.0 | 36.9 | 39.1 | 41.2 | 43.0 |
| 3 | 2.9 | 3.4 | +5.2 | +3.7 | +7.9 | +7.8 | +8.1 | +7.8 | 2.6 | 7.7 | 13.0 | 17.8 | 21.5 | 25.0 | 27.7 | 30.0 | 32.0 | 33.5 |
| 6 | 2.5 | 0 | +8.7 | +11.0 | +14.3 | +14.1 | +14.3 | +14.2 | +5.8 | +2.8 | 1.2 | 4.7 | 8.2 | 11.6 | 14.0 | 16.1 | 18.0 | 19.3 |
| 10 | 14.4 | 15.6 | 9.7 | 25.4 | 27.1 | 27.1 | 27.1 | 27.1 | 21.3 | 18.8 | 16.4 | 13.8 | 11.9 | 9.5 | 8.1 | 6.1 | 4.7 | 3.6 |
| Dgw. | 59.6 | 54.7 | 35.0 | 0 | 0 | 0 | 0 | 0 | 26.7 | 39.7 | 51.2 | 61.8 | 68.8 | 76.5 | 80.7 | 85.8 | 88.9 | 91.5 |

Runoff started after 41 minutes 50 seconds.

Total volume = 1010 ml.

Table 2b: Drainage Condition B with rainfall sequence 2

| Soil | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Layer | 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.0 | 12.5 | 15.0 | 16.5 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 |
| 1 | 40.6 | 24.9 | 29.9 | 33.3 | 10.4 | 22.6 | ? | 5.5 | 15.5 | 26.8 | 7.0 | 9.6 | 16.4 | 5.5 | 11.3 | 1.0 | 7.5 |
| 3 | 30.2 | 29.5 | 26.3 | 26.3 | 12.4 | 14.1 | 20.0 | 11.0 | 9.8 | 15.6 | 7.9 | 7.0 | 8.6 | 4.9 | 5.1 | 1.5 | 6.9 |
| 6 | 15.1 | 15.1 | 14.1 | 13.4 | 12.8 | 10.1 | 10.1 | 9.8 | 7.5 | 6.8 | 6.1 | 5.5 | 4.4 | 3.2 | 1.5 | 0 | +7.0 |
| 9x | 0 | 0 | 0 | 0.6 | 0.6 | 0.9 | 1.8 | 2.2 | 3.2 | 4.0 | 4.8 | 5.3 | 5.8 | 6.7 | 8.3 | 9.4 | 14.2 |
| Dgw. | 80 | 80 | 80 | 78.9 | 78.9 | 78.2 | 78.2 | 75.4 | 73.2 | 71.3 | 69.4 | 68.1 | 66.9 | 64.5 | 59.8 | 56.8 | 40.3 |

| | 32.5 | 35.0 | 37.5 | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | +4.4 | +4.2 | +4.0 | +4.2 | +4.4 | +4.2 | +4.4 | +4.2 | 7.0 | 12.8 | 18.2 | 22.2 | 25.3 | 28.4 | 30.9 | 32.7 | 34.0 | 35.0 |
| 3 | +8.8 | +8.2 | +8.6 | +8.6 | +8.5 | +8.2 | +8.5 | +8.2 | 0.7 | 4.5 | 8.6 | 13.0 | 16.0 | 10.0 | 21.3 | 23.3 | 24.8 | 25.8 |
| 6 | +13.8 | +14.2 | +14.7 | +14.7 | +14.7 | +14.7 | +14.7 | +14.6 | +8.0 | +5.1 | +2.8 | 0 | 2.8 | 5.2 | 7.4 | 9.0 | 10.2 | 11.2 |
| 9 | 20.5 | 21.6 | 22.0 | 22.0 | 22.0 | 21.9 | 21.9 | 22.0 | 16.9 | 14.8 | 13.1 | 10.7 | 9.0 | 7.3 | 5.7 | 4.5 | 3.9 | 3.0 |
| Dgw. | 10.5 | 3.9 | 1.4 | 1.4 | 1.4 | 2.1 | 2.1 | 1.4 | 28.9 | 37.9 | 44.5 | 52.8 | 58.1 | 62.9 | 67.1 | 70.1 | 72.7 | 73.6 |

Runoff started after 36 minutes 30 seconds.

Total volume = 1790 ml.

**Table 2c: Drainage Condition C with rainfall sequence 2**

| Soil Layer | Time (minutes) 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.0 | 12.5 | 15.0 | 16.5 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40.7 | 24.7 | 30.7 | 34.7 | 12.7 | 23.2 | 29.3 | 6.2 | 13.9 | 23.0 | 4.6 | 8.5 | 19.0 | 7.0 | 14.6 | 3.2 | 9.7 |
| 3 | 30.2 | 28.3 | 25.0 | 26.3 | 14.1 | 17.0 | 21.4 | 10.4 | 9.3 | 15.5 | 8.2 | 7.5 | 11.4 | 6.0 | 7.4 | 3.4 | 4.1 |
| 6 | 15.0 | 13.8 | 13.8 | 13.0 | 12.4 | 10.0 | 10.0 | 9.5 | 8.0 | 7.0 | 6.7 | 6.2 | 4.5 | 3.4 | 2.0 | 1.0 | +1.9 |
| 9x | 0 | 0 | 0 | 1.0 | 1.0 | 1.4 | 2.2 | 2.2 | 2.7 | 3.5 | 3.9 | 4.0 | 5.1 | 6.1 | 6.8 | 8.3 | 10.0 |
| Dgw. | 80 | 80 | 80 | 77.9 | 77.9 | 77.0 | 75.2 | 75.2 | 74.2 | 71.9 | 70.8 | 70.5 | 67.2 | 63.9 | 61.3 | 55.1 | 46.7 |

| | 32.5 | 35.0 | 37.5 | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | +1.5 | 6.5 | +4.2 | +5.7 | +4.2 | 0.5 | +4.1 | +3.6 | 10.2 | 18.0 | 23.6 | 28.0 | 31.3 | 33.7 | 35.9 | 37.7 | 38.1 | 38.8 |
| 3 | 0 | 0 | +7.2 | +7.0 | +7.0 | +3.6 | +6.9 | +6.6 | +3.5 | 8.7 | 14.2 | 18.5 | 21.8 | 24.1 | 26.2 | 27.1 | 28.2 | 28.9 |
| 6 | +2.9 | +5.8 | +12.3 | +12.3 | +12.3 | +9.9 | +12.1 | +11.8 | +4.7 | +1.4 | 2.0 | 5.1 | 8.1 | 10.1 | 11.8 | 12.6 | 13.3 | 14.0 |
| 9 | 10.8 | 13.2 | 17.2 | 17.2 | 17.2 | 16.4 | 17.2 | 17.2 | 12.6 | 10.5 | 8.3 | 6.4 | 4.5 | 3.8 | 2.5 | 1.9 | 1.5 | 1.2 |
| Dgw. | 42.0 | 24.0 | 0 | 0 | 0 | 0 | 0 | 0 | 29.2 | 43.8 | 55.1 | 62.8 | 69.0 | 71.6 | 74.4 | 75.9 | 76.8 | 77.5 |

Runoff started after 41 minutes 50 seconds.

Total volume = 1080 ml.

Table 3a : Drainage Condition A with rainfall sequence 3.

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 31.( |
| 1 | 50.0 | 10.2 | +0.5 | 7.9 | +1.7 | +2.4 | 5.0 | +0.9 | +2.7 | 5.6 | +5.1 | +5.1 | +5.2 | +5.1 | +5.1 | +5.1 | +5.1 |
| 3 | 40.0 | 29.3 | 10.0 | 6.0 | 6.0 | 3.6 | 2.4 | 2.6 | 0.4 | 0.8 | +7.4 | +7.4 | +7.4 | +7.1 | +7.1 | +7.1 | +7.1 |
| 6 | 24.8 | 24.8 | 18.0 | 9.0 | 8.0 | 7.0 | 4.6 | 3.6 | 2.3 | +6.0 | +13.7 | +13.7 | +13.7 | +13.2 | +13.4 | +13.4 | +13.4 |
| 10 | 0 | 0 | +0.3 | +1.8 | +2.8 | +3.2 | +7.7 | +8.2 | +10.9 | +18.6 | +24.2 | +24.2 | +24.7 | +25.0 | +25.3 | +25.3 | +25.3 |
| Dgw. | 100 | 100 | 99.0 | 95.8 | 93.6 | 90.4 | 81.8 | 80.4 | 72.1 | 40.8 | 6.2 | 6.2 | 2.4 | 0 | 0 | 0 | 0 |

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 32.5 | 35.0 | 36.0 | 37.5 | 40.0 | 41.0 | 42.5 | 45.0 | 46.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 |
| 1 | +5.1 | +4.1 | +4.1 | +4.1 | 4.2 | 2.0 | 5.5 | 8.9 | 7.5 | 9.5 | 14.0 | 20.4 | 25.3 | 29.5 | 32.8 | 35.7 | 38.1 |
| 3 | +7.1 | +7.6 | +7.6 | +7.6 | +1.6 | +2.0 | 0 | 2.4 | 3.0 | 3.5 | 6.0 | 11.4 | 16.3 | 20.5 | 23.7 | 26.5 | 29.0 |
| 6 | +13.4 | +13.2 | +13.2 | +13.3 | +9.6 | +9.6 | +7.2 | +5.3 | +4.8 | +4.6 | +2.8 | 0 | 4.0 | 7.3 | 10.5 | 13.2 | 15.5 |
| 10 | +25.3 | +25.2 | +25.2 | +25.4 | +23.2 | +22.9 | +22.2 | +20.9 | +20.4 | +20.2 | +20.0 | +16.9 | +14.6 | +12.0 | +10.2 | +8.6 | +6.7 |
| Dgw. | 0 | 0 | 0 | 0 | 13.4 | 15.5 | 20.1 | 28.2 | 31.2 | 32.2 | 38.7 | 48.9 | 58.8 | 68.4 | 74.4 | 79.2 | 84.5 |

| Soil Layer | Time (minutes) | | | |
|---|---|---|---|---|
| | 85.0 | 90.0 | 95.0 | 100.0 |
| 1 | 40.3 | 41.9 | 43.5 | 44.5 |
| 3 | 31.1 | 32.7 | 34.1 | 35.0 |
| 6 | 17.4 | 18.8 | 20.4 | 21.1 |
| 10 | +5.0 | +4.0 | +2.8 | +2.4 |
| Dgw. | 88.9 | 90.8 | 93.4 | 94.5 |

Runoff started after 11 mins. 30 secs.

Total volume = 510 ml.

Table 3b : Drainage condition B with rainfall sequence 3

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 1.5 | 5.0 | 6.0 | 7.5 | 10.0 | 12.5 | 15.0 | 16.5 | 17.5 | 20.0 | 22.5 | 25.0 | 26.0 | 21.5 | 30.0 | 31.0 |
| 1 | 40.2 | 15.4 | 1.2 | 7.3 | +1.6 | +2.7 | 3.6 | +4.6 | +4.6 | +4.6 | +4.6 | +4.0 | +4.2 | +3.9 | +3.9 | +3.9 | +4.2 | +4.4 |
| 3 | 30.0 | 29.3 | 12.0 | 5.0 | 4.7 | 1.5 | 0.4 | +9.3 | +9.3 | +9.3 | +9.3 | +8.2 | +8.7 | +8.6 | +8.6 | +8.6 | +7.6 | +8.7 |
| 6 | 4.8 | 4.8 | 12.7 | 6.9 | 5.7 | 4.4 | 0.5 | +14.2 | +14.2 | +14.5 | +14.5 | +15.2 | +15.6 | +15.5 | +15.5 | +15.7 | +15.5 | +15.6 |
| 9 | 0 | 0 | 0 | +1.7 | +3.1 | +4.8 | +8.4 | +20.1 | +20.1 | +20.1 | +20.1 | +21.4 | +21.9 | +22.1 | +22.1 | +22.1 | +22.1 | +22.3 |
| Dgw | 80 | 80 | 80 | 76.5 | 73.4 | 69.4 | 59.8 | 12.8 | 12.8 | 12.8 | 12.8 | 4.6 | 2.1 | 0.8 | 0.8 | 0.8 | 0.8 | 0 |

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 32.5 | 35.0 | 36.0 | 37.5 | 40.0 | 41.0 | 42.5 | 45.0 | 46.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 85.0 |
| 1 | +4.4 | +4.2 | +4.2 | +4.2 | +4.1 | +4.1 | +4.1 | 5.0 | 5.5 | 7.5 | 9.7 | 15.8 | 20.3 | 24.0 | 27.4 | 29.8 | 33.5 |
| 3 | +8.7 | +8.6 | +8.6 | +8.6 | +8.5 | +8.5 | +8.5 | +2.4 | +0.5 | 0.9 | 3.0 | 7.0 | 11.0 | 14.6 | 18.0 | 20.3 | 34.0 |
| 6 | +15.6 | +15.5 | +15.5 | +15.5 | +15.5 | +15.6 | +15.6 | +10.0 | +9.2 | +8.5 | +6.7 | +3.7 | +1.2 | 1.7 | 4.4 | 6.2 | 9.5 |
| 9 | +22.3 | +22.2 | +22.4 | +22.4 | +22.3 | +22.3 | +22.3 | +18.3 | +17.6 | +16.9 | +15.6 | +13.3 | +11.2 | +9.4 | +7.5 | +6.1 | +4.1 |
| Dgw | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 22.3 | 25.7 | 24.8 | 34.7 | 43.8 | 51.1 | 56.8 | 62.4 | 66.1 | 71.1 |

| Soil Layer | Time(minutes) | | |
|---|---|---|---|
| | 90.0 | 95.0 | 100.0 |
| 1 | 34.8 | 35.9 | 36.8 |
| 3 | 25.2 | 26.2 | 27.0 |
| 6 | 10.6 | 11.7 | 12.3 |
| 9 | 3.7 | 3.0 | 2.6 |
| Dgw | 73.2 | 75.2 | 76.1 |

Runoff started after 15 mins. 45 seconds

Total volume = 940 ml.

Table 3c : Drainage condition C with rainfall sequence 3

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.0 | 12.5 | 15.0 | 16.5 | 17.5 | 20.0 | 22.5 | 25.0 | 26.0 | 27.5 | 30.0 |
| 1 | 40.2 | 9.0 | +1.7 | 6.4 | +1.9 | +2.4 | +3.2 | +2.8 | +4.2 | +4.2 | +4.3 | +4.3 | 0.5 | 4.3 | 4.1 | 4.1 | 4.1 | 0.3 |
| 3 | 30.0 | 28.0 | 9.0 | 5.3 | 5.3 | 2.5 | 0.4 | 0 | +7.2 | +6.9 | +6.9 | +6.9 | +3.3 | +7.2 | +7.2 | +7.2 | +7.2 | ? |
| 6 | 15.0 | 15.0 | 9.8 | 7.7 | 5.8 | 4.2 | 0 | 0 | +10.7 | +10.7 | +10.7 | +11.2 | +8.8 | +11.4 | +11.2 | +11.2 | +11.2 | +8.9 |
| 9 | 0 | 0 | 0 | +2.1 | +2.9 | +4.2 | +6.9 | +7.9 | +14.4 | +14.9 | +14.9 | +14.9 | +14.6 | +15.2 | +15.2 | +15.2 | +15.2 | +14.0 |
| Dgw | 80 | 80 | 80 | 75.4 | 73.4 | 69.3 | 60.9 | 56.9 | 12.1 | 6.2 | 6.2 | 6.2 | 9.8 | 2.4 | 2.4 | 2.4 | 2.4 | 16.4 |

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 31.0 | 32.5 | 35.0 | 36.0 | 37.5 | 40.0 | 41.0 | 42.5 | 45.0 | 46.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 |
| 1 | 4.1 | 4.1 | 2.9 | 4.0 | 4.0 | 6.0 | 3.6 | 6.5 | 9.5 | 8.0 | 10.5 | 14.0 | 20.7 | 25.1 | 28.5 | 31.5 | 33.6 | 35.4 |
| 3 | 7.2 | 7.2 | +1.5 | +6.4 | +6.4 | 0 | 0.6 | 1.0 | 3.5 | 4.0 | 4.5 | 6.5 | 12.0 | 16.3 | 19.5 | 22.0 | 24.3 | 26.0 |
| 6 | +11.2 | +11.1 | +7.3 | +10.3 | +10.3 | +6.2 | +6.2 | +5.5 | +4.2 | +3.4 | +2.8 | +2.3 | 0.3 | 3.6 | 6.0 | 8.7 | 10.3 | 11.7 |
| 9 | +15.2 | +15.2 | +13.1 | +14.9 | +15.0 | +12.3 | +12.2 | +12.0 | +10.9 | +10.8 | +10.2 | +9.9 | +8.4 | +6.7 | +5.2 | +3.7 | +2.8 | +2.2 |
| Dgw | 2.4 | 2.4 | 25.0 | 6.2 | 5.0 | 31.6 | 32.3 | 33.8 | 41.3 | 42.0 | 45.5 | 47.2 | 55.1 | 61.7 | 66.9 | 71.3 | 73.7 | 75.2 |

| Soil Layer | Time (minutes) | | | | |
|---|---|---|---|---|---|
| | 85.0 | 90.0 | 95.0 | 100.0 | |
| 1 | 36.6 | 37.6 | 38.3 | 38.8 | |
| 3 | 27.0 | 27.7 | 28.4 | 28.9 | |
| 6 | 12.8 | 13.3 | 13.8 | 14.2 | |
| 9 | +1.4 | +1.1 | +0.9 | +0.7 | |
| Dgw | 77.0 | 77.9 | 79.1 | 79.6 | |

Time Runoff started and volume were not recorded

Table 4a Drainage condition A with rainfall sequence 4

| Soil layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.5 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 |
| 1 | 50.0 | 23.0 | 34.6 | 39.9 | 6.3 | 17.1 | 48.1 | 0.7 | 6.4 | 15.2 | + 0.6 | 9.0 | + 2.2 | 4.8 | + 3.9 | + 4.0 | + 4.2 |
| 3 | 40.0 | 38.5 | 31.7 | 32.3 | 18.2 | 14.0 | 21.2 | 9.5 | 7.5 | 9.0 | 5.8 | 5.8 | 3.0 | 1.8 | + 7.6 | + 7.7 | + 8.0 |
| 6 | 24.9 | 24.5 | 23.3 | 21.5 | 21.0 | 13.5 | 13.5 | 11.5 | 9.9 | 8.5 | 7.3 | 5.5 | 3.8 | 1.0 | +13.7 | +14.0 | +14.1 |
| 10 | 0 | 0 | 0 | + 0.2 | + 0.2 | + 0.8 | + 2.6 | + 3.3 | + 3.6 | + 4.8 | + 7.7 | + 9.9 | +11.8 | +15.6 | +26.1 | +26.8 | +27.1 |
| Dgw. | 100 | 100 | 100 | 99.6 | 99.6 | 98.4 | 94.5 | 92.9 | 92.2 | 89.4 | 81.8 | 75.3 | 69.1 | 54.7 | 0 | 0 | 0 |

| | 35.0 | 36.5 | 40.0 | 42.5 | 45.0 | 46.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.8 | + 4.3 | + 4.1 | + 4.1 | 4.8 | 5.5 | 7.5 | 11.3 | 17.9 | 23.2 | 27.8 | 31.6 | 34.6 | 37.3 | 40.0 | 41.7 | 43.5 | 44.5 |
| 3 | + 3.9 | + 7.3 | + 7.7 | + 7.7 | + 1.2 | 0 | 1.2 | 3.5 | 8.5 | 14.0 | 18.4 | 22.0 | 25.3 | 28.0 | 30.0 | 32.0 | 33.8 | 34.8 |
| 6 | +11.5 | +14.2 | +14.0 | +14.0 | + 8.7 | + 7.7 | + 6.8 | + 5.2 | + 1.6 | 2.1 | 5.5 | 8.7 | 12.0 | 14.3 | 16.5 | 18.1 | 19.9 | 20.5 |
| 10 | +26.0 | +27.0 | +27.0 | +27.0 | +23.4 | +22.6 | +22.1 | +20.7 | +18.2 | +15.8 | +13.5 | +11.4 | + 9.3 | + 7.8 | + 6.2 | 4.8 | + 3.3 | + 2.6 |
| Dgw. | 0 | 0 | 0 | 0 | 12.0 | 17.5 | 20.8 | 29.4 | 42.8 | 53.8 | 63.0 | 70.5 | 77.1 | 81.5 | 85.8 | 88.9 | 92.9 | 94.5 |

Runoff started after 26 mins. 45 secs.
Total volume = 700 ml.

Table 4b Drainage condition B with rainfall sequence 4

| Soil layer | 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.5 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40.1 | 15.7 | 27.8 | 32.6 | 5.6 | 12.6 | 23.1 | 0 | 6.3 | 15.7 | + 1.7 | 8.7 | + 3.9 | + 4.2 | + 4.5 | + 4.2 | + 4.4 |
| 3 | 30.0 | 27.1 | 21.5 | 24.5 | 12.0 | 9.0 | 16.3 | 9.0 | 7.0 | 8.5 | 3.8 | 3.7 | + 8.0 | + 8.6 | + 9.0 | + 8.7 | + 8.8 |
| 6 | 15.0 | 15.0 | 12.5 | 12.1 | 11.0 | 8.9 | 0.6 | 7.0 | 6.0 | 3.9 | 1.3 | + 3.0 | +14.9 | +16.1 | +16.3 | +16.3 | +16.4 |
| 9 | 0 | 0 | +0.5 | + 1.0 | + 1.4 | + 2.2 | + 3.6 | + 4.5 | + 5.3 | + 7.1 | + 9.4 | +13.1 | +21.6 | +23.3 | +23.5 | +23.4 | +23.5 |
| Dgw. | 80 | 80 | 78.6 | 77.5 | 77.1 | 75.0 | 71.8 | 69.6 | 67.6 | 62.9 | 56.2 | 43.8 | 2.7 | 0 | 0 | 0 | 0 |

| | 35.0 | 36.5 | 40.0 | 42.5 | 45.0 | 46.0 | 41.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | + 4.2 | + 4.4 | + 4.2 | + 4.2 | 1.1 | 3.6 | 6.0 | 8.8 | 14.9 | 20.0 | 24.0 | 27.1 | 29.6 | 31.8 | 33.5 | 34.9 | 36.0 | 37.0 |
| 3 | + 8.8 | + 9.2 | + 9.0 | + 9.0 | + 4.7 | + 2.7 | + 1.2 | 1.5 | 6.0 | 10.5 | 14.3 | 17.6 | 20.0 | 22.0 | 23.8 | 25.0 | 26.0 | 26.8 |
| 6 | +16.4 | +16.4 | +16.5 | +16.5 | +13.5 | +11.4 | + 9.8 | + 8.2 | + 4.7 | + 1.6 | 1.3 | 4.0 | 6.0 | 8.0 | 9.4 | 10.5 | 11.4 | 12.2 |
| 9 | +23.5 | +23.6 | +23.6 | +23.6 | +21.6 | +19.9 | +18.7 | +17.4 | +14.7 | +12.3 | +10.2 | + 8.3 | + 7.1 | + 5.6 | + 4.5 | + 3.7 | + 3.1 | +2.5 |
| Dgw. | 0 | 0 | 0 | 0 | 2.7 | 12.8 | 19.2 | 25.7 | 37.5 | 46.7 | 53.7 | 59.5 | 62.9 | 66.9 | 69.6 | 71.8 | 72.9 | 74.3 |

Runoff started after 26 minutes.
Total volume = 1210 ml.

Table 4c Drainage condition C with rainfall sequence 4

| Soil layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 6.0 | 7.5 | 10.0 | 11.5 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 |
| 1 | 40.3 | 19.0 | 28.0 | 33.2 | 5.0 | 12.8 | 23.4 | 0.4 | 6.1 | 14.8 | 0 | 8.7 | + 1.9 | 0 | + 4.2 | + 3.8 | + 4.2 |
| 3 | 30.0 | 28.0 | 22.5 | 25.0 | 12.0 | 9.0 | 16.4 | 8.5 | 6.8 | 8.0 | 4.0 | 4.4 | 0.7 | + 4.1 | + 7.3 | + 7.1 | + 7.2 |
| 6 | 14.8 | 14.7 | 13.1 | 12.3 | 11.0 | 8.5 | 7.7 | 7.0 | 6.5 | 4.7 | 3.0 | 0 | + 4.0 | +10.7 | +12.4 | +12.3 | +12.3 |
| 9 | 0 | 0 | 0 | + 0.6 | + 0.6 | + 1.1 | + 2.4 | + 2.9 | + 4.3 | + 5.0 | + 5.9 | + 8.1 | +10.2 | +15.9 | +16.3 | +16.4 | +16.4 |
| Dgw | 80 | 80 | 80 | 78.7 | 78.7 | 77.6 | 74.7 | 73.4 | 69.6 | 67.5 | 61.2 | 56.0 | 45.5 | 0 | 0 | 0 | 0 |

| | 35.0 | 37.0 | 40.0 | 42.5 | 45.0 | 46.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 96.0 | 100.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.2 | + 4.2 | + 3.7 | + 3.7 | 5.5 | 6.2 | 8.2 | 12.5 | 18.8 | 24.0 | 28.0 | 31.1 | 33.8 | 35.5 | 37.0 | 37.8 | 38.8 | 39.0 |
| 3 | + 2.9 | + 6.8 | + 7.0 | + 7.0 | 0 | 0.4 | 2.0 | 4.4 | 9.3 | 14.5 | 18.5 | 21.5 | 23.8 | 25.7 | 27.0 | 27.9 | 28.5 | 29.0 |
| 6 | + 9.8 | +12.1 | +12.1 | +12.1 | + 9.3 | + 8.9 | + 5.5 | + 4.2 | + 1.2 | 2.3 | 5.1 | 8.0 | 9.7 | 11.5 | 12.4 | 13.2 | 13.7 | 14.0 |
| 9 | +15.2 | +16.2 | +16.3 | +16.3 | +13.3 | +13.1 | +12.3 | +11.3 | + 9.4 | + 7.4 | + 5.9 | + 4.1 | + 3.3 | + 2.3 | + 1.6 | + 1.1 | + 0.7 | +0.6 |
| Dgw | 2.4 | 0 | 0 | 0 | 23.2 | 25.0 | 31.6 | 38.8 | 49.9 | 59.0 | 64.6 | 70.2 | 72.4 | 74.9 | 76.1 | 77.6 | 78.6 | 78.8 |

Runoff started after 26 mins. 30 secs.
Total volume = 760+ ml.

Table 5a : Drainage condition A with rainfall sequence 5

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 7.5 | 10 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 26.0 | 28.0 | 30.0 | 31.5 | 35.0 |
| 1 | 50.0 | 11.3 | +0.3 | 8.5 | +2.2 | 7.5 | 2.9 | 8.9 | 6.0 | 12.2 | 12.2 | 16.0 | 11.0 | 17.8 | 20.7 | 6.7 | 17.8 |
| 3 | 40.0 | 38.5 | 12.0 | 7.0 | 4.5 | 4.8 | 3.0 | 4.8 | 4.0 | 5.5 | 5.8 | 8.1 | 8.1 | 9.5 | 12.2 | 8.7 | 10.0 |
| 6 | 24.9 | 24.9 | 19.0 | 9.0 | 7.5 | 5.5 | 4.0 | 2.0 | 0 | +2.2 | +1.9 | +1.2 | +0.7 | +0.3 | 1.0 | 1.9 | 1.9 |
| 10 | 0 | 0 | 0 | +1.8 | +4.0 | +2.7 | +0.3 | +3.9 | +14.6 | +18.0 | +18.0 | +17.6 | +17.3 | +16.7 | +16.4 | +15.7 | +15.6 |
| Dgw | 100 | 100 | 100 | 96.3 | 91.3 | 83.4 | 74.1 | 61.5 | 50.3 | 43.8 | 43.8 | 45.7 | 47.1 | 49.8 | 51.2 | 54.2 | 54.7 |

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 37.5 | 40.0 | 42.0 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
| 1 | 4.8 | 12.0 | +2.2 | 7.0 | +4.2 | +4.0 | 8.5 | 15.2 | 21.7 | 26.4 | 30.5 | 33.7 | 36.6 | 39.0 | 41.1 | 42.7 |
| 3 | 5.5 | 6.0 | 3.5 | 2.3 | +7.2 | +7.2 | 2.1 | 7.0 | 12.6 | 17.3 | 21.2 | 24.7 | 27.3 | 29.8 | 31.5 | 33.1 |
| 6 | 1.9 | 0.8 | 0 | +4.8 | +13.4 | +13.4 | +5.7 | +2.8 | 1.0 | 4.6 | 8.1 | 11.3 | 13.6 | 16.1 | 17.8 | 19.0 |
| 10 | +15.6 | +16.0 | +16.4 | +19.7 | +26.0 | +26.3 | +4.0 | +18.8 | +16.5 | +14.0 | +11.9 | +9.7 | +8.3 | +6.2 | +4.8 | +3.6 |
| Dgw | 54.7 | 52.9 | 51.2 | 35.0 | 0 | 0 | 27.6 | 39.7 | 50.7 | 61.1 | 68.7 | 75.9 | 78.6 | 85.8 | 89.9 | 92.2 |

Runoff started after 46 mins. 45 secs.

total volume = 256 ml.

Table 5b : Drainage condition B with rainfall sequence 5

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 23.5 | 25.0 | 26.0 | 27.5 | 30.0 | 31.0 | 32.5 |
| 1 | 40.2 | 8.8 | +1.2 | 7.3 | +3.0 | 6.0 | +2.6 | 2.0 | +4.0 | 2.2 | 6.0 | 7.8 | 6.3 | 8.0 | 11.1 | ? | 6.3 |
| 3 | 30.0 | 28.0 | 9.1 | 5.8 | 2.7 | 2.5 | +7.2 | +? | +? | +? | 0 | 1.0 | 1.5 | 2.0 | 8.0 | ? | 2.6 |
| 6 | 15.0 | 15.0 | 10.8 | 6.3 | 3.8 | +0.7 | +12.7 | +11.2 | +14.7 | +? | +8.5 | +8.1 | +7.6 | +7.2 | +6.0 | +5.8 | +6.0 |
| 9 | 0 | 0 | +0.1 | +2.5 | +5.8 | +9.4 | +16.8 | +18.4 | +20.7 | +18.4 | +16.1 | +15.6 | +15.6 | ? | +14.3 | +14.1 | +14.3 |
| Dgw | 80 | 80 | 79.8 | 74.7 | 66.9 | 56.8 | 30.3 | 21.8 | 9.4 | 21.8 | 32.5 | 35.5 | 35.5 | ? | 40.0 | 40.7 | 40.0 |

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35.0 | 37.5 | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
| 1 | 9.3 | +4.0 | 4.0 | +4.4 | +4.3 | +4.4 | +4.2 | 7.8 | 13.2 | 18.3 | 22.3 | 25.6 | 28.5 | 30.8 | 32.5 | 33.9 | 35.0 |
| 3 | 3.4 | +8.0 | +2.2 | +8.2 | +8.2 | +8.5 | +8.2 | 1.0 | 5.2 | 9.0 | 13.3 | 16.6 | 19.2 | 21.0 | 23.0 | 24.5 | 25.7 |
| 6 | +5.9 | +14.9 | +10.6 | +15.4 | +15.4 | +15.8 | +15.8 | +8.5 | +5.4 | +2.5 | 0.3 | 3.1 | 5.3 | 7.3 | 8.8 | 10.0 | 11.1 |
| 9 | +14.4 | +20.4 | +17.8 | +21.1 | +20.9 | +22.2 | +22.2 | +17.1 | +14.6 | +12.6 | +10.6 | +8.5 | +7.1 | +5.5 | +4.3 | +3.7 | +2.9 |
| Dgw | 39.6 | 11.2 | 24.7 | 7.0 | 8.2 | 0.1 | 0.1 | 28.0 | 38.8 | 46.3 | 53.1 | 59.5 | 63.5 | 67.6 | 70.6 | 72.0 | 73.8 |

Runoff started after 42 mins.

total volume = 790 ml.

Table 5c : Drainage condition C with rainfall sequence 5

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.5 | 2.0 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 26.0 | 27.5 | 30.0 | 31.0 | 32.5 |
| 1 | 40.2 | 9.7 | +1.5 | 7.5 | +2.3 | 6.2 | +3.1 | 6.0 | 1.0 | 6.6 | 8.0 | 12.0 | 8.8 | 12.5 | 6.3 | 3.9 | 8.9 |
| 3 | 30.0 | 29.1 | 9.3 | 5.8 | 2.5 | 3.0 | +5.5 | +4.2 | +2.8 | 0.7 | 3.0 | 4.5 | 5.0 | 5.7 | 8.0 | 7.3 | 6.2 |
| 6 | 14.8 | 14.8 | 10.0 | 6.4 | 4.0 | 0.3 | +8.2 | +6.7 | +9.1 | +6.4 | +4.8 | +4.5 | +3.1 | +2.8 | +1.6 | +1.2 | +0.5 |
| 9 | 0 | 0 | +0.5 | +2.2 | +4.5 | +7.9 | +11.6 | +12.8 | +14.8 | +12.7 | +11.8 | +10.9 | +10.5 | +10.4 | +9.7 | +9.2 | +9.1 |
| Dgw | 80 | 80 | 79.0 | 75.2 | 69.0 | 57.3 | 36.7 | 27.5 | 7.5 | 28.4 | 35.3 | 41.3 | 43.8 | 45.0 | 48.3 | 51.0 | 51.4 |

| Soil Layer | Time (minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35.0 | 37.5 | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
| 1 | 14.5 | 3.9 | 9.2 | +2.7 | 5.0 | +4.2 | +3.9 | 9.3 | 16.7 | 22.2 | 26.5 | 30.0 | 32.7 | 34.5 | 36.0 | 37.2 | 38.0 |
| 3 | 7.5 | 3.6 | 4.3 | 0.5 | 0 | +6.8 | +6.5 | 3.3 | 8.0 | 13.3 | 17.6 | 21.0 | 23.3 | 25.3 | 26.5 | 27.5 | 28.1 |
| 6 | +0.5 | +0.5 | +3.1 | +3.7 | +6.8 | +11.7 | +11.5 | +4.8 | +1.9 | 1.5 | 4.5 | 7.5 | 9.3 | 11.2 | 12.3 | 13.0 | 13.6 |
| 9 | +9.2 | +9.2 | +9.8 | +10.1 | +12.7 | +16.0 | +16.0 | +11.8 | +9.9 | +7.9 | +6.2 | +4.3 | +3.4 | +2.2 | +1.5 | +1.1 | +0.7 |
| Dgw | 51.0 | 51.0 | 47.8 | 46.1 | 28.4 | 0 | 0 | 35.3 | 47.2 | 56.9 | 63.5 | 69.6 | 71.6 | 75.2 | 76.8 | 77.7 | 78.6 |

Runoff started after 47 minutes

total volume = 415 ml.

Table 6a: Drainage Condition A with Jakarta rainfall of December, 1938

| | Time (minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vessel | 0 | 2.5 | 5.0 | 7.5 | 0.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 | 35.0 | 37.5 |
| 1 | 50.0 | 50.0 | 50.0 | 45.5 | - | 37.4 | 41.0 | .0.0 | .+2.2 | 7.0 | 14.0 | 5.0 | 12.7 | 13.9 | 10.7 | 08.2 |
| 3 | 40.0 | 40.0 | 40.0 | 39.0 | 38.6 | 32.8 | 33.6 | .9.5 | 3.7 | 4.0. | 7.9 | 6.0 | 7.0 | 7.3 | 10.0 | 13.7 |
| 6 | 24.8 | 24.8 | 24.8 | 24.5 | 24.3 | 22.9 | 21.7 | 12.8 | 8.6 | 6.2 | 6.4 | 4.0 | 2.4 | 1.3 | 1.0 | 0.0 |
| 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.4 | 0.8 | 2.5 | 4.5 | 8.3 | 11.3 | 13.0 | 15.4 | 15.7 | 17.4 |
| Sum | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 99.4 | 99.2 | 99.4 | 94.7 | 90.1 | 90.1 | 70.3 | 61.0 | 55.6 | 54.2 | 55.3 |
| | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 52.5 | 55.0 | 57.5 | 60.0 | 62.5 | 65.0 | 67.5 | 70.0 | 72.5 | 75.0 | 77.5 |
| 1 | 24.7 | 5.3 | - | 21.5 | 25.3 | 20.0 | 30.1 | 29.3 | 32.0 | 32.3 | 34.2 | 21.0 | 20.8 | 26.8 | 31.9 | 34.5 |
| 3 | 15.8 | 0.0 | 9.9 | 13.5 | 15.6 | 10.7 | 21.0 | 21.0 | 22.7 | 23.7 | 25.5 | 15.5 | 21.2 | 20.0 | 25.5 | 25.7 |
| 6 | 7.6 | 4.0 | 3.2 | 3.3 | 4.5 | 6.0 | 7.9 | 9.2 | 9.8 | 11.4 | 12.5 | 10.0 | 11.1 | 11.9 | 12.3 | 13.3 |
| 10 | 14.3 | 3.8 | 14.1 | 14.2 | 13.9 | 12.9 | 12.0 | 11.2 | 10.2 | 9.3 | 8.7 | 8.3 | 8.5 | 8.5 | 8.4 | 7.8 |
| Sum | 62.4 | 13.1 | 69.7 | 60.3 | 61.5 | 65.2 | 60.4 | 71.1 | 74.4 | 77.2 | 78.0 | 60.1 | 70.6 | 73.5 | 78.0 | 81.5 |
| | 80.0 | 82.5 | 85.0 | 87.5 | 90.0 | 92.5 | 95.0 | 97.5 | 100.0 | 102.5 | 105.0 | 107.5 | 110.0 | 112.5 | 115.0 | 117.5 |
| 1 | 33.3 | 29.3 | 33.2 | 36.1 | 31.0 | 30.8 | 41.0 | 41.7 | 42.5 | 43.2 | 44.0 | 44.6 | 44.6 | + 1.5 | 6.6 | 9.2 |
| 3 | 27.3 | 23.2 | 25.5 | 27.7 | 29.2 | 30.2 | 31.5 | 32.4 | 33.0 | 33.6 | 34.5 | 35.0 | 35.5 | 11.2 | 6.2 | 5.5 |
| 6 | 14.3 | 14.0 | 14.5 | 15.5 | 16.3 | 17.3 | 18.1 | 18.7 | 19.3 | 20.0 | 20.6 | 21.0 | 21.4 | 16.6 | 9.1 | 7.3 |
| 10 | 7.4 | 6.6 | 6.8 | 6.2 | 5.7 | 5.0 | 5.0 | 3.8 | 3.3 | 3.0 | 2.6 | 2.2 | 2.0 | 1.8 | 3.0 | 6.2 |
| Sum | 82.3 | 73.3 | 80.0 | 85.5 | 82.2 | 83.3 | 95.6 | 96.6 | 98.1 | 99.8 | 101.7 | 102.8 | 103.5 | 90.1 | 84.9 | 88.2 |
| | 120.0 | 122.5 | 125.0 | 127.5 | 130.0 | 132.5 | 135.0 | 137.5 | 140.0 | 142.5 | 145.0 | 147.5 | 150.0 | 152.5 | 155.0 | 157.5 |
| 1 | 13.0 | 20.3 | 25.4 | 20.2 | 31.0 | 14.3 | 24.0 | 25.3 | 29.6 | + 1.7 | 8.2 | 1.0 | 9.3 | + 2.3 | + 4.3 | 8.3 |
| 3 | 5.0 | 15.0 | 17.3 | 20.0 | 22.0 | 11.0 | 15.0 | 19.0 | 21.7 | 8.5 | 6.6 | 4.1 | 5.4 | 2.5 | + 7.6 | 1.4 |
| 6 | 5.6 | 5.0 | 6.1 | 6.0 | 3.0 | 3.0 | 0.0 | 8.6 | 9.7 | 3.0 | 6.0 | 4.7 | 2.2 | 0 | + 14.0 | + 7.3 |
| 10 | 8.7 | 11.0 | 11.0 | 11.0 | 11.1 | 10.4 | 10.4 | 10.4 | 10.1 | 9.7 | 10.8 | 11.7 | 14.6 | 16.6 | 22.0 | 22.8 |
| Sum | 72.3 | 69.3 | 60.0 | 69.1 | 71.5 | 73.7 | 73.7 | 75.7 | 74.7 | 75.0 | 74.1 | 71.1 | 70.3 | 80.7 | 0 | 60.1 |
| | 160.0 | 162.5 | 165.0 | 167.5 | 170.0 | 172.5 | 175.0 | 177.5 | 180.0 | 182.5 | 185.0 | 187.5 | 190.0 | 192.5 | 195.0 | 197.5 |
| 1 | 44.0 | 31.3 | 26.3 | 33.3 | 37.0 | 33.3 | 38.2 | 41.2 | 42.8 | 44.2 | 45.2 | 47.3 | 47.8 | 48.4 | 48.2 | |
| 3 | 8.6 | 12.3 | 17.0 | 21.7 | 24.5 | 27.3 | 29.5 | 31.6 | 43.0 | 34.5 | 36.4 | 37.8 | 38.7 | 39.3 | 39.8 | |
| 6 | -1.5 | 0.3 | 4.3 | 8.0 | 11.1 | 13.5 | 16.2 | 18.0 | 19.3 | 20.6 | 22.0 | 23.1 | 23.7 | 24.8 | 24.5 | |
| 10 | 11.1 | 12.4 | 14.2 | 16.1 | 8.0 | 6.5 | 6.3 | 5.0 | 3.6 | 2.7 | 1.6 | 0.8 | 0.5 | 0.3 | 0.1 | |
| Sum | 21.2 | 10.4 | 59.0 | 69.1 | 78.3 | 79.5 | 85.6 | 90.0 | 92.2 | 94.3 | 96.7 | 97.6 | 99.0 | 99.4 | 99.1 | |

Table for Drainage Condition B with J knots method 21 of December, 1930.

| Depth | Time(Minutes) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2.5 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 | 35.0 | 37.5 |
| 1 | 41.7 | 40.3 | 40.3 | 39. | 37.1 | 36.1 | 35.4 | +1.7 | +1.7 | 7.0 | 13.0 | 5.0 | 0.5 | 0.0 | 12.5 | 13.0 |
| 2 | 30.0 | 30.0 | 30.0 | 27.5 | 27.8 | 23.0 | 24.6 | 7.7 | 2.5 | 3.0 | 5.4 | 3.5 | 2.5 | 2.5 | 4.0 | 5.0 |
| 3 | 15.1 | 15.1 | 15.1 | 14.1 | 14.0 | 12.6 | 12.3 | 8.9 | 5.9 | 1.6 | +4.3 | +5.7 | +7.4 | +7.3 | -6.4 | - 4.9 |
| 4* | 0 | 0 | 0 | 0 | 0 | 0.7 | 0.9 | 2.0 | 3.4 | 3.2 | 13.5 | 14.7 | 16.3 | 16.3 | 15.3 | 14.5 |
| D- | 30.0 | 30.0 | 30.0 | 69.0 | 69.0 | 72.6 | 73.2 | 75.0 | 72.7 | 37.5 | 41.5 | 38.4 | 31.4 | 31.5 | 33.4 | 33.0 |
| | 42.5 | 42.5 | 45.0 | 47.5 | 50.0 | 52.5 | 55.0 | 57.5 | 60.0 | 62.5 | 65.0 | 67.5 | 70.0 | 72.5 | 75.0 | 77.5 |
| 1 | 17.8 | 9.3 | 13.1 | 15.0 | 16.0 | 20.0 | 22.0 | 20.0 | 23.5 | 24.2 | 26.2 | 14.5 | 22.0 | 21.3 | 29.2 | 27.4 |
| 2 | 3.7 | 4.4 | 5.1 | 6.5 | 8.5 | 10.5 | 12.6 | 12.3 | 14.2 | 15.2 | 16.8 | 9.3 | 14.3 | 13.5 | 15.2 | 13.0 |
| 3 | + 3.8 | +4.3 | +4.5 | +4.3 | + 3.2 | +1.7 | +1.2 | 0.8 | 1.9 | 2.7 | 3.6 | 3.5 | 2.8 | 2.8 | 3.5 | 4.5 |
| 4 | 15.7 | 15.7 | 14.2 | 14.1 | 17.4 | 12.2 | 10.9 | 10.7 | 7.0 | 9.2 | 9.2 | 8.0 | 8.5 | 8.6 | 6.4 | 3.9 |
| D- | 40.3 | 40.3 | 40.3 | 40.7 | 47.3 | 47.7 | 52.1 | 52.8 | 63.7 | 57.5 | 60.4 | 60.3 | 58.5 | 58.2 | 59.4 | 59.3 |
| | 77.5 | 80.0 | 82.5 | 85.0 | 87.5 | 90.0 | 92.5 | 95.0 | 97.5 | 100.0 | 102.5 | 105.0 | 107.5 | 110.0 | 112.5 | 115.0 | 117.5 |
| 1 | 27.7 | 33.3 | 27.2 | 29.2 | 30.7 | 31.8 | 32.8 | 33.6 | 34.2 | 35.0 | 35.6 | 36.1 | 36.5 | +1.5 | 5.2 | 5.2 |
| 2 | 19.3 | 16.0 | 18.2 | 19.9 | 21.0 | 22.0 | 23.0 | 23.7 | 24.3 | 25.0 | 25.6 | 26.1 | 26.5 | 8.5 | 4.0 | 2.8 |
| 3 | 8.3 | 5.7 | 5.6 | 6.2 | 7.3 | 8.1 | 8.9 | 9.6 | 10.1 | 10.6 | 11.5 | 11.7 | 12.0 | 8.1 | 5.0 | 0.5 |
| 4 | 7.4 | 6.9 | 6.9 | 6.6 | 5.9 | 5.2 | 4.6 | 4.2 | 3.9 | 3.6 | 3.2 | 2.9 | 2.6 | 2.9 | 4.9 | 10.3 |
| D- | 61.3 | 64.0 | 64.0 | 64.9 | 66.6 | 68.4 | 69.9 | 70.8 | 71.5 | 72.2 | 73.2 | 74.3 | 74.5 | 74.9 | 69.1 | 55.0 |
| | 130.0 | 132.5 | 135.0 | 137.5 | 140.0 | 142.5 | 145.0 | 147.5 | 150.0 | 152.5 | 155.0 | 157.5 | 160.0 | 162.5 | 165.0 | 167.5 |
| 1 | 11.5 | 14.1 | 17.4 | 18.4 | 21.5 | 12.7 | 18.2 | 19.3 | 22.2 | +1.2 | 8.5 | +3.7 | 7.9 | +4.3 | +4.3 | +4.1 |
| 2 | 4.3 | 5.7 | 8.0 | 9.6 | 12.0 | 7.3 | 9.5 | 10.5 | 13.0 | 5.2 | 3.8 | +8.6 | +3.2 | +9.5 | +9.5 | +9.2 |
| 3 | +1.4 | +5.0 | +3.6 | +0.3 | +0.3 | +0.4 | +1.2 | +1.2 | 0.5 | 0.3 | +4.7 | +16.2 | +12.2 | +17.3 | +17.2 | +17.0 |
| 4 | 14.3 | 14.6 | 13.7 | 13.7 | 11.4 | 11.2 | 11.6 | 11.6 | 10.9 | 10.9 | 14.2 | 23.2 | 20.5 | 24.1 | 24.1 | 24.1 |
| D- | 29.2 | 29.8 | 42.8 | 46.0 | 50.5 | 51.1 | 49.8 | 49.8 | 52.1 | 52.1 | 40.3 | 0 | 10.5 | 0 | 0 | 0 |
| | 170.0 | 175.0 | 180.0 | 185.0 | 190.0 | 195.0 | 200.0 | 205.0 | 210.0 | 215.0 | 220.0 | 225.0 | 230.0 | 235.0 | 240.0 | 250.0 |
| 1 | 5.6 | 10.0 | 13.0 | 21.5 | 25.0 | 28.0 | 30.3 | 32.4 | 34.0 | 35.3 | 36.5 | 38.0 | 38.9 | 39.5 | 39.6 | |
| 2 | +1.5 | 3.5 | 6.4 | 10.0 | 15.2 | 18.2 | 20.5 | 22.3 | 24.0 | 25.3 | 26.3 | 27.8 | 28.7 | 29.3 | 29.5 | |
| 3 | +4.8 | +6.7 | +7.7 | + 0.7 | 2.0 | 4.8 | 6.3 | 8.3 | 9.6 | 10.7 | 11.7 | 13.0 | 13.7 | 14.2 | 14.4 | |
| 4 | 10.3 | 16.2 | 13.8 | 11.6 | 9.8 | 8.0 | 6.6 | 5.1 | 4.4 | 3.5 | 2.8 | 1.9 | 1.4 | 0.9 | 0.7 | |
| D- | 17.1 | 29.1 | 41.9 | 49.5 | 55.6 | 60.4 | 64.8 | 68.6 | 70.4 | 72.5 | 74.1 | 76.0 | 77.1 | 78.2 | 79.6 | |

Table 6c: Drainage Condition C with Jakarta rainfall of December,,1938

| Time (Minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2.5 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 | 32.5 | 35.0 | 37.5 |
| 1 | 43.7 | 43.7 | 43.7 | 37.0 | 38.0 | 30.5 | 33.5 | +1.7 | +2.4 | 6.9 | 12.0 | 5.4 | 11.0 | 3.5 | 14.7 | 15.2 |
| 3 | 33.4 | 30.4 | 30.4 | 28.0 | 28.6 | 23.6 | 29.0 | 8.0 | 2.9 | 3.3 | 5.0 | 3.8 | 4.5 | 4.6 | 6.5 | 9.0 |
| 6 | 15.2 | 15.7 | 15.7 | 14.7 | 14.5 | 13.5 | 13.1 | 8.6 | 5.9 | 2.3 | +1.6 | +2.1 | +3.5 | +3.5 | +3.0 | +1.5 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 1.4 | 2.8 | 6.9 | 10.0 | 10.2 | 11.1 | 11.1 | 11.1 | 10.1 |
| D-- | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 78.3 | 77.1 | 74.1 | 67.4 | 63.2 | 46.7 | 45.5 | 40.1 | 40.1 | 40.1 | 45.1 |

| | 40.0 | 42.5 | 45.0 | 47.5 | 50.0 | 52.5 | 55.0 | 57.5 | 60.0 | 62.5 | 65.0 | 67.5 | 70.0 | 72.5 | 75.0 | 77.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.1 | 7.8 | 14.3 | 18.4 | 22.0 | 24.3 | 26.7 | 25.8 | 27.4 | 27.5 | 30.3 | 15.3 | 20.0 | 22.6 | 27.5 | 30.4 |
| 3 | 11.8 | 6.5 | 7.5 | 9.6 | 12.8 | 15.0 | 17.2 | 16.0 | 18.4 | 19.0 | 21.0 | 10.5 | 17.0 | 15.7 | 19.0 | 21.0 |
| 6 | 0 | 1.0 | 0.2 | 0.2 | 1.3 | 2.8 | 4.0 | 4.9 | 5.5 | 6.8 | 8.0 | 7.0 | 6.4 | 6.0 | 6.7 | 7.8 |
| 9 | 9.3 | 8.6 | 8.7 | 8.9 | 8.5 | 7.6 | 6.9 | 6.3 | 5.8 | 5.1 | 4.4 | 4.3 | 4.6 | 5.1 | 4.9 | 4.4 |
| D-- | 51.4 | 53.8 | 53.3 | 52.4 | 54.2 | 56.2 | 60.9 | 63.2 | 64.9 | 67.2 | 60.4 | 69.5 | 71.6 | 67.2 | 67.8 | 64.4 |

| | 80.0 | 82.5 | 85.0 | 87.5 | 90.0 | 92.5 | 95.0 | 97.5 | 100.0 | 102.5 | 105.0 | 107.5 | 110.0 | 112.5 | 115.0 | 117.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30.0 | 25.6 | 29.8 | 32.1 | 34.0 | 34.6 | 35.7 | 35.4 | 37.0 | 37.7 | 38.0 | 38.4 | 38.5 | 0.5 | 6.2 | 5.9 |
| 3 | 20.3 | 18.5 | 21.0 | 22.6 | 24.3 | 25.0 | 26.0 | 26.5 | 27.0 | 27.7 | 28.0 | 28.3 | 28.5 | 9.0 | 5.2 | 4.2 |
| 6 | 8.8 | 8.4 | 8.8 | 9.4 | 10.3 | 11.0 | 11.8 | 12.2 | 12.7 | 13.0 | 13.3 | 13.6 | 13.8 | 9.0 | 6.0 | 2.7 |
| 9 | 3.9 | 3.9 | 3.8 | 3.5 | 3.1 | 2.7 | 2.4 | 1.9 | 1.6 | 1.5 | 1.4 | 1.9 | 1.1 | 1.4 | 3.3 | 6.1 |
| D-- | 70.8 | 70.5 | 71.0 | 71.9 | 72.9 | 73.9 | 74.7 | 76.1 | 76.5 | 76.8 | 77.0 | 77.3 | 77.7 | 77.0 | 72.4 | 63.9 |

| | 120.0 | 122.5 | 125.0 | 127.5 | 130.0 | 132.5 | 135.0 | 137.5 | 140.0 | 142.5 | 145.0 | 147.5 | 150.0 | 152.5 | 155.0 | 157.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13.5 | 17.5 | 21.0 | 23.5 | 25.5 | 14.0 | 22.0 | 21.8 | 26.0 | +1.5 | 8.8 | 1.5 | 8.6 | +4.2 | +3.9 | 3.0 |
| 3 | 6.2 | 8.8 | 11.8 | 14.0 | 16.3 | 8.9 | 13.5 | 14.1 | 17.0 | 6.6 | 5.4 | 2.3 | 2.7 | +7.2 | +7.5 | +2.0 |
| 6 | 1.0 | 1.2 | 0 | 1.8 | 3.6 | 3.5 | 3.0 | 3.5 | 4.4 | 4.2 | 1.8 | +1.9 | 5.3 | 12.8 | 13.0 | 8.9 |
| 9 | 9.2 | 9.7 | 9.3 | 8.3 | 6.9 | 6.8 | 6.9 | 6.9 | 6.7 | 6.4 | 7.8 | 10.0 | 12.4 | 17.1 | 17.4 | 15.2 |
| D-- | 50.9 | 48.3 | 50.4 | 55.1 | 60.9 | 61.3 | 60.9 | 60.9 | 61.7 | 62.8 | 57.3 | 46.7 | 30.8 | 0 | 0 | 2.4 |

| | 160.0 | 165.0 | 170.0 | 175.0 | 180.0 | 185.0 | 190.0 | 195.0 | 200.0 | 205.0 | 210.0 | 220.0 | 230.0 | 240.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.5 | 14.7 | 21.2 | 25.8 | 29.0 | 32.2 | 34.2 | 36.0 | 37.2 | 38.0 | 38.8 | 39.6 | 40.0 | 40.2 |
| 3 | 1.0 | 6.2 | 12.0 | 16.4 | 19.6 | 22.5 | 24.5 | 26.0 | 27.2 | 28.0 | 28.7 | 29.4 | 29.8 | 30.0 |
| 6 | 7.0 | 3.0 | 0 | 3.6 | 6.3 | 8.8 | 10.5 | 11.9 | 12.8 | 13.3 | 13.8 | 14.4 | 14.6 | 14.8 |
| 9 | 13.7 | 11.1 | 9.1 | 6.9 | 5.4 | 4.0 | 3.0 | 2.3 | 1.6 | 1.3 | 1.0 | 0.8 | 0.6 | 0.5 |
| D-- | 19.4 | 40.1 | 51.4 | 60.9 | 66.2 | 70.5 | 73.2 | 74.9 | 76.7 | 77.3 | 77.9 | 78.3 | 78.8 | 79.0 |