MEASURED AND CALCULATED DISTRIBUTIONS OF FLUOMETURON AND WATER DURING INFILTRATION

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The use of herbicides in food production systems has steadily increased over the past several years. There is little doubt that the use of these chemicals has contributed to increased yields and in many cases, reduced production costs. However, the effects of these chemicals are not always beneficial. In many instances, crop damage or failure has resulted from herbicide residues remaining in the soil from previous cropping systems. Also, environmental pollution is a possibility with the widespread use of any chemical. It would be very beneficial, therefore, to be able to predict what happens to a herbicide after it is applied to the soil surface in an agricultural system. Since many of the chemicals are applied to the soil or eventually reach the soil, it is of particular interest to know the behavior of the herbicide in the soil. Many soil factors may influence the movement and attenuation of the herbicide in the soil. Many of these factors may be important at the time of chemical application as well as with time. If soil properties such as water content, pore size distribution, pore-water velocity, bulk density, organic matter content, pH, and biological activity could be characterized as to their effects on herbicide displacement, much better predictions could be made of the fate of herbicides in the soil. The effects of some of these soil properties such as organic matter content and pH can be characterized by determining the interaction of the herbicide with the soil. Soil-water content, pore-water velocity and other soil properties must be individually evaluated for their effect on herbicide displacement.

Several mathematical models have been presented to describe chemical movement in soil for steady-state water flow. However, few attempts have been made at describing herbicide displacement for transient flow systems. Relatively little data are available for evaluating the influence of various soil parameters on the movement of herbicide through soils under these transient flow conditions.

The objectives of this study were as follows:

(1) To evaluate equilibrium adsorption and desorption between 1,1-dimethyl-3-(a,a,a-trifluoro-m-tolyl) urea (fluometuron) and Cobb sand.

(2) To determine the effect of initial soil-water content on the movement of fluometuron through Cobb sand during water infiltration.

(3) To determine the influence of infiltration rate and its associated boundary conditions on the displacement of fluometuron through Cobb sand.

(4) To evaluate the usefulness of a mathematical model for predicting the movement of herbicide through soil under conditions of transient water flow using independently measured parameters.

CHAPTER II

LITERATURE REVIEW

The extensive use of agricultural herbicides has resulted in greater attention being focused on their fate in the soil. The fate of herbicides is important to the user as well as the environmentalist. The safest and most efficient use of these chemicals can be obtained only from a knowledge of what happens to them after application. Although much work has been done on the fate of herbicides, most of this work has been for conditions which seldom, if ever, exist under normal field conditions.

The attenuation of soil applied chemicals influence the residue levels in the soil as well as the effectiveness of the chemical and its interaction with the soil material. Miscible displacement techniques have been used extensively to study the movement and attenuation of herbicides in soil-water systems. The primary factors influencing the attenuation and movement of these chemicals in soils are: pore-water velocity, adsorptive properties of the soil, soil-water content, solubility of the herbicide, molecular diffusion of the herbicide, pore-size distribution, aggregate size, and biological degradation (Lindstrom et al., 1967; Lindstrom et al., 1968; Davidson et al., 1968).

Day (1956) and Day and Forsythe (1957) used Scheidegger's statistical model to describe the process of hydrodynamic dispersion in porous media. They discussed the significance of diffusion and dispersion in the longitudinal mixing of a solute moving through porous media. Von Rosenberg (1956) found that convection and radial diffusion played at least a part in controlling the shape of the invading front during miscible displacement. Biggar and Nielsen (1962), and Nielsen and Biggar (1963) concluded that molecular diffusion must be included in any general theory of dispersion in porous media.

Pore-water velocity, soil-water content, bulk density, and pore-size distribution are soil physical properties which affect herbicide movement through soils. Miscible displacement techniques have been used to determine the relationship of these properties to solute movement (Biggar and Nielsen, 1963; Davidson et al., 1968; Kay and Elrick, 1967; Miller et al., 1965; Elrick et al., 1966; and Davidson and Chang, 1972).

Nielsen and Biggar (1962) examined several theoretical models for the miscible displacement of solutes in porous material and presented the mathematical equations describing these models. They discussed the usefulness of these models in describing the individual mechanisms involved in miscible displacement. However, none of these models accounted for the interaction between the solute and the soil.

The adsorption of herbicides to soil has been examined by several investigators (Kay and Elrick, 1967; Bailey et al., 1968; Biggar and Cheung, 1973; Hornsby and Davidson, 1973). In almost every case, adsorption was found to follow the simple Freundlich adsorption equation. Adsorption may be chemical or physical.

Leenheer and Ahlricho (1971) studying the adsorption of carbaryl (1-naphtyl methylcarbamate) and parathion (O,O-Diethyl O-p-nitrophenyl phosphorothioate) on soil organic matter concluded that the adsorption of these chemicals was a physical process with the formation of Van der Waals bonds. The effects of pH, temperature and nature of the adsorbent on the adsorption of various herbicides was investigated by Harris and Warren (1964). Variations were too great for a generalization to be made about the relationship between pH and adsorption, but adsorption was inversely related to temperature in most cases.

Hance (1967) determined the length of time required for the establishment of equilibrium adsorption of herbicides on several absorbents. Adsorption equilibrium was reached between 4 and 24 hours in most cases. However, as a general rule, desorption took longer. Lindstrom et al. (1970) tested the adsorption of three organic compounds and found that most of the adsorption occurred within the first hour.

Most herbicide transport models require a single-valued relationship between adsorption and desorption. These two processes do not always meet this requirement as was shown by Davidson and McDougal (1973) and van Genuchten et al. (1974). This non-singular relationship for adsorption and desorption had been suggested earlier by Kay and Elrick (1967) and Davidson and Chang (1972).

Chromatography theory has been the source of most of the transport models used in describing herbicide movement. Lapidus and Amundson (1952) presented a model based on longitudinal diffusion and convective transport for ion exchange in chromatographic columns. Their model included an adsorptive sink term.

A mathematical description of miscible displacement with ion exchange using a retardation factor to account for adsorption was given by Hashimoto et al. (1964). This retardation factor is the ratio of the equivalent column volume to the actual pore volume of the column, and it represents the apparent change in pore volume due to adsorption. Equilibrium adsorption and a linear adsorption isotherm was assumed in this study.

More recently, mathematical models for the movement of adsorbed chemicals through porous media have been given by Oddson et al. (1970), Lindstrom and Boersma (1971), and Lindstrom et al. (1971). Lindstrom and Boersma (1971) extended the theory presented by Lapidus and Amundson to include the pore-size distribution of the soil and a pore-size dependent diffusion coefficient. Oddson et al. (1970) neglected hydrodynamic dispersion in their description of the transport process.

Some studies have indicated that pointwise equilibrium may not exist at high pore-water velocities. (Abernathy and Davidson, 1971 and Davidson and McDougal, 1973). However, van Genuchten et al. (1974) were unable to predict the movement of picloram (4-amino-3,5,6-trichloropicolinic acid) at high pore-water velocities with a kinetic adsorption model which also accounted for the non singular character of the adsorption-desorption process. Because of this, they suggested that only a fraction of the soil participated in the adsorption process. They found this fraction to be a function of the average pore-water velocity.

Almost all of the solute transport studies presented to date have been for saturated and/or steady-state flow conditions. Little work has been reported on chemical displacement under transient flow conditions. In a study of solute displacement during infiltration, Evans and Levin (1968) pointed out that existing models derived for steady-state conditions do not apply to the case of infiltration. A brief theoretical analysis of some of the differences in solute transport for infiltration and steady-state flow are given.

Miller et al. (1965) studied the effect of water application method on the displacement of surface applied chloride. They found that the amount of chloride moved from a given depth was not uniquely related to the displacing water. Keller and Alfaro (1966) reported an inverse relationship between leaching efficiency and water application rate when they displaced chloride through the soil. A reduction in hydrodynamic dispersion and an increase in transverse molecular diffusion with lower application rates were the reasons given for this relationship between leaching efficiency and water application rate.

The movement of lindane (δ-1,2,3,4,5,6-Hexachlorocyclohexane) in soil during infiltration was studied by Huggenberger et al. (1972). They attempted to predict the observed chemical distribution using the model described by Oddson et al. (1970). Failure of the theory to predict the shape of the observed distribution curves was attributed to hysteresis or non singularity in the adsorption-desorption isotherms. They also found that the quantity of lindane applied to the soil in their study had no effect on the depth of penetration.

Equations describing solute movement under transient water flow conditions have been used by Bresler and Hanks (1969) and Warrick et al. (1971) to predict salt movement during infiltration. However, Warrick et al. (1971) assumed that steady-state flow occurred in the region of solute transport and solved this transient problem as a steady-state system. They used their model to numerically study the effects of surface soil-water content and the initial soil-water content on solute transport. From the numerical analysis they concluded that solute movement during infiltration was independent of initial soil-water content but highly dependent upon the boundary conditions during infiltration. Bresler and Hanks (1969) solved the water flow and solute transport equations simultaneously but they neglected the effects of dispersion and adsorption.

Kirda et al. (1973) also found solute displacement to vary with water infiltration rate and boundary conditions during infiltration. They observed that for large pore-water velocities, predicted values of the apparent diffusion coefficient varied directly with the pore-water velocities. However, the apparent diffusion coefficient was a constant for pore-water velocities below 0.01 cm/min.

Almost all of the work reported to date on solute movement in transient water flow systems has considered only non-interacting or non-adsorbing solutes. Few studies have been reported on the effects of soil physical properties such as initial soil-water content and infiltration rate on the displacement of adsorbed chemicals through the soil under transient water flow conditions. The objective of this study was to evaluate the influence of the surface soil-water content and initial soil-water content prior to infiltration on the movement of a specific herbicide in a soil system. Also, a model for describing the displacement of organic chemicals and water in soil for non steady-state conditions was evaluated using the experimental data obtained in this study.

CHAPTER III

THEORY

The general form of the equation describing soil water flow in one dimension is:

$$\frac{\partial \Theta}{\partial t} = \frac{\partial}{\partial z} K(\Theta) \frac{\partial H}{\partial z} \tag{1}$$

where Θ is the volumetric soil-water content (cm^3/cm^3), t is time (hr), z is depth (cm) measured positively downward, H is hydraulic head (cm), and $K(\Theta)$ is hydraulic conductivity (cm/hr) expressed as a function of water content. A numerical solution of (1) has been presented by Hanks and Bowers (1962).

The partial differential equation for one dimensional solute transport is:

$$\frac{\partial(\Theta C)}{\partial t} = \frac{\partial}{\partial z}\left(\Theta D_o \frac{\partial C}{\partial z}\right) - \frac{\partial (VC)}{\partial z} - \rho \frac{\partial S}{\partial t} \tag{2}$$

where C is the solute solution concentration ($\mu g/cm^3$), S is the solute concentration ($\mu g/g$) in the adsorbed phase, ρ is the bulk density of the soil (g/cm^3), D_o is the dispersion or apparent diffusion coefficient (cm^2/hr), and V is the volumetric water flux (cm/hr). The D_o term describes the combined effects of molecular diffusion and dispersion resulting from the pore-water velocity distribution. The three terms on the right hand side of (2) describe the contributions from dispersion, convective transport, and adsorption, respectively, to the displacement of a solute through soil. If D_o is assumed constant and the equation of continuity $\frac{\partial V}{\partial z} = - \frac{\partial \theta}{\partial t}$ is used, (2) is simplified to:

$$\frac{\partial C}{\partial t} = D_o \frac{\partial^2 C}{\partial z^2} - \left(\frac{V}{\theta} - \frac{D_o}{\theta} \frac{\partial \theta}{\partial z}\right) \frac{\partial C}{\partial z} - \rho \frac{\partial S}{\partial t} \tag{3}$$

Equation (3) will be used to describe solute transport under transient soil-water flow conditions.

Assuming a first-order kinetic reaction between the solution and adsorbed solute phases, the rate of mass transfer to the adsorbed phase during adsorption, $\left.\frac{\partial C}{\partial t}\right|_z > 0$, is described by:

$$\frac{\partial S}{\partial t} = k_D \left[\left(\frac{k_A}{k_D} \frac{\theta}{\rho}\right) C^{1/N} - S\right] \tag{4}$$

where k_A and k_D are the adsorption and desorption rate coefficients. When equilibrium conditions exist between the adsorbed and solution phases, $\frac{\partial S}{\partial t} = 0$, and (4) becomes the Freundlich equation:

$$S = K_A C^{1/N} \tag{5}$$

where $K_A = (k_A \theta / k_D \rho)$ is the distribution coefficient for adsorption.

For desorption, $\left.\frac{\partial C}{\partial t}\right|_z < 0$, the rate of mass transfer from the adsorbed phase can be expressed as follows:

$$\frac{\partial S}{\partial t} = k_D' \left[\left(\frac{k_A'}{k_D'} \frac{\theta}{\rho}\right) C'^{1/N'} - S'\right] \tag{6}$$

where prime (') denotes desorption. When equilibrium conditions exist (6) can be written as:

$$S' = K_D C'^{1/N'} \tag{7}$$

where $K_D = (k'_A \theta / k'_D \rho)$ is the desorption distribution coefficient.

Equations (5) and (7) are equal when the adsorption-desorption process is single-valued. However, Davidson and McDougal (1973) have reported that adsorption and desorption of picloram (4-amino-3,5,6-

trichloropicolinic acid) was not single-valued. In this case, the solution and adsorbed concentrations in equations (5) and (7) are equal only at the instant the adsorption process ceases, $\left.\frac{\partial C}{\partial t}\right|_z = 0$. At this point, the solution and adsorbed concentration are maximums (C_{max}, S_{max}). Solving (5) for C_{max} and substituting this into (7) and solving for K_D gives:

$$K_D = K_A C_{max}^{(1/N-1/N')} \qquad (8)$$

It is obvious from (8) that the desorption distribution coefficient, K_D, is a function of the maximum solution concentration.

In this study, numerical solutions of equations (1) and (2) were used to calculate fluometuron and water displacement through Cobb sand during infiltration. The boundary conditions were:

(a) $C = C_i$	$z = 0$	$0 < t \leq t_o$	
(b) $-D_o \frac{\partial C}{\partial z} + VC = 0$	$z = 0$	$t > t_o$	
(c) $C = 0$	$z > I(t)$	$t > 0$	(9)
(d) $C = 0$	$z > 0$	$t = 0$	
(e) $\theta = \theta_i$	$z > 0$	$t = 0$	

where t_o is the time required for the complete dissolution of the fluometuron spread on the soil surface, C_i is the constant surface concentration (maximum solubility) maintained until t_o, I(t) is the depth ahead of the displacing solution, and O_i is the initial soil-water content. The value of C_i was assumed to be equal to the maximum solubility of the herbicide in water.

Equation (1) was solved implicitly using the finite difference scheme:

$$\frac{h_i^t - h_i^{t-1}}{\Delta t} = \frac{(h_{i-1}^{t-1} + h_{i-1}^t + 2G - h_i^{t-1} - h_i^t)\, K_{i-1/2}^{t-1/2}}{2\,(\Delta z)^2\, C_i^{t-1/2}} - \frac{(h_i^{t-1} + h_i^t + 2G - h_{i+1}^{t-1} - h_{i+1}^t)\, K_{i+1/2}^{t-1/2}}{2\,(\Delta z)^2\, C_i^{t-1/2}} \quad (10)$$

where h is pressure head, G is the gravitational term, the subscripts, i, refer to distance, the superscripts, t, refer to time, and C is the specific moisture capacity, $\frac{\partial \theta}{\partial h}$.

Equations (5) and (7) were used in the solute transport equation (equation 2) to describe adsorption and desorption of fluometuron during the displacement of the chemical through the soil. After the addition of the appropriate adsorptive sink term, equation (2) was solved explicitly subject to conditions (9a) - (9d) with the finite difference analog:

$$\frac{C_i^{t+\Delta t} - C_i^t}{\Delta t} = \frac{1}{W}\frac{D_o'}{\Delta z^2}\left[C_{i+1}^t - 2C_i^t + C_{i-1}^t\right] - \frac{1}{W}\frac{V}{\Delta z}\left[C_i^t - C_{i-1}^t\right] \quad (11)$$

For adsorption:

$$W = 1 + \frac{\rho}{\theta}\,\frac{1}{N}\,K_A C^{1/N-1} \quad (12)$$

and for desorption:

$$W = 1 + \frac{\rho}{\theta N'}\,K_D C^{1/N'-1} \quad (13)$$

D_o' in equation (11) is the coefficient $D_o - D_n$, where D_n is the correction for numerical dispersion introduced by $\partial C/\partial z$ and $\partial C/\partial t$. These two terms were approximated by Taylor series expansion using only first and second order terms.

CHAPTER IV

MATERIALS AND METHODS

Packed soil columns were used to study the influence of initial soil-water content and infiltration rate on the displacement of 1,1-dimethyl-3-(a,a,a-trifluoro-m-tolyl) urea (fluometuron) through soil. To simulate field conditions, the herbicide was uniformily applied to the soil surface prior to the application of water. The quantity of fluometuron distributed on the surface of each column was equivalent to a field application rate of 3.24 kg/ha. All infiltration experiments were conducted at $25 \pm 1^{o}C$.

Soil

The soil used in this study was obtained from the top 15-cm of a profile classified as Cobb fine sandy loam. The sampling site was located on the Caddo Research Station near Fort Cobb, Oklahoma. As a result of the particle size distribution and for convenience, the sampled soil will be referred to as Cobb sand in this paper. The soil was air-dried and passed through a 2.0 mm sieve. Gravimetric water content of the air-dry soil was 0.50% by weight. The pH, organic matter content and cation exchange capacity of the soil were 7.0, 0.5%, and 3.9 meq/100g, respectively. The soil had 91.8% sand, 6.0% silt and 2.2% clay.

The air-dry soil was packed into rectangular acrylic columns one meter in length and having 13 by 13 cm inside dimensions. Soil was added to the column in 2-cm increments with each layer stirred into the top of the previous layer. After each soil addition, each side of the column was tapped four times with a rubber-faced mallet. This procedure was repeated until the total depth of soil reached 95 cm. The average bulk density of the soil in each column was 1.53 $\pm$ 0.015 g/cm^3.

Gamma-Ray Attenuation Equipment

The volumetric water content and initial bulk density at various locations along the length of the soil was measured by gamma-ray attenuation. The apparatus, Figure 1, consisted of a 250 millicurie Cesium-137 source, thallium-activated NaI crystal scintillation detector (Harshaw Type 4S4), and the following Harshaw electronic equipment: preamplifier (Model NB-11), linear amplifier (Model NA-11) single channel pulse height analyzer (Model NC-11), scaler (Model NS-30), timer (Model NT-29), and high voltage supply (Model NV-19). The scaler was coupled to a Hewlett Packard 5050B digital recorder. The system was found to have a resolving time and mass adsorption coefficients for water and soil of 3.3 microseconds, 0.0855 cm^2/g and 0.0797 cm^2/g, respectively. A method similar to that described by Fritton (1969) was used to determine resolution time.

Herbicide Application

A substituted urea herbicide (fluometuron) was used throughout the study. A fluometuron concentration of 1.832 μg/ml in absolute ethanol was obtained by combining 80% wettable powder (technical grade) and ^{14}C-labeled fluometuron (100 μc/9.7mg) in proper proportions to yield a

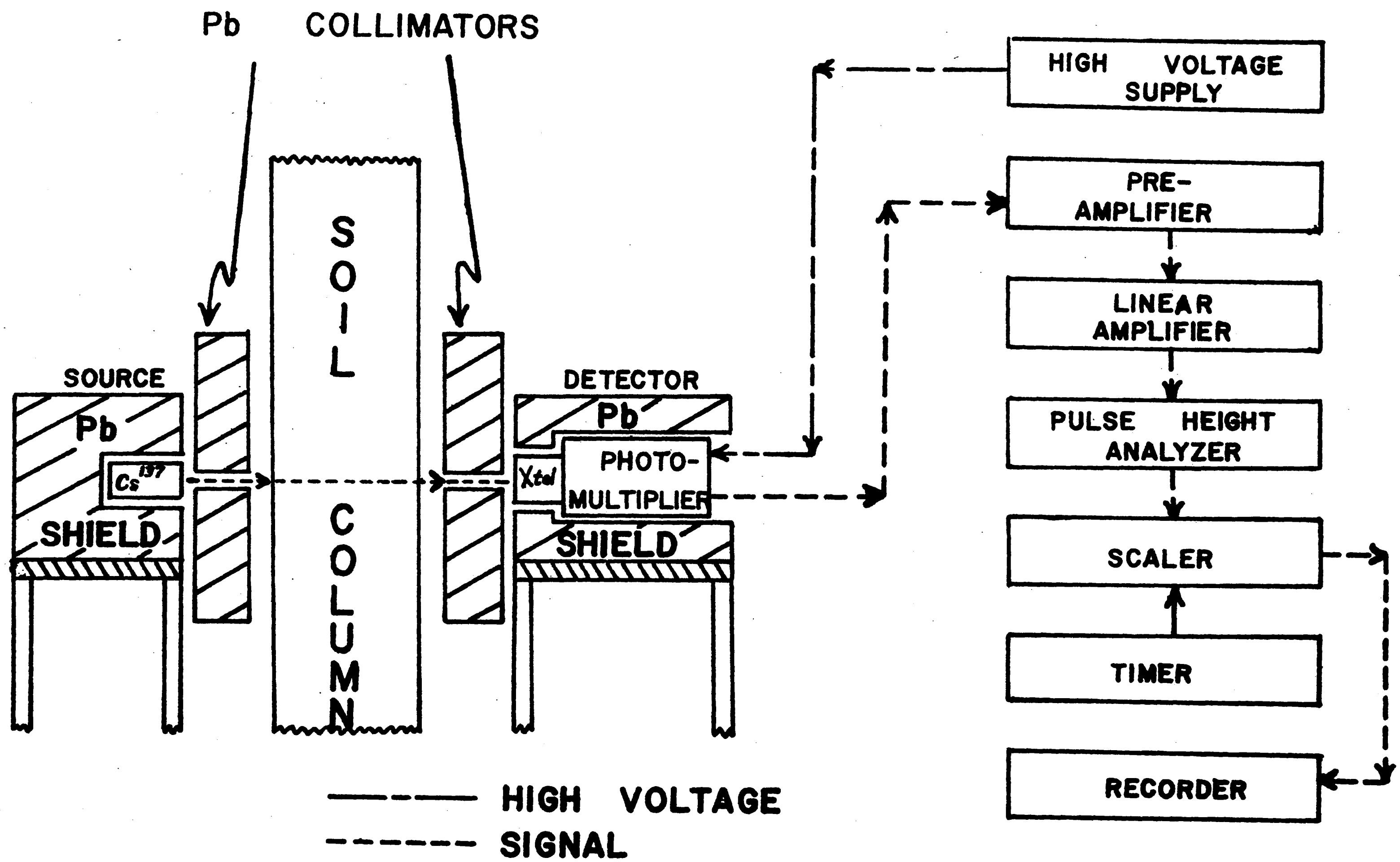

Figure 1. Schematic of Gamma-Ray Attenuation Apparatus.

^{14}C activity of 0.556 μc per ml of solution. Three milliliters of this solution were applied uniformly to the soil surface prior to initiating infiltration. This was equivalent to an application rate of 3.24 kg/ha. The soil surface was divided into three equal areas and the solution containing the fluometuron was added dropwise at random to each area with a 1-ml pipette. The ethanol was allowed to evaporate prior to the application of water.

Liquid Scintillation Technique

Carbon-14 activity in the soil-water and leachate samples was measured by liquid scintillation. Aliquots of 0.5 ml were pipetted into counting vials containing 15 ml scintillation cocktail solution. The scintillation solution consisted of 120 g naphthalene, 4 g 2,5-Diphenyloxazale (PPO) and 50 mg 1,4-bis-2-(5-Phenyloxazolyl)-Benzene (POPOP) made to one liter volume with p-dioxane.

Infiltration

After application of the herbicide, a 2 cm layer of 0.5-1.0 mm diameter quartz sand was placed on top of the soil. This was done to achieve a uniform distribution of water at the soil surface for the low infiltration rates and prevent puddling of the soil surface.

Constant application rates of 1 or 5 cm/hr of 0.01 N $CaSO_4$ solution to the soil surface were obtained with a constant volume pump. The pump supplied water to a manifold with thirteen outlets. Each outlet was connected to a two-inch length of capillary tubing mounted in a 20 cm square acrylic plate, Figure 2. The capillary tubing had an inside diameter of 0.5 $\pm$ 0.25 mm. The plate was designed to fit on top

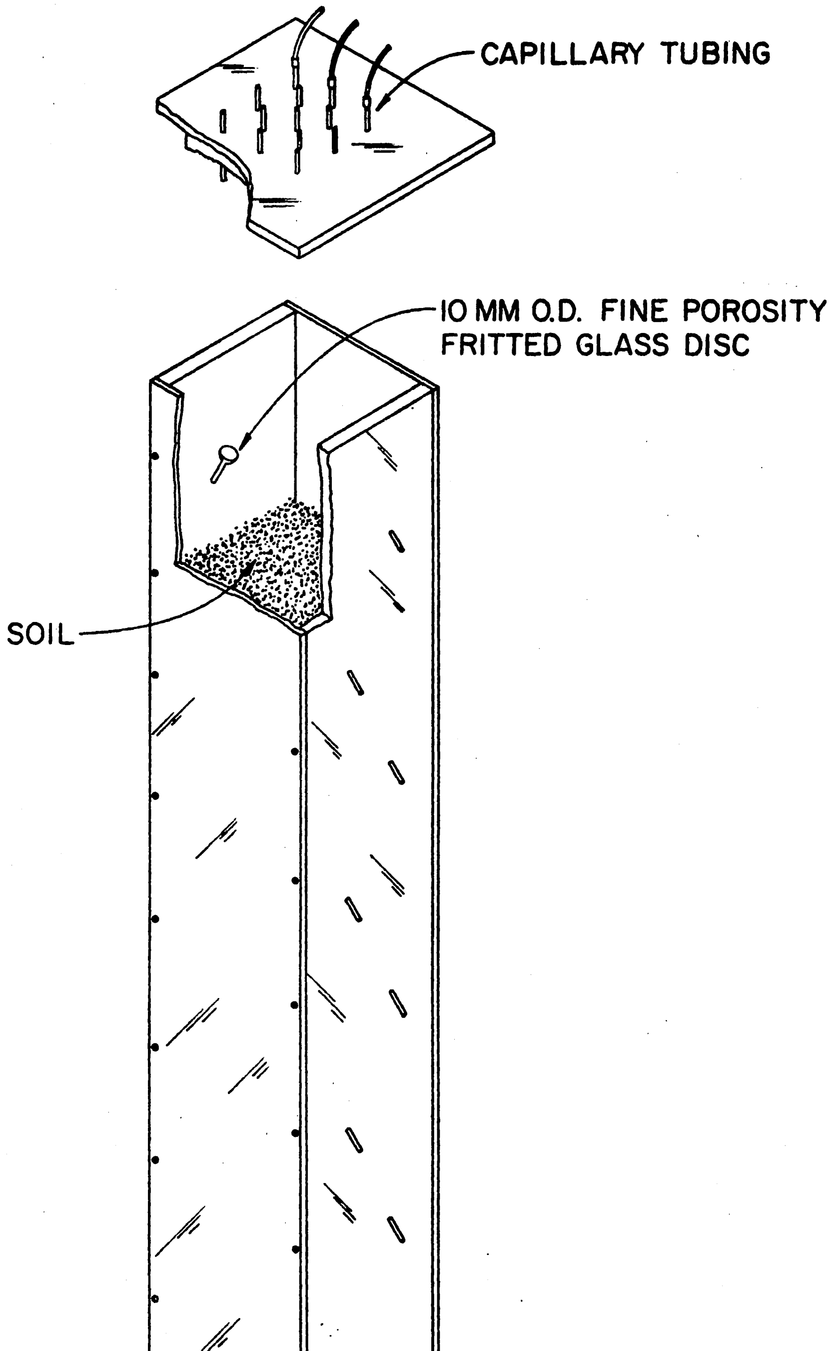

Figure 2. Soil Column and Water Application Apparatus Used in Infiltration Study.

of the acrylic columns containing the soil. The plate was moved over the soil surface from time to time to achieve complete coverage of the soil area. In order to monitor the rate of water addition, the 0.01N $CaSO_4$ solution source was pumped from a flask positioned on a Mettler model P3 balance.

A one centimeter head of water was maintained on the soil surface for the case where the infiltration rate was not controlled. Two four-liter Erlenmeyer flasks containing 0.01 N $CaSO_4$ solution were used to maintain this head. These flasks were mounted on platforms attached to the elevator of the gamma-ray attenuation apparatus. The flasks were weighed before and after infiltration to determine the total quantity of water that had entered the soil.

Sampling the Soil Solution

Samples of soil-water were collected at various soil depths during infiltration through 10 mm fine-porosity fritted-glass immersion tubes. The tubes were located in the sides of the acrylic container beginning 5 cm below the soil surface and extending to 75 cm in 5 cm increments, Figure 2. An additional tube was placed 2 cm below the soil surface. Rubber septums mounted on the open ends of the immersion tubes allowed soil solution samples to be drawn through the fritted discs. Glass syringes were used to draw samples from the soil after the wetting front had passed a given sampler.

Sampling the Soil Column

Immediately after cessation of infiltration, the column of soil was removed from the elevator on the gamma-ray attenuation apparatus.

One side of the acrylic column was removed and the soil was sampled at three centimeter intervals beginning at the wetted front. A #9 brass cork borer was used to remove the soil samples. The samples were transferred to fritted-glass filters, Figure 3, and centrifuged at approximately 800 x gravity for 15 minutes. The soil samples were removed from the column and placed in the centrifuge as quickly as possible to prevent additional changes in the composition of the soil solution. The solution sample obtained with this procedure was analyzed for ^{14}C activity and represented the solution concentration. The samples were weighed following centrifugation to determine the soil-water content of the sample.

To remove the remaining herbicide, the soil samples were leached with two successive 5-ml increments of absolute ethanol with centrifugation following each increment. It had been previously determined that 10 ml of leachate was adequate to remove all the fluometuron from the soil. The herbicide concentration in the ethanol leachate was measured by liquid scintillation for ^{14}C activity. The amount of herbicide remaining in the soil solution after the first centrifugation was substracted from the amount in the ethanol leachate to give the quantity of adsorbed herbicide. The concentration of adsorbed fluometuron ($\mu g/g$) was determined and expressed on an oven-dry soil basis.

Sorption Studies

The equilibrium adsorption of fluometuron with Cobb sand at 25 $\pm$ 1°C was determined using 1:1 weight ratios of soil to volume of herbicide solution. Ten milliliters of 0.01 N $CaCl_2$ solution containing the desired concentration of fluometuron was added to 10 g of soil in

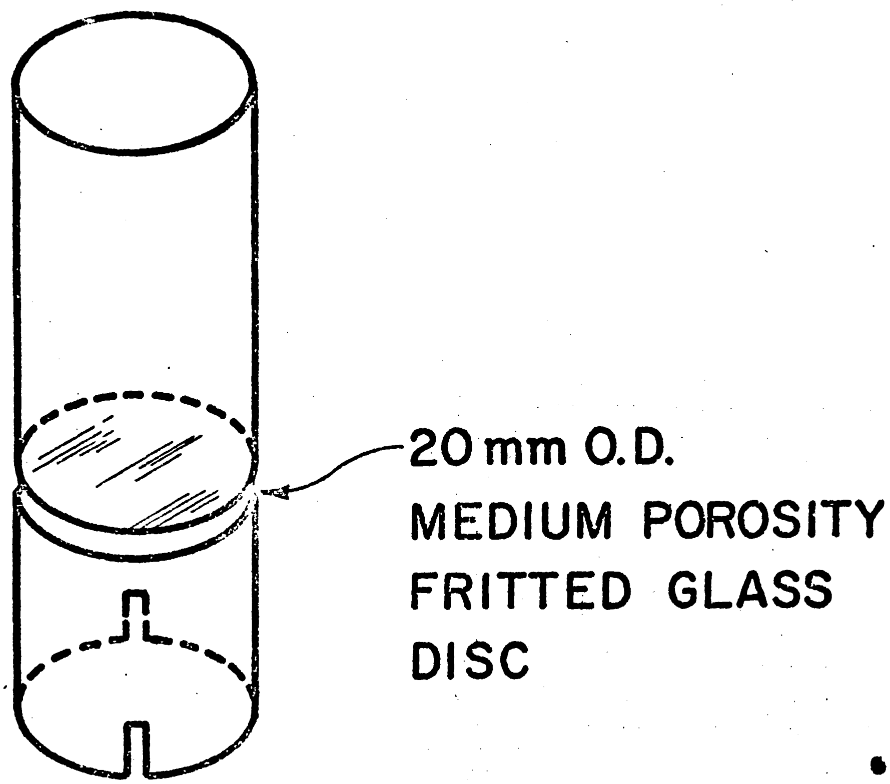

Figure 3. Apparatus Used to Separate Adsorbed and Solution Fluometuron Phases

a 50 ml glass test tube, shaken for twelve hours, and centrifuged at 800 x gravity. The ^{14}C activity in 0.5 ml aliquots of the supernatant solution was determined. Duplicate samples were run for each herbicide concentration. The difference in the initial herbicide concentration added to the soil and the concentration in the supernatant was assumed to be the amount adsorbed by the soil.

Equilibrium desorption of fluometuron from Cobb sand at $25 \pm 1^{o}C$ was also evaluated. Again 1:1 soil-herbicide ratios were used by combining 10 grams of soil and 10 ml of various herbicide concentrations. The samples were shaken for twelve hours and the amount of herbicide adsorbed was determined as in the adsorption experiment. A sample of the supernatant was removed and analyzed for herbicide concentration. The volume of supernatant solution extracted was replaced with herbicide-free 0.01 N $CaCl_2$ solution. This procedure was continued for nine dilutions.

Soil-Water Characteristics

Soil moisture characteristics for Cobb sand packed to a density equal to that used in the soil columns were determined for both wetting and drying cycles. Soil cores 7.62 cm in diameter were placed on water saturated fritted glass plates in Buechner funnels. The soil was saturated for 24 hours and then allowed to drain to an equilibrium water content at a pressure of -4 cm of water. By increasing the pressure in the Buechner funnels by given increments and measuring the quantity of water drained from the soil between these increments, a soil-water content-pressure relationship for the drainage cycle was obtained. When the soil reached equilibrium at the last pressure increment, a constant head burette was connected to the outflow end of the system. The pressure was then decreased by given increments and the amount of water flowing out of the burette and into the soil was measured. In this way, a soil-water content-pressure relationship was determined for a wetting cycle. The pressure at which wetting was initiated was varied in order to obtain several soil moisture characteristic curves for water adsorption scanning curves.

Soil moisture diffusivities were determined with the method outlined by Bruce and Klute (1956). Water was applied to air-dry soil packed in a 3.1 cm diameter acrylic column. The pressure at the inflow end of the column was maintained at -2 cm. At the end of infiltration the column was sectioned into one centimeter segments and the moisture content of each segment was measured gravimetrically.

CHAPTER V

RESULTS AND DISCUSSION

The equilibrium adsorption and desorption isotherms given in Figure 4 were described by the Freundlich equation:

$$S = KC^{1/N} \tag{14}$$

As can be seen from Figure 4, adsorption and desorption were not described by a single-valued relationship. For adsorption, the values of K_A and $1/N$ were 0.21 (cm^3/g) and 0.84, respectively. For desorption K_D and $1/N'$ were dependent upon the maximum amount of herbicide adsorbed. Table I gives the K_D and $1/N'$ values for each C_{max} studied. A reaction time of 10 min. was sufficient for equilibrium adsorption, however 12 hr. was used to obtain all adsorption and desorption data.

N' appears to be a function of C_{max} (van Genuchten et al. 1974) but for this study will be assumed constant. Using equation (8), the concentration dependent desorption distribution coefficient, K_D, can be easily calculated in the numerical solution. From preliminary desorption isotherm data for low herbicide concentrations, the average of the measured N' values was 1.7. This value was used to calculate the desorption distribution coefficient in the numerical solution. When all the desorption data over the concentration range given in Table I were collected the average N' was 1.5. As shown in Figure 5, using an N' of 1.5 resulted in much better agreement between measured and calculated values of K_D at high fluometuron concentrations.

TABLE I

PARAMETERS ASSOCIATED WITH DESORPTION OF FLUOMETURON FROM COBB SAND AT 25 ± 1°C

C_{max} g/cm^3	K_d	1/N'
0.42	0.17	0.60
1.26	0.22	0.64
2.12	0.25	0.63
7.82	0.25	0.76
15.8	0.34	0.66
24.1	0.48	0.57
32.3	0.34	0.68
40.4	0.36	0.69

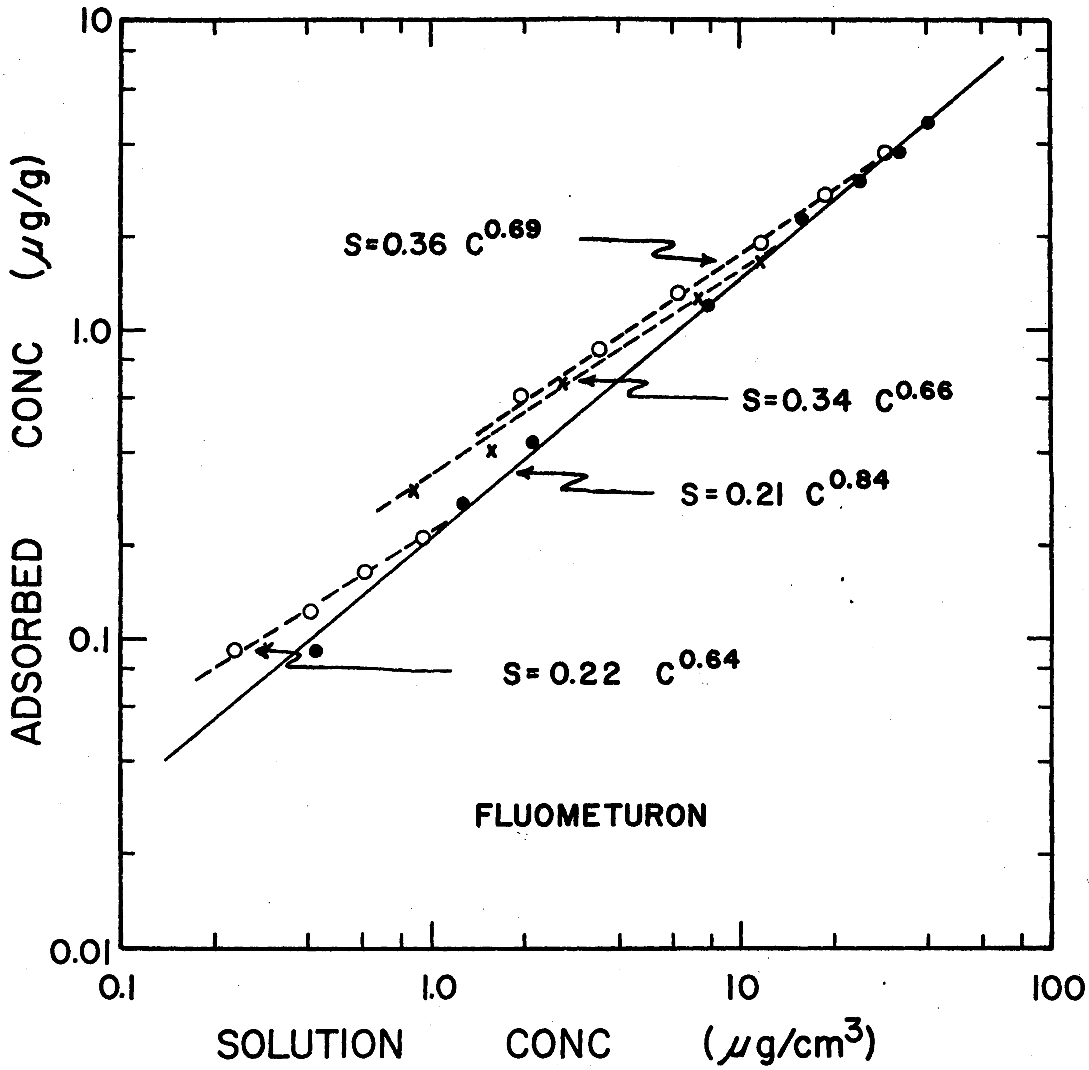

Figure 4. Adsorption and Desorption Isotherms for Fluometuron on Cobb Sand. Solid and Broken Lines are Best Fit Curves for Adsorption and Desorption, Respectively.

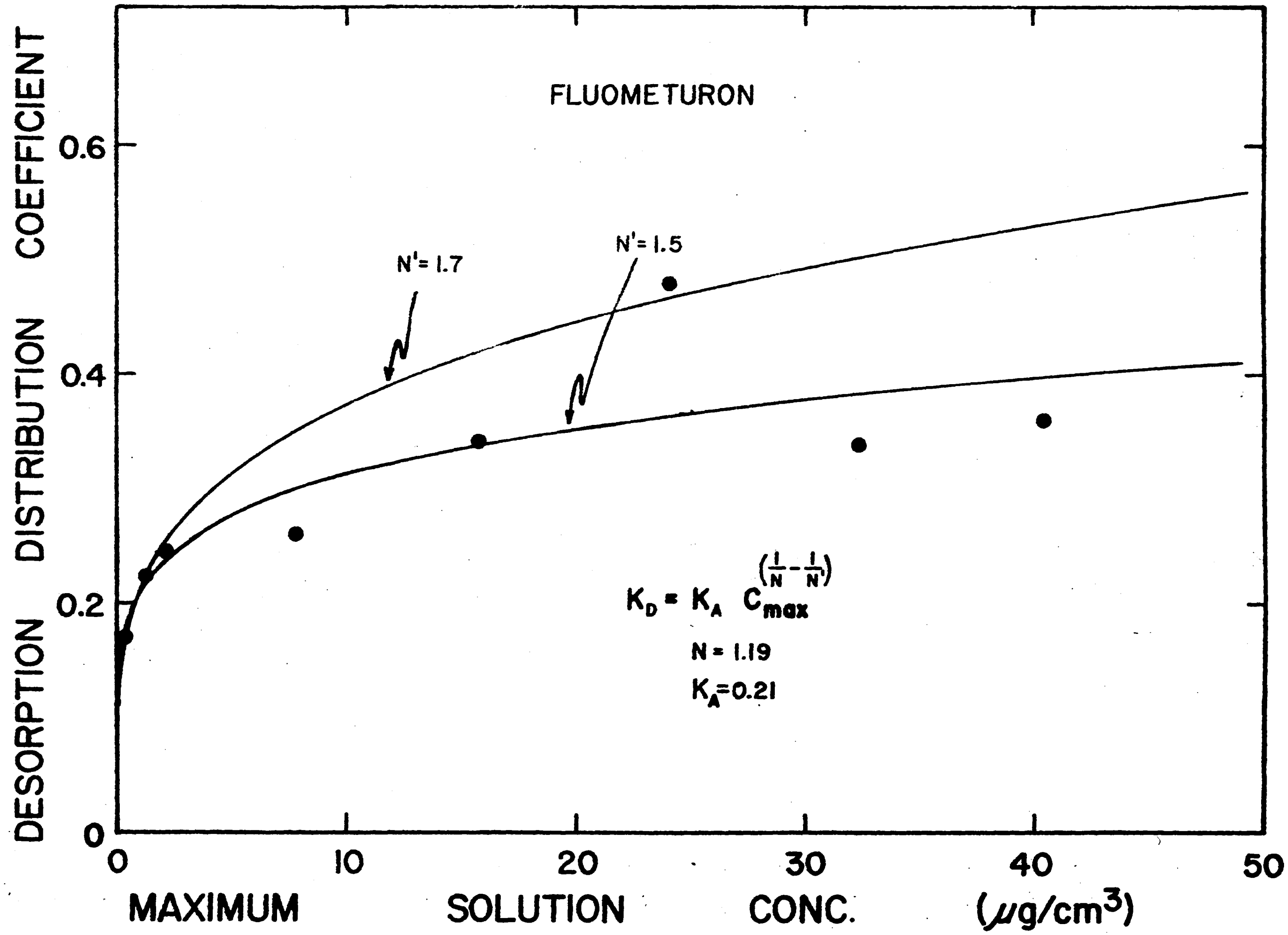

Figure 5. Relationship Between the Desorption Distribution Coefficient and the Maximum Fluometuron Concentration in Solution. Continous Lines Are Calculated Curves Using Equation (8) and N' Values of 1.5 and 1.7. Solid Dots Are Measured Desorption Distribution Coefficients.

However, the measured desorption distribution coefficients for low herbicide concentrations were predicted reasonably well using either 1.7 or 1.5. It was found that the calculated herbicide distributions were not significantly changed by decreasing N' from 1.7 to 1.5.

The soil parameters associated with each experiment in this study are summarized in Table II. The three water application rates used were: 1) 1.0 cm/hr, 2) 5.0 cm/hr, and 3) a variable rate achieved by maintaining one centimeter head of water on the soil surface.

The numerical solution procedure given by Hanks and Bowers (1962) was used to solve equation (1) for the water infiltration process. The soil-water characteristic curves for Cobb sand are given in Figure 6. Curves are shown for both wetting (broken lines) and drying (solid line). The relationship between soil-water content and head for wetting is dependent upon the soil-water content prior to wetting. The soil characteristic curve used for each column was selected on the basis of initial soil-water content.

Soil moisture diffusivities were determined with the method presented by Bruce and Klute (1956). Hydraulic conductivity values were then calculated using the relation:

$$K(\theta) = D(\theta)\ (d\theta/dh) \qquad (15)$$

Curve A in Figure 7 shows the relationship between hydraulic conductivity and soil-water content calculated from this equation for an initially dry soil. This relationship for hydraulic conductivity and the appropriate soil-water characteristic curve were used in equation (1). Predicted infiltration proceeded too rapidly for the initially wet column when Curve A in Figure 7 was used. This was probably caused by a change in the pore geometry of the soil as a result of pre-wetting

TABLE II

EXPERIMENTAL PARAMETERS AND SOIL CHARACTERISTICS

Column	Bulk Density g/cm^3	Initial Water Content cm^3/cm^3	Average Infiltration Rate cm/hr	Total Infiltration Time Min	Residual At Soil C μg/cm^3	Herbicide Surface S μg/g
1	1.53	0.005	18.1	90	-	-
2	1.52	0.005	29.0	59	0.2	0.2
3	1.54	0.005	4.89	266	38.3	16.7
4	1.54	0.005	1.00	980	44.2	18.4
5	1.54	0.130	10.1	69	0.2	0.3
6	1.53	0.140	17.6	62	0.5	0.6
7	1.54	0.130	5.16	161	45.7	10.3
8	1.53	0.125	1.03	585	3.1	2.6

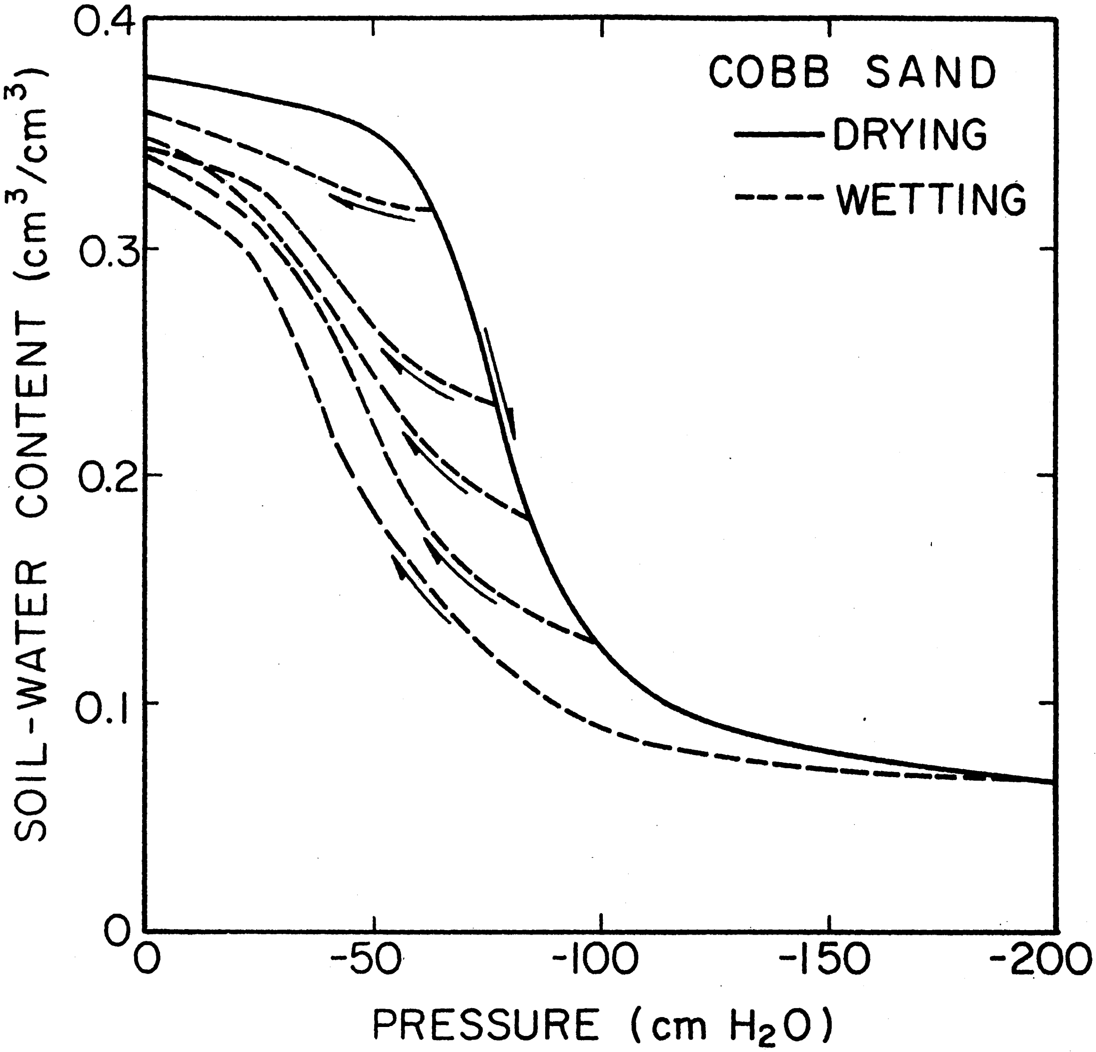

Figure 6. Soil-Water Characteristic Curves for Cobb Sand. Solid Line is for Drying and Broken Lines are for Wetting.

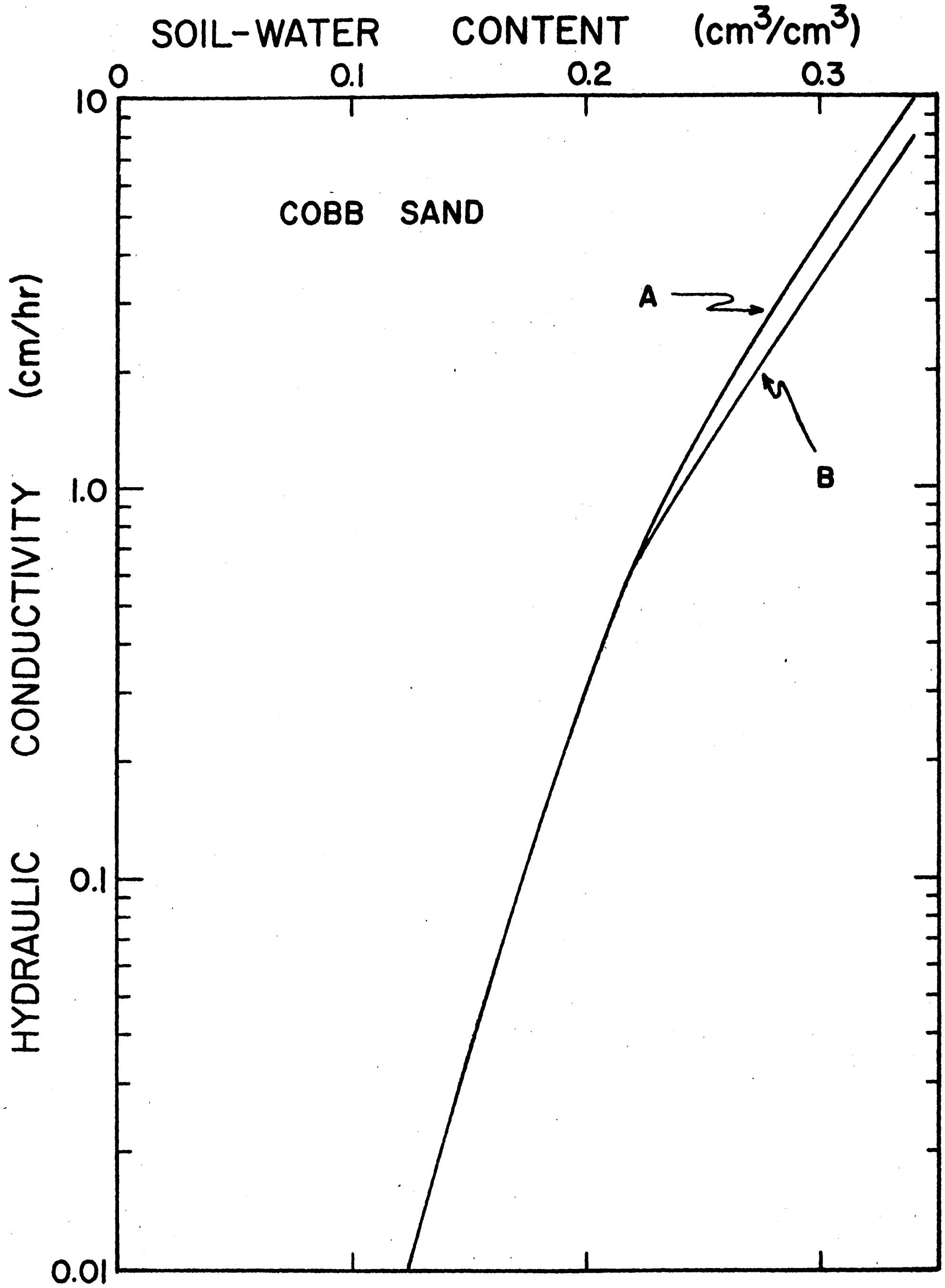

Figure 7. Hydraulic Conductivity Versus Soil-Water Content for Cobb Sand. Curve A is for an Initially Dry Soil and Curve B is for an Initially Wet Soil.

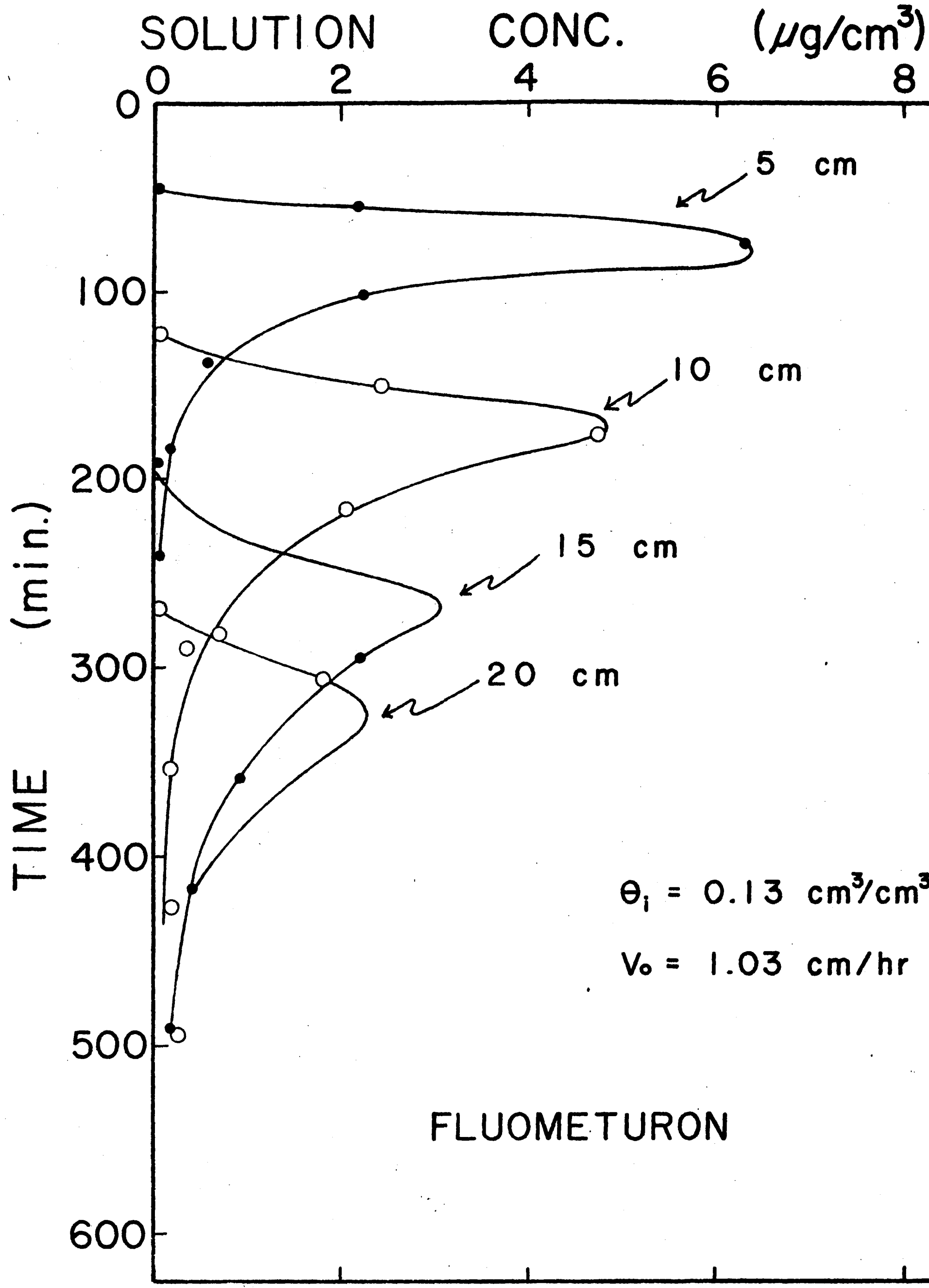

Figure 8. Fluometuron Concentration Distributions Versus Time for Selected Soil Depths. V_0 is Flux and θ_i is the Initial Soil-Water Content. Solid Lines are Eye-Fitted Curves Connecting Measured Fluometuron Concentrations Shown as Open and Solid Data Points.

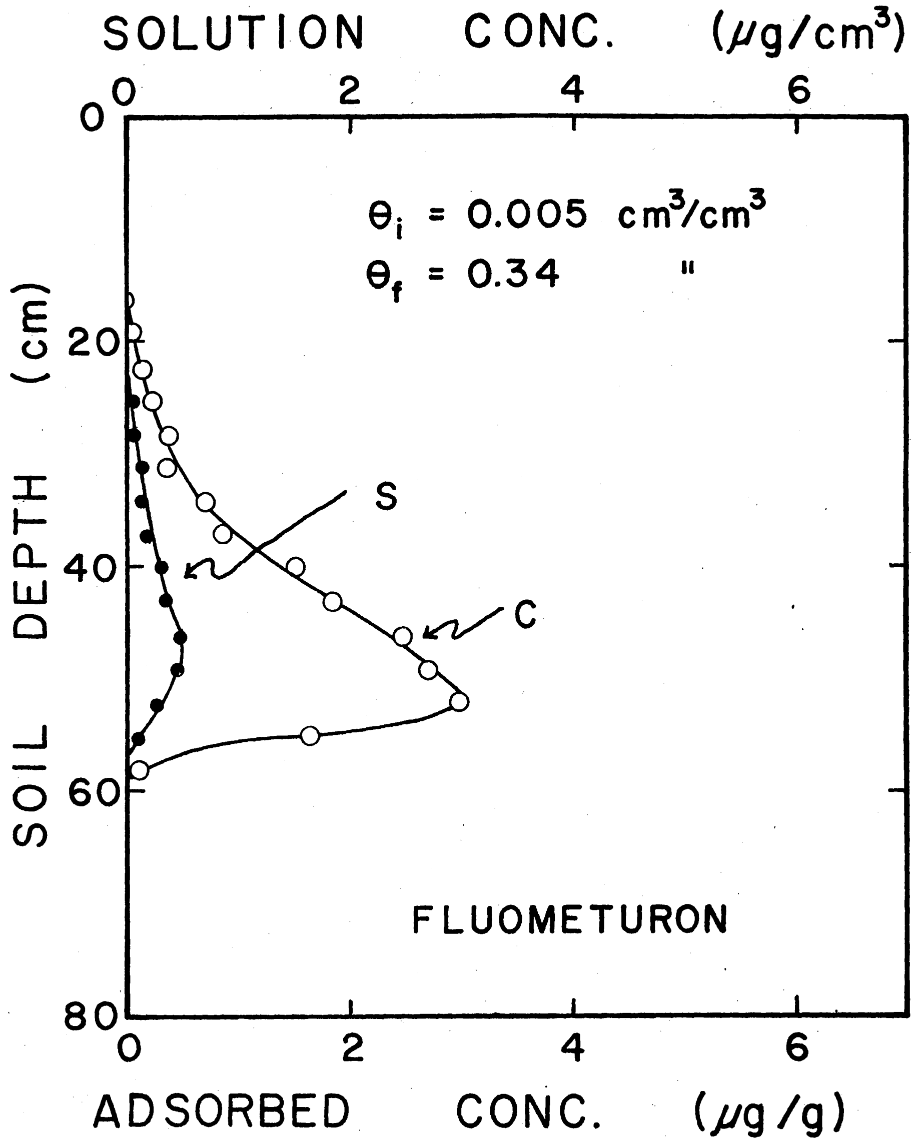

Figure 9. Solution and Adsorbed Fluometuron Concentration Distributions Immediately Following Infiltration. Average Flux Was 29.0 cm/hr. Θ_i is Initial Soil-Water Content and Θ_f is the Final Soil-Water Content at the Soil Surface. Solid Lines Are Eye-Fitted Curves Connecting Adsorbed, S, and Solution, C, Fluometuron Concentrations Shown as Solid and Open Data Points, Respectively.

the soil. In order to describe the infiltration into the wet columns, Curve B in Figure 7 was used.

Fluometuron concentration with time at various soil depths for column 8 in Table II are given in Figure 8. These concentrations were determined by collecting samples of the soil-water through the fritted filter discs during infiltration. The reduction in peak height and the increased spreading with depth shown in Figure 8 are a result of mixing by velocity dispersion and adsorption of the fluometuron on the soil. The tailing is an indication of the non-singular relationship between adsorption and desorption. Additional soil solution data are given in Table III in the Appendix.

Figures 9 and 10 give adsorbed and solution herbicide distributions for columns 2 and 5. These distributions were measured by taking samples from the soil columns immediately after the cessation of infiltration. The maximum adsorbed and solution concentrations generally occurred at approximately the same depth for all treatments. However, some lagging of the adsorbed phase is shown for the ponded infiltration into initially dry soil, Figure 10. This is an indication that non-equilibrium conditions exist at the fast pore-water velocities associated with this column. The data obtained from soil samples are given in Table IV in the Appendix.

The initial soil-water content prior to infiltration had little affect on the displacement of fluometuron for a given quantity of infiltrated water. This is illustrated in Figure 11 where fluometuron concentrations are compared for initial soil-water contents of 0.005 (air-dry) and 0.130 cm^3/cm^3. One centimeter of water was maintained on the soil surface of both columns throughout the infiltration process.

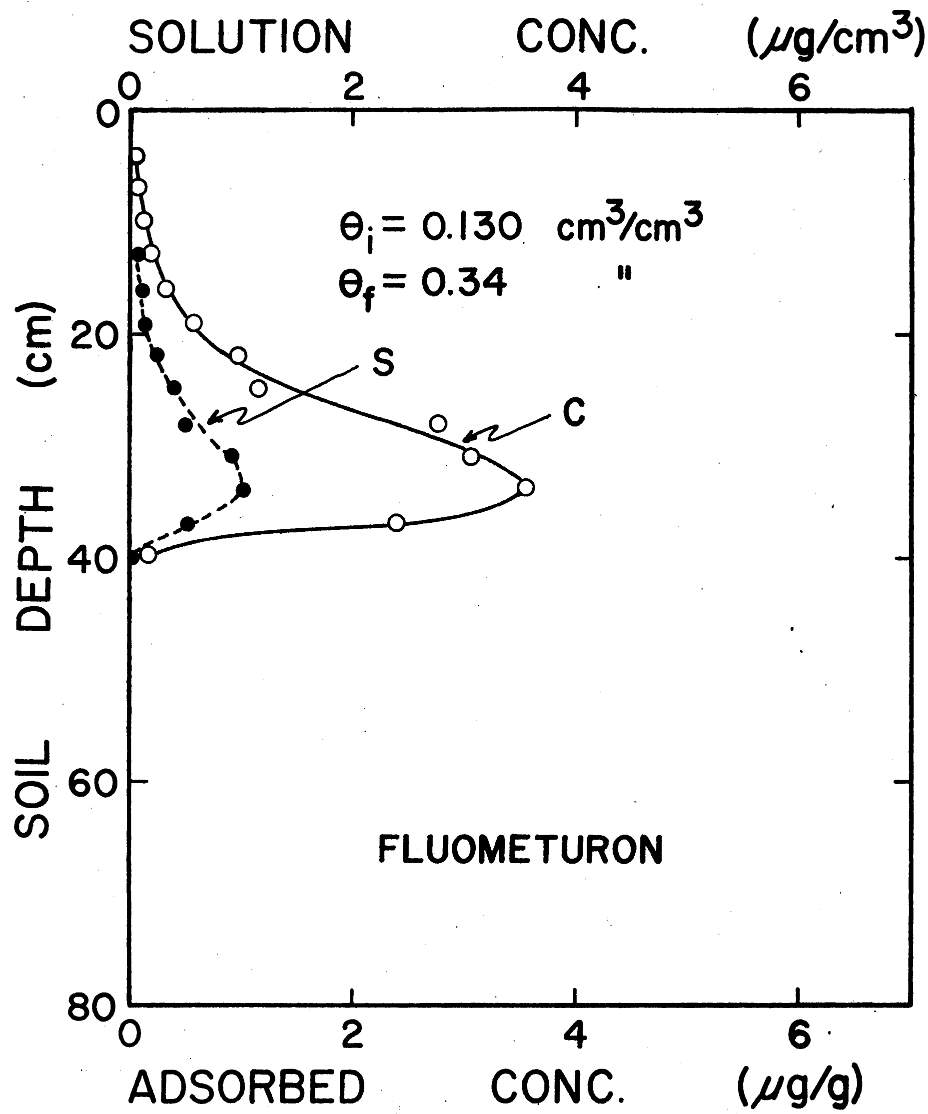

Figure 10. Solution and Adsorbed Fluometuron Concentration Distributions Immediately Following Infiltration. Average Flux Was 10.0 cm/hr. θ_i is Initial Soil-Water Content and θ_f is the Final Soil-Water Content at the Soil Surface. Continous and Broken Lines Are Eye-Fitted Curves Connecting Adsorbed, S, and Solution, C, Fluometuron Concentrations, Respectively.

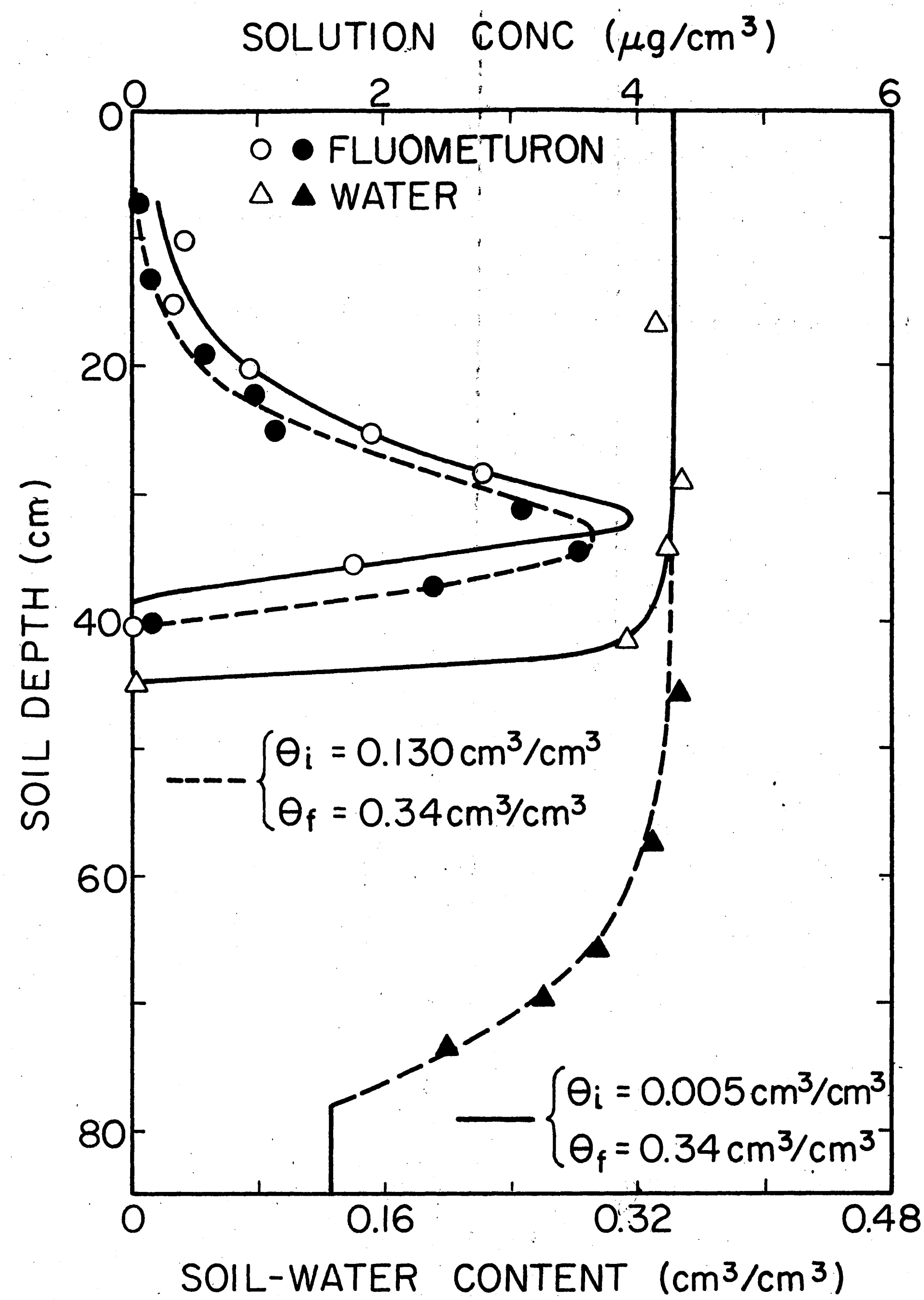

Figure 11. Fluometuron Solution Concentration and Water Distributions for the Same Accumulative Infiltration Into an Initially Wet and Dry Soil. θ_i is the Initial Soil-Water Content and θ_f is the Final Soil-Water Content at the Soil Surface. Continuous and Broken Lines Are Eye-Fitted Curves Connecting Water and Fluometuron Contents.

The fluometuron displacement depths are independent of the initial soil-water content, whereas the wetting front position is related to the initial water content. Apparently, the original soil solution in the top of the column was displaced by the infiltrating water.

Figure 12 shows the influence of the water application rate and associated boundary conditions on the displacement of fluometuron. The cumulative infiltration is the same for both columns (columns 2 and 4). The inverse relationship between leaching efficiency and surface water content shown here has been reported by several investigators (Keller and Alfaro, 1966; Warrick et al., 1971, and Kirda et al., 1973). However, this inverse relationship was not necessarily valid when comparing fluometuron displacement for ponded and 5.0 cm/hr application rates. This was a result of the final soil-water content at the soil surface and in the transmission zone being only slightly different for these rates. Also, the smaller pore-water velocities during the 5.0 cm/hr application rate allowed more time for diffusion controlled adsorption to occur. The areas under the herbicide distribution curves in Figure 12 are not equal as a result of some fluometuron remaining at the soil surface for the 1.0 and 5.0 cm/hr application rates. At least a portion of this residual fluometuron appeared to be in solution. However, the validity of the measured solution concentrations of fluometuron at the soil surface given in Table II are questionable since some herbicide may have gone into solution as a result of the sampling procedure. The residual adsorbed fluometuron concentration reported in Table II is a measure of the quantity of undesolved and adsorbed herbicide.

Experimental data from this study were used to determine the

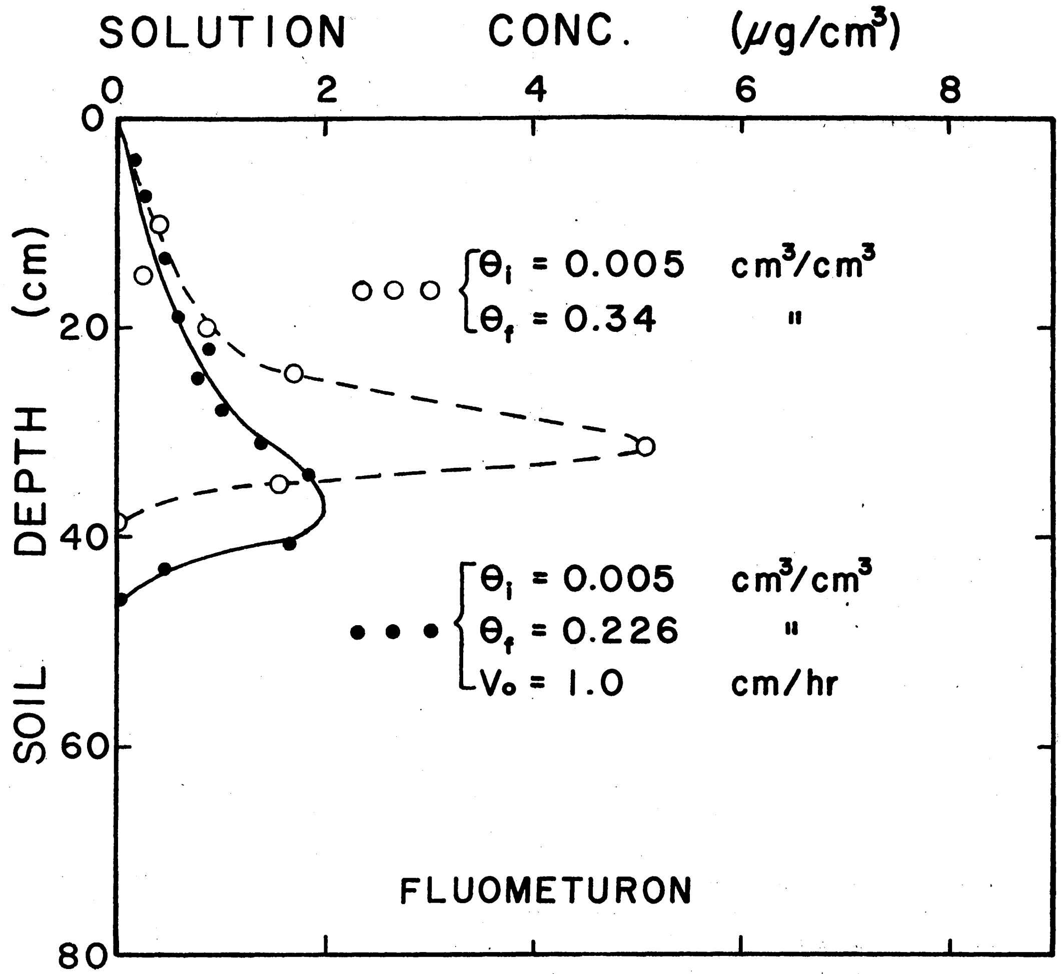

Figure 12. Distributions of Fluometuron Solution Concentration for Equal Values of Cumulative Water Infiltration. The Average Fluxes, V_o, Were 29.0 and 1.0 cm/hr. θ_i is Initial Soil- water Content and θ_f is the Final Soil-Water Content at the Soil Surface. Continuous and Broken Lines Are Eye-Fitted Curves.

usefulness of a mathematical model for predicting herbicide displacement for transient flow conditions. The model is similar to the one used by Kirda et al. (1973). However, the model used in this study included an adsorption or sink term. The solute transport and water flow equations (equations 1 and 3) were solved simultaneously in order to predict both fluometuron and water distributions. Equilibrium adsorption and desorption as described by equations (5) and (7) were also used. The dispersion coefficient, D_o, was assumed constant for each column.

Figures 13, 14, and 15 show comparisons of calculated and experimental distributions of herbicide and water. The calculated fluometuron distributions lagged behind the measured distributions in each case. However, the positions of the peak concentration and the tailing edge seem to be predicted somewhat better for the slower 4.89 cm/hr infiltration rate (Figure 15) than for the soil columns on which water was ponded. These calculated distributions were obtained using values of 0.22, 0.84, and 1.7 for K_A, 1/N, and 1/N', respectively. The value of D_o used was dependent upon the water application rate and was 0.07 cm^2/hr for application rate of 1.0 and 5.0 cm/hr and 0.10 cm^2/hr for columns on which water was ponded during infiltration. Equation (8) was used to calculate values of the distribution coefficient, K_D. The velocity and soil-water content terms used in the solute transport model were obtained from the numerical solution of the water flow equation (equation 1).

As shown in Figures 13, 14, and 15, the numerical solution of equation (1) adequately described the measured soil-water content distributions (Table V, Appendix). A uniform soil-water content

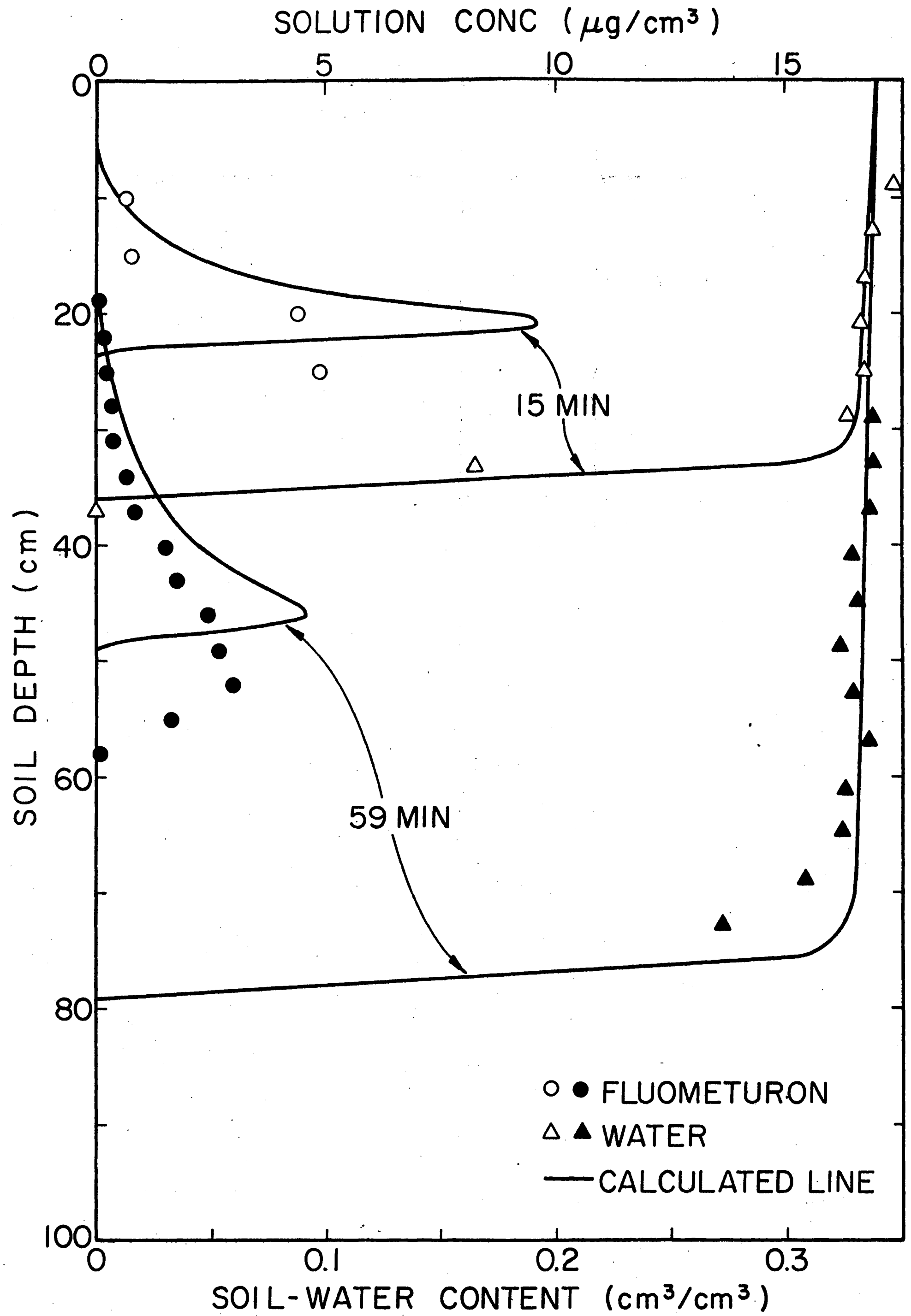

Figure 13. Experimental and Calculated Fluometuron Solution Concentration and Water Distributions After 15 and 59 min of Infiltration. Initial Soil-Water Content Was 0.005 cm^3/cm^3 and Average Flux Was 29.0 cm/hr (Column 2, Table II). Solid Lines Were Calculated Using Equations (10) and (11).

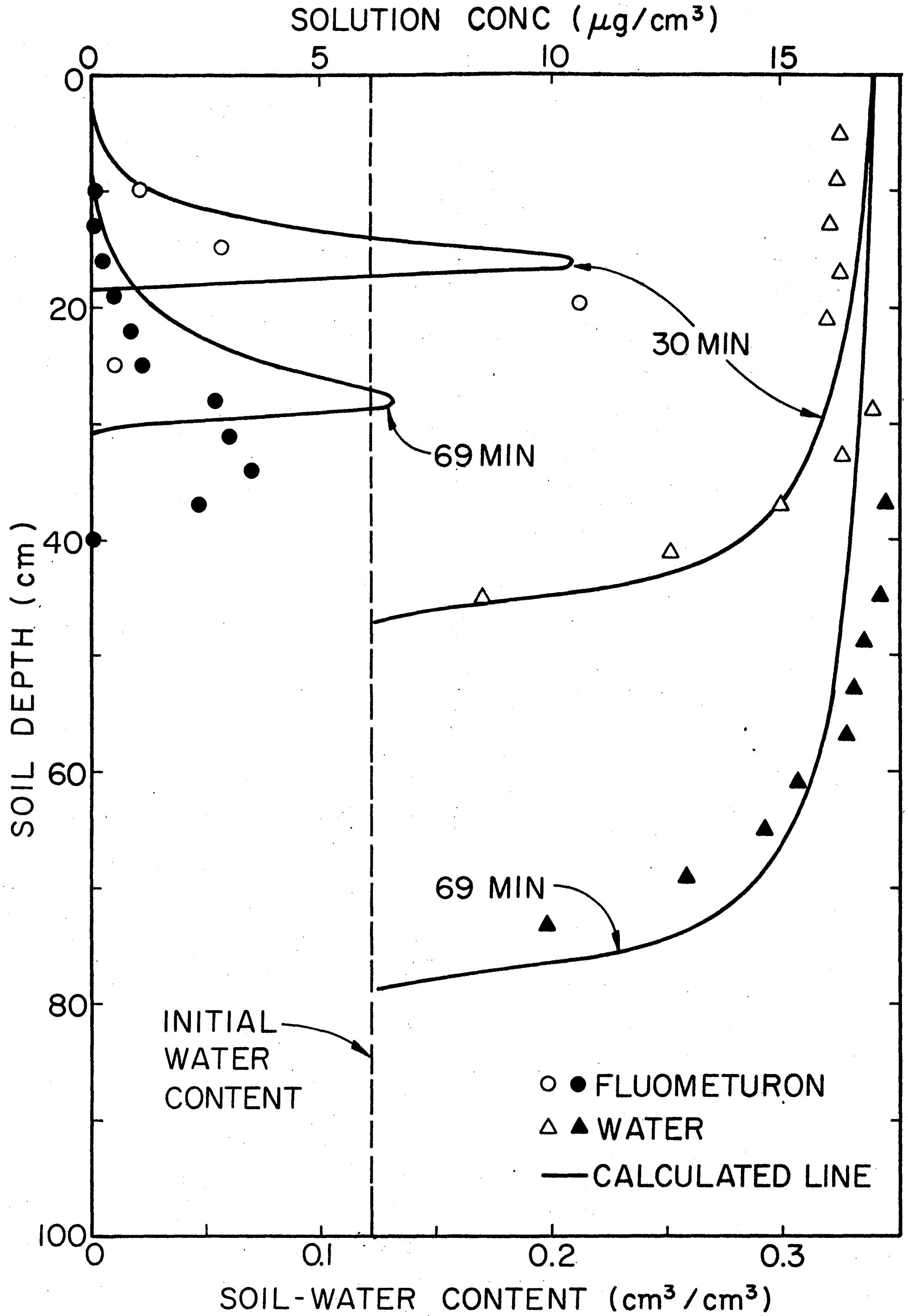

Figure 14. Experimental and Calculated Fluometuron Solution Concentration and Water Distributions After 30 and 69 min Infiltration. Initial Soil-Water Content Was 0.130 cm^3/cm^3 and Average Flux Was 10.1 cm/hr (Column 5, Table II). Solid Lines Were Calculated Using Equations (10) and (11).

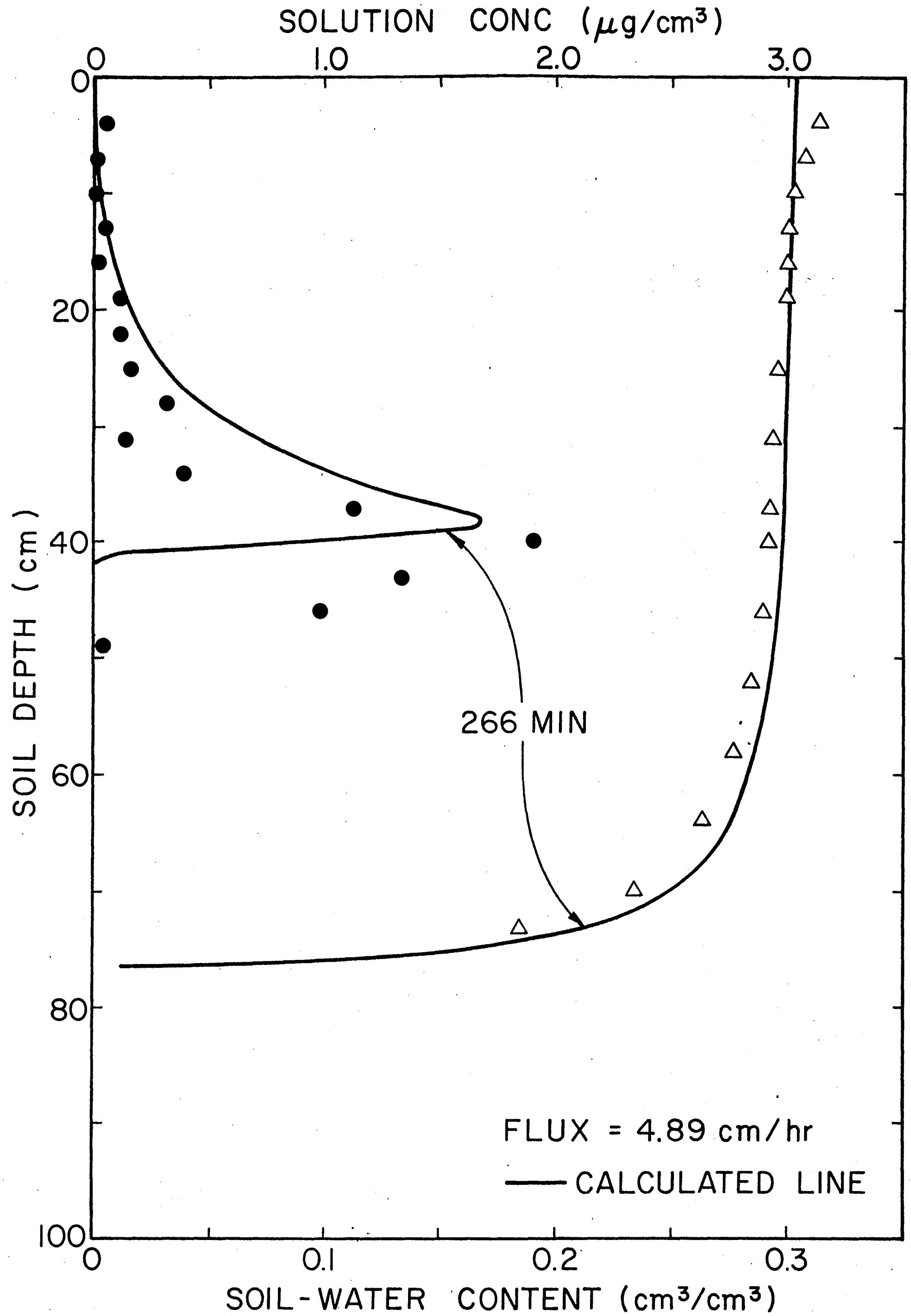

Figure 15. Experimental and Calculated Fluometuron Solution Concentration and Water Distributions After 266 Min of Infiltration. Initial Soil-Water Content Was 0.005 cm^3/cm^3 and the Flux Was 4.89 cm/hr (Column 3, Table II). Solid Lines Were Calculated Using Equations (10) and (11).

distribution was used to approximate the actual initial soil-water content distribution (Table VI, Appendix) for each initially wet soil column.

van Genuchten, Davidson and Wierenga (1974) have suggested that at high pore-water velocities, equilibrium may exist, but that only a fraction of the soil participates in the adsorption process. If there was insufficient time for the fluometuron to diffuse into smaller pores at the high pore-water velocities existing in this study, then less adsorption than predicted would have occurred. To account for the non-adsorbing fraction, a term similar to the FREQ term used by van Genuchten et al. (1974) was added to the model. Since the bulk density, ρ, is a measure of the mass of soil per unit volume, the FREQ term was multiplied by ρ to give a measure of the mass of soil per unit volume which was actively adsorbing and desorbing herbicide. The value of FREQ was selected on the basis of its ability to describe the experimental data. It should be emphasized that a change in the ρ value as a result of multiplying it by FREQ does not indicate an actual change in the bulk density of the soil. Rather, it is an indication of a change in the surface area which was participating in the adsorption and desorption of fluometuron. For convenience and as a first approximation, the bulk density was used as a measure of the surface area of the soil. The model could be made more descriptive of the physical system by the addition of a surface area term.

Figure 16 gives the calculated fluometuron distributions for an initially wet soil on which water was ponded (column 5) during infiltration. As can be seen, the tailing edge and the position of maximum concentration were described very well by using a FREQ value of 0.5,

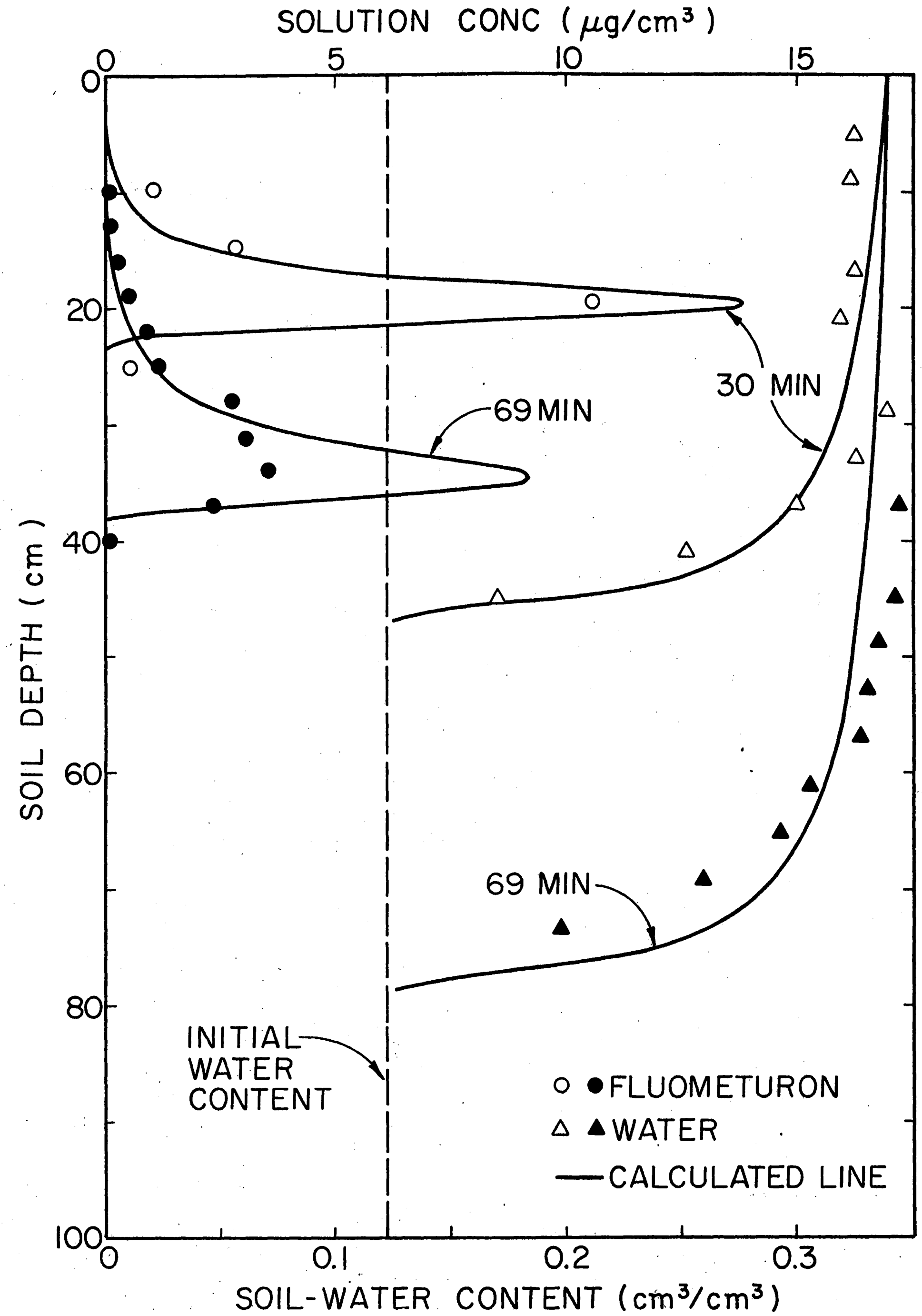

Figure 16. Experimental and Calculated Fluometuron Solution Concentration and Water Distributions for an Initial Soil-Water Content of 0.130 cm^3/cm^3 and an Average Flux of 10.1 cm/hr (Column 5, Table II). Solid Lines Were Calculated Using Equations (10) and (11) for a $\rho = 0.77$ g/cm^3 (FREQ = 0.5).

but the calculated peak concentration was much larger than the measured concentration. However, the calculated and measured maximum concentrations were approximately the same for column 6 (Table II). There also appears to be more dispersion of the displacing front than predicted by the model. The measured and calculated distributions of the adsorbed fluometuron for the conditions in Figure 16 are given in Figure 17. The solid line represents the distribution predicted for a value of ρ of 1.54 g/cm^3 and the broken line is the calculated curve for a ρ of 0.77 g/cm^3 (FREQ = 0.5). As with the solution herbicide, the model fails to describe the measured adsorbed distributions when all the soil is assumed to be in equilibrium with the herbicide. When it is assumed that only half of the soil material is actively participating in the adsorption process (ρ = 0.77 g/cm^3), the calculated and experimental curves agree very well.

Similar comparisons of calculated and measured solution and adsorbed distributions of fluometuron for ponded infiltration into initially dry soil (column 2) using FREQ values are given in Figures 18 and 19. The solution distribution for an elapsed time of 15 minutes seemed to be predicted reasonably well. However, the data for this time was insufficient to make a good comparison. After 59 minutes of infiltration, the model described the tailing portion of the distribution adequately but failed to describe the location of the peak and the displacing front. Again the displacing front was more disperse than predicted by the model. The failure of the model to describe the location of the maximum concentration may have been due to non-equilibrium conditions between the herbicide and the soil even for the soil fraction participating in the adsorption process. This non-equilibrium

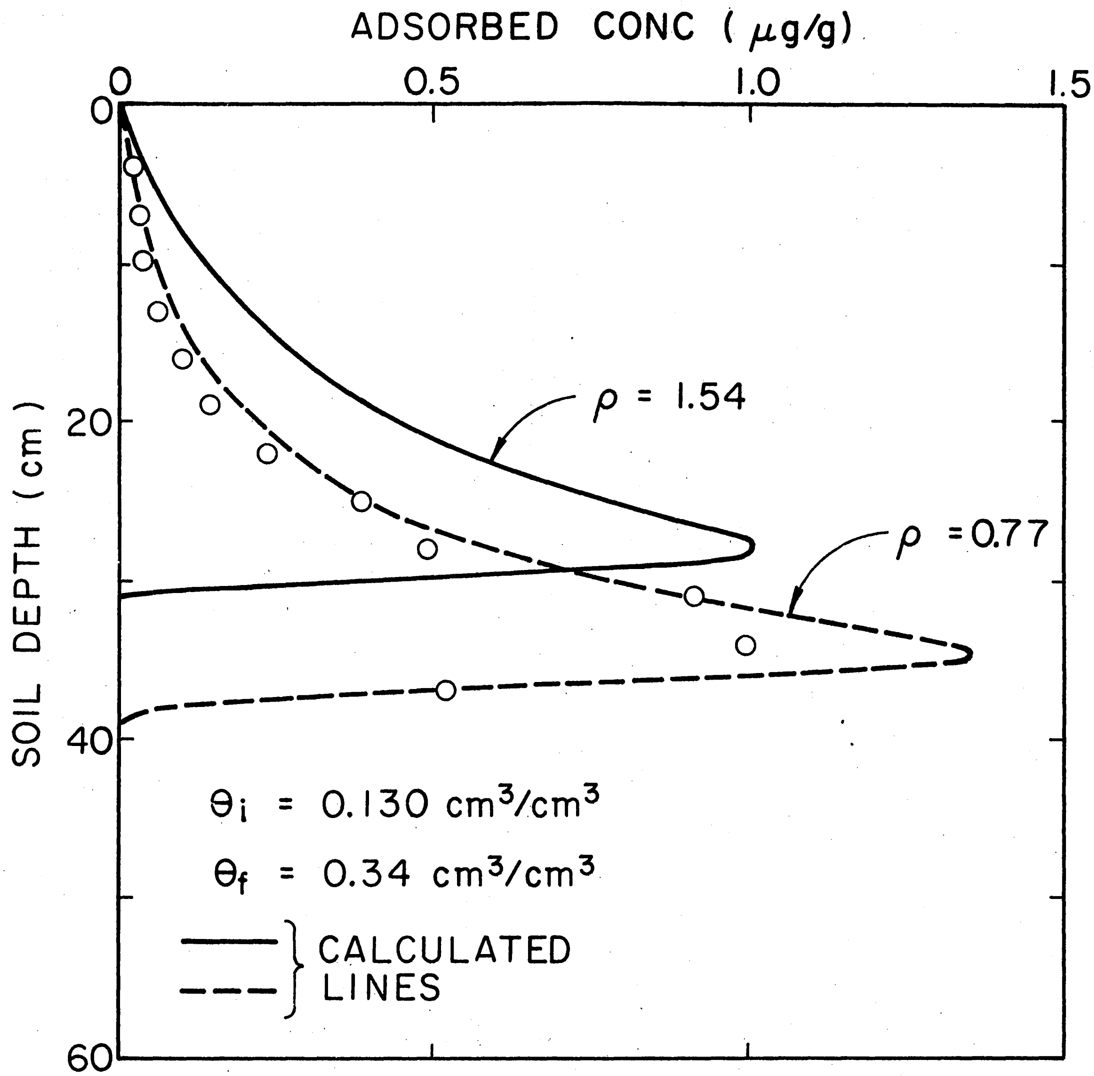

Figure 17. Experimental and Calculated Distributions of Adsorbed Fluometuron. θ_i is the Initial Soil-Water Content and θ_f is the Final Soil-Water Content at the Soil Surface. The Average Flux Was 10.1 cm/hr (Column 5, Table II). Solid and Broken Lines Were Calculated Curves for $\rho = 1.54$ and $\rho = 0.77$ g/cm^3, Respectively

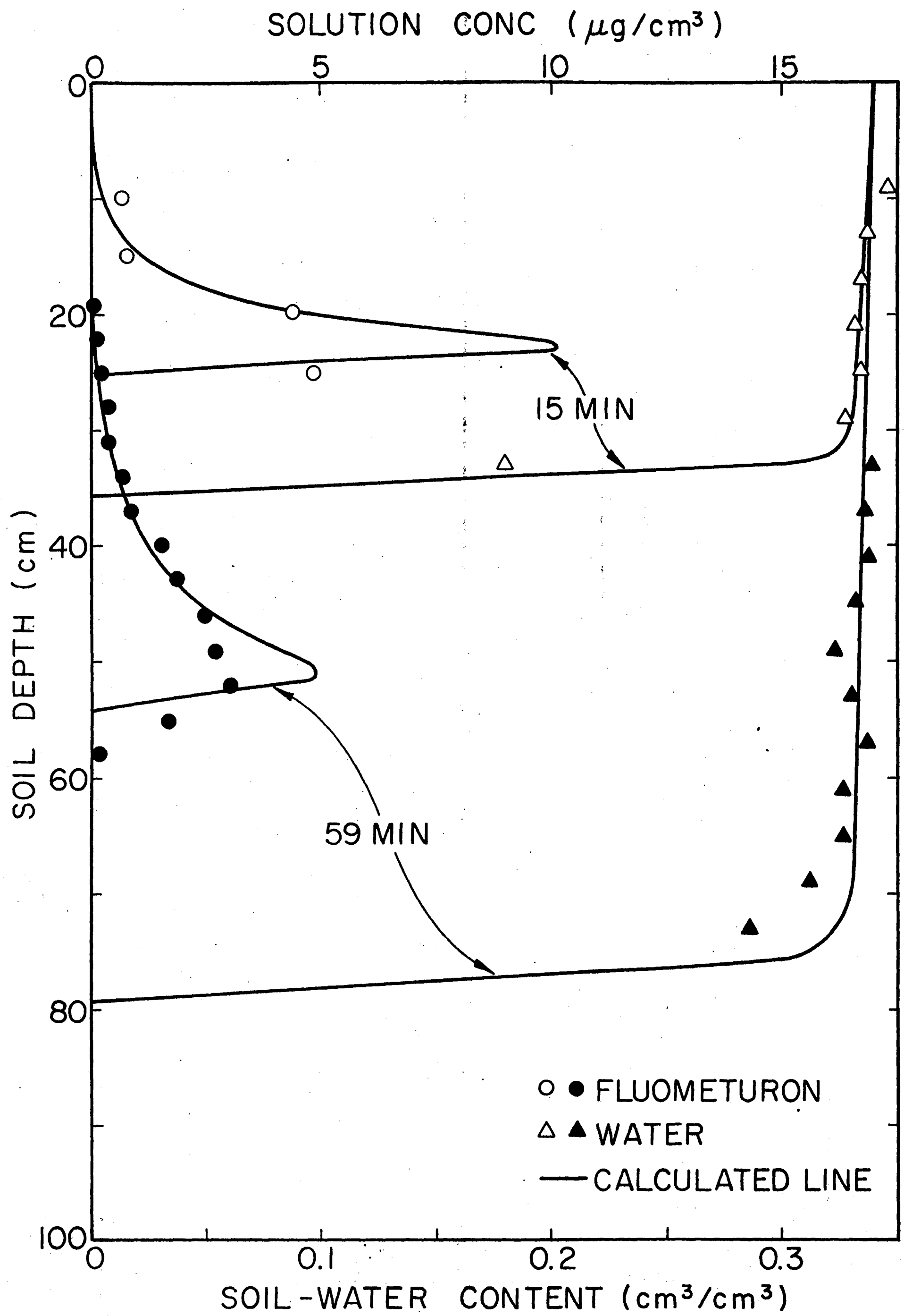

Figure 18. Experimental and Calculated Fluometuron Solution Concentration and Water Distributions For an Initial Soil-Water Content of 0.005 cm^3/cm^3 and an Average Flux of 29.0 cm/hr (Column 2, Table II). Solid Lines Were Calculated Using Equations (10) and (11) for $\rho = 1.16$ g/cm^3 (FREQ = 0.75).

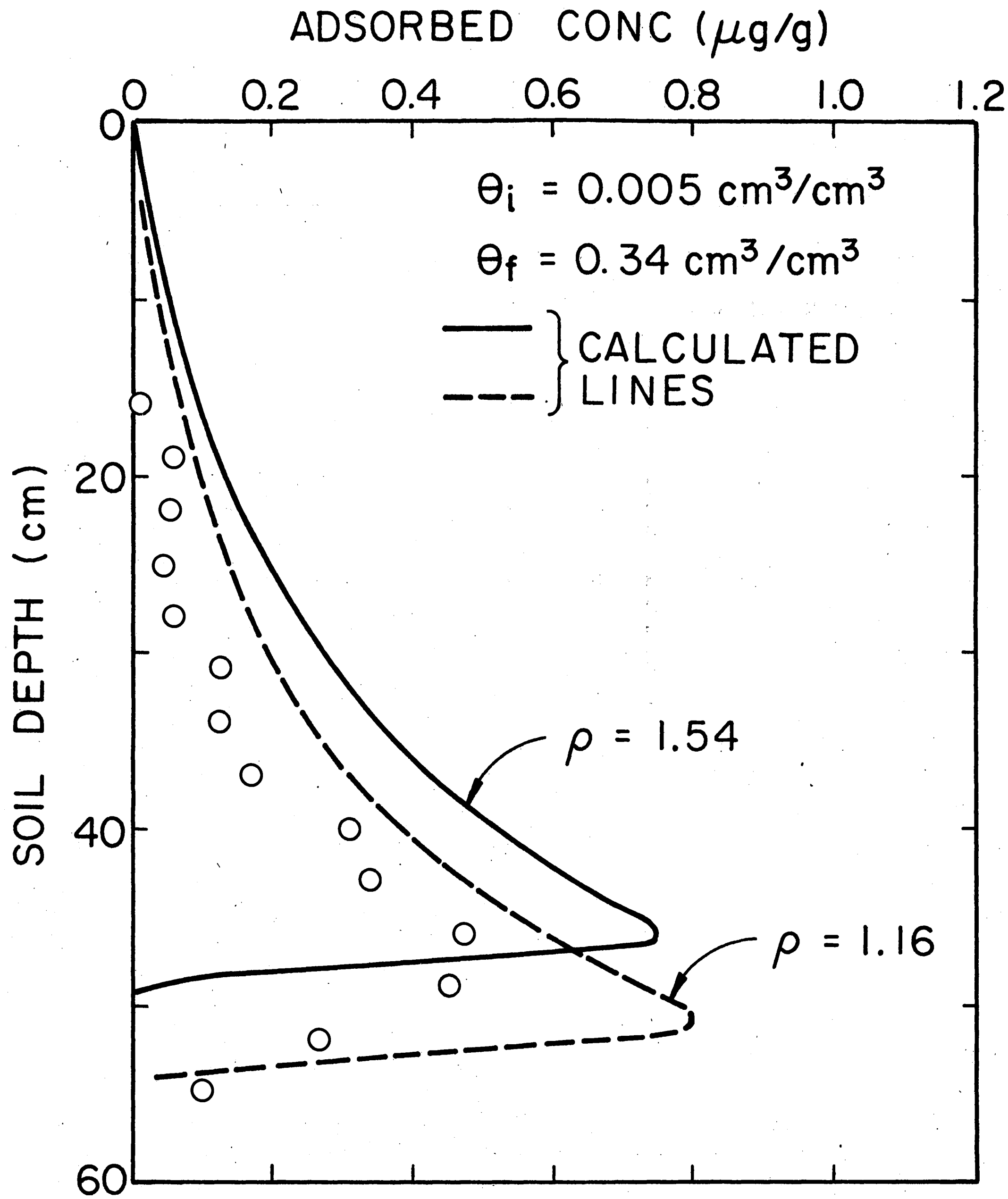

Figure 19. Experimental and Calculated Distributions of Adsorbed Fluometuron. θ_i is the Initial Soil-Water Content and θ_f is the Final Soil-Water Content at the Soil Surface. The Average Flux Was 29.0 cm/hr (Column 2, Table II). Solid and Broken Lines Were Calculated for $\rho = 1.54$ and $\rho = 1.16$ g/cm^3, Respectively.

is also indicated when the calculated and experimental adsorbed curves are compared, Figure 19. The predicted peak for the adsorbed concentration is at a greater depth than the measured peak. Also, the measured quantity adsorbed is less than predicted. The direction in which the calculated peaks are shifted from the experimentally observed peaks are opposite for the solution and adsorbed phases. This too would suggest non-equilibrium conditions. The non-equilibrium in this column was probably a result of the extremely large pore-water velocities. The average infiltration rate and pore-water velocities were higher in this treatment than in any of the other treatments examined.

The failure of the model to describe the shape of the displacing fluometuron front may be the result of using a constant value for the dispersion coefficient or too low a value for this parameter. The velocity dependence of the dispersion coefficient has been shown by several investigators (Kay and Elrick, 1967, and Kirda et al., 1973).

In general, the mathematical model adequately described the shape and position of the fluometuron and water distributions when a FREQ term was used to account for the fraction of the total surface area participating in the adsorption process. However, further studies need to be conducted on the influence of pore-size distribution and pore-water velocity on the adsorption and dispersion of herbicides moving through soil. Also, the usefulness of the mathematical model used in this study should be evaluated with additional laboratory and field data. Of particular interest would be the ability of this model to describe herbicide movement for infiltration rates and associated pore-water velocities small enough to allow radial diffusion of the herbicide.

CHAPTER VI

SUMMARY

A laboratory study was conducted to evaluate the movement of surface applied fluometuron during infiltration through a soil column. The soil (referred to as Cobb sand) was the top 15-cm of a profile classified as Cobb fine sandy loam soil. Samples of the soil solution were collected at various soil depths during infiltration. Equilibrium adsorption-desorption between fluometuron and Cobb sand was measured and characterized by the Freundlich equation. The solution and adsorbed herbicide distributions in the soil at the cessation of infiltration were obtained by collecting soil samples immediately after the infiltration process. Fluometuron distributions in the soil at various times during infiltration were obtained from the soil solution samples.

Fluometuron distributions were measured for three water application rates and two initial soil-water contents. It was concluded that fluometuron movement through the soil was independent of the soil-water content prior to infiltration as long as the soil surface water content was the same. This occurred because the invading or infiltrating water displaced the orginal soil water in the top of the column.

The effect of the soil-water content at the soil surface during infiltration on the displacement of fluometuron was evaluated by using various infiltration rates. The depth to which fluometuron was moved for a given quantity of water was found to be dependent on the surface

water content during infiltration. Decreasing the soil-surface water content by reducing the water application rate resulted in a deeper displacement of fluometuron for the same accumulative infiltration.

The experimental data indicated that equilibrium adsorption and desorption occurred for all treatments except ponded infiltration into initially dry soil. The non-equilibrium conditions for this column were probably the result of very large pore-water velocities. The infiltration rates used in this sutdy were larger than those normally found over long periods of time under field conditions. It could, therefore, be concluded that equilibrium adsorption and desorption processes between fluometuron and Cobb sand would exist under most conditions observed in the field.

The mathematical model failed to predict the position of the fluometuron distribution in the soil. However, when it was assumed that only a fraction of the soil was participating in the adsorption process and the surface-area related term (ρ) was adjusted accordingly, the model predicted the adsorbed and solution distributions of fluometuron reasonably well. The shape of the displacing front for the herbicide was inadequately described by the model. This was an indication that the dispersion term used in the model was too low and perhaps not a constant but velocity dependent.

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APPENDIX

TABLE III

EXPERIMENTAL DATA FROM SOIL SOLUTION SAMPLES

Column 1

Flux = 18.1 cm/hr (Ponded) Initial 0 = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
4.6	3.3	1.21
4.6	7.6	0.58
4.6	33.6	0.17
10.0	6.1	5.44
10.0	9.7	2.17
10.0	35.4	0.31
10.0	45.7	0.33
10.0	60.7	0.24
15.0	11.6	3.35
15.0	19.5	1.15
15.0	29.5	0.52
15.0	49.6	0.21
20.0	14.8	9.84
20.0	22.0	4.39
20.0	26.9	2.86
20.0	36.8	1.41
20.0	44.5	0.93
20.0	57.5	0.62
20.0	71.8	1.24
24.6	23.9	4.23
24.6	28.3	0.52
24.6	42.9	1.74
24.6	48.4	1.30
24.6	55.7	1.03
24.6	67.5	0.68
29.5	31.4	7.13
29.5	38.8	4.81
29.5	50.9	2.50
29.5	70.5	1.70
29.5	78.6	0.81
29.5	87.3	0.86
34.7	40.4	5.34
34.7	47.0	4.46
34.7	59.3	2.49
34.7	69.0	1.76
34.7	79.9	1.08
34.7	88.7	0.77

TABLE III (Continued)

Column 1

Flux = 18.1 cm/hr (Ponded) Initial 0 = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
40.0	41.8	0.24
40.0	52.5	4.80
40.0	62.5	5.64
40.0	76.7	3.19
40.0	91.5	1.94
44.8	54.4	0.16
44.8	65.9	1.67
44.8	72.3	2.58
44.8	81.3	2.60
50.0	64.0	0.07
50.0	82.8	4.72
55.0	74.9	0.02
55.0	90.1	1.54

TABLE III (Continued)

Column 2

Flux = 29.0 cm/hr (Ponded) Initial θ = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. (μg/cm^3)
5.0	7.7	0.52
5.0	49.3	0.04
10.0	6.2	7.33
10.0	10.2	1.83
10.0	16.3	0.61
15.0	8.2	3.40
15.0	12.7	1.21
15.0	19.0	0.48
15.0	32.4	0.17
15.0	41.2	0.13
15.0	51.6	0.21
20.0	8.70	5.86
20.0	11.8	7.75
20.0	15.0	4.39
20.0	27.1	0.84
20.0	34.8	0.45
20.0	45.9	0.31
24.6	11.3	0.67
24.6	14.0	4.96
24.6	24.7	2.01
24.6	35.9	0.87
35.0	20.2	**
35.0	23.2	0.52
35.0	30.4	2.31
35.0	39.9	1.47
35.0	47.0	0.86
35.0	55.2	0.57
40.0	29.0	2.37
40.0	33.7	5.90
40.0	37.9	5.39
40.0	45.0	3.49
40.0	54.3	2.10
45.0	29.5	**
45.0	36.8	1.28
45.0	42.8	3.27
45.0	50.3	2.86
50.0	38.9	0.03
50.0	48.4	6.95

TABLE III (Continued)

Column 2

Flux = 29.0 cm/hr (Ponded) Initial θ = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. (ug/cm^3)
50.0	52.9	7.48
60.0	56.9	0.22

** Less than 0.01

TABLE III (Continued)

Column 3

Flux = 4.89 cm/hr   Initial θ = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
2.0	14.0	1.14
2.0	25.0	0.10
2.0	35.0	0.03
2.0	53.0	0.01
2.0	90.0	0.01
2.0	226.0	**
5.0	20.0	0.01
5.0	28.0	0.02
5.0	37.0	0.04
5.0	45.0	0.09
5.0	56.0	0.15
5.0	68.0	0.09
5.0	78.0	0.08
5.0	134.0	0.04
5.0	229.0	0.05
10.0	42.0	0.02
10.0	49.0	0.12
10.0	58.0	1.00
10.0	70.0	2.13
10.0	81.0	3.20
10.0	96.0	5.87
10.0	107.0	8.39
10.0	186.0	2.19
15.0	65.0	0.09
15.0	75.0	0.48
15.0	84.0	1.05
15.0	94.0	1.33
15.0	103.0	1.11
15.0	117.0	0.87
15.0	152.0	0.32
20.0	87.0	0.01
20.0	99.0	0.02
20.0	110.0	0.01
20.0	122.0	0.01
20.0	137.0	0.02
20.0	161.0	0.01
20.0	176.0	0.01
20.0	190.0	0.01

TABLE III (Continued)

Column 3

Flux = 4.89 cm/hr   Initial θ = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
20.0	254.0	**
25.0	113.0	0.01
25.0	125.0	**
25.0	139.0	0.01
25.0	155.0	0.04
25.0	166.0	0.08
25.0	181.0	0.10
25.0	196.0	0.07
25.0	211.0	0.05
25.0	232.0	0.03
30.0	130.0	0.01
30.0	141.0	0.03
30.0	157.0	0.07
30.0	169.0	0.40
30.0	178.0	1.22
30.0	193.0	3.65
30.0	208.0	5.45
30.0	234.0	5.74
35.0	173.0	0.01
35.0	184.0	0.08
35.0	199.0	0.31
35.0	216.0	0.55
35.0	241.0	0.59
40.0	202.0	**
40.0	219.0	**
40.0	246.0	0.01
45.0	222.0	**
45.0	252.0	**

** Less than 0.01

TABLE III (Continued)

Column 4

Flux = 1.00 cm/hr Initial 0 = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
4.5	54.0	0.07
4.5	87.0	0.03
4.5	139.0	0.02
4.5	195.0	0.01
4.5	267.0	0.01
4.5	355.0	0.02
4.5	505.0	0.01
4.5	864.0	**
9.7	184.0	0.02
9.7	244.0	0.16
9.7	280.0	0.33
9.7	318.0	1.23
9.7	364.0	2.29
9.7	406.0	2.47
9.7	444.0	2.44
9.7	513.0	1.67
9.7	723.0	0.37
9.7	869.0	0.25
14.7	227.0	0.01
14.7	297.0	0.05
14.7	385.0	0.05
14.7	418.0	0.06
14.7	457.0	0.08
14.7	490.0	0.07
14.7	545.0	0.05
14.7	622.0	0.01
14.7	669.0	0.03
14.7	915.0	0.01
20.0	323.0	0.01
20.0	374.0	0.02
20.0	412.0	0.04
20.0	450.0	0.06
20.0	498.0	0.02
20.0	553.0	0.05
20.0	631.0	0.07
20.0	677.0	0.06
20.0	713.0	0.06
20.0	821.0	0.04
24.5	380.0	0.03

TABLE III (Continued)

Column 4

Flux = 1.00 cm/hr | Initial 0 = 0.005 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
24.5	522.0	0.82
24.5	566.0	1.70
24.5	614.0	1.72
24.5	660.0	1.38
24.5	707.0	1.03
24.5	759.0	0.84
24.5	799.0	0.75
24.5	959.0	0.65
29.8	559.0	0.01
29.8	605.0	0.02
29.8	651.0	0.01
29.8	700.0	0.05
29.8	754.0	0.29
29.8	789.0	0.57
29.8	829.0	0.99
29.8	899.0	1.67
34.5	763.0	0.02
34.5	794.0	0.01
40.0	806.0	**
40.0	849.0	**
40.0	892.0	**
40.0	945.0	**
44.4	814.0	**
44.4	858.0	**
44.4	909.0	0.03
44.4	887.0	**

** Less than 0.01

TABLE III (Continued)

Column 5

Flux = 10.1 cm/hr (Ponded) Initial 0 = 0.130 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
5.0	3.3	9.21
5.0	10.5	2.08
5.0	16.0	0.90
5.0	33.5	0.21
5.0	59.0	0.20
10.0	5.0	20.21
10.0	8.5	12.59
10.0	18.5	3.15
10.0	24.3	1.67
10.0	38.6	0.52
10.0	59.5	0.21
15.0	4.8	0.03
15.0	12.2	12.91
15.0	17.4	9.05
15.0	23.3	4.51
15.0	29.0	2.92
15.0	39.0	1.82
15.0	45.0	0.77
15.0	66.0	0.24
20.0	6.5	**
20.0	10.0	**
20.0	17.0	1.77
20.0	22.2	12.39
20.0	28.3	11.46
20.0	35.0	6.79
20.0	47.5	2.35
20.0	58.0	0.95
20.0	67.5	0.53
25.0	9.3	**
25.0	13.9	0.03
25.0	19.0	0.03
25.0	24.0	0.10
25.0	31.3	2.33
25.0	40.0	12.55
25.0	47.2	8.11
25.0	55.0	4.78
25.0	68.0	1.82
30.0	14.3	0.04

TABLE III (Continued)

Column 5

Flux = 10.1 cm/hr (Ponded) Initial θ = 0.130 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. (μg/cm^3)
30.0	21.0	**
30.0	26.5	**
30.0	30.5	0.06
30.0	41.0	1.70
30.0	51.5	10.43
30.0	65.5	4.89
35.0	21.5	**
35.0	27.0	**
35.0	37.6	0.01
35.0	43.0	0.08
35.0	53.0	1.29
35.0	61.5	7.67
40.0	32.3	**
40.0	36.5	**
40.0	43.5	**
40.0	49.5	0.03
40.0	56.5	0.03
40.0	64.0	0.22
44.0	35.5	**
44.0	49.0	0.03
44.0	57.5	0.02
44.0	63.2	0.05

** Less than 0.01

TABLE III (Continued)

Column 6

Flux = 17.6 cm/hr (Ponded) Initial θ = 0.140 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
5.0	1.8	9.95
5.0	2.8	15.23
5.0	4.2	5.59
5.0	9.0	1.18
5.0	12.1	0.41
5.0	55.1	0.04
10.0	5.0	**
10.0	7.8	11.81
10.0	14.4	5.62
10.0	18.1	2.52
10.0	26.4	0.80
10.0	45.1	0.17
15.0	8.0	0.03
15.0	10.7	0.06
15.0	13.8	3.83
15.0	17.0	17.59
15.0	22.3	10.13
15.0	26.6	5.80
15.0	36.1	2.20
15.0	47.5	0.71
20.0	12.7	0.04
20.0	16.4	0.02
20.0	24.3	5.66
20.0	38.9	2.26
20.0	42.3	1.48
20.0	52.3	0.66
20.0	60.7	0.37
25.0	20.7	**
25.0	24.0	0.06
25.0	28.4	0.09
25.0	33.7	3.86
25.0	38.3	4.07
25.0	41.2	2.70
25.0	45.0	1.75
25.0	50.5	0.91
25.0	58.0	0.43
30.0	22.2	**
30.0	27.2	**

TABLE III (Continued)

Column 6

Flux = 17.6 cm/hr (Ponded) Initial 0 = 0.140 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
30.0	31.4	0.07
30.0	36.6	0.19
30.0	40.6	5.04
30.0	47.4	10.33
30.0	50.8	7.50
30.0	53.2	5.82
30.0	57.2	3.95
35.0	39.6	0.06
35.0	42.7	0.05
35.0	49.1	1.25
35.0	52.7	4.37
35.0	56.0	5.69
35.0	59.5	4.91
40.0	34.6	**
40.0	43.8	**
40.0	48.7	0.05
40.0	55.4	0.04
40.0	58.3	0.11

** Less than 0.01

TABLE III (Continued)

Column 7

Flux = 5.16 cm/hr   Initial θ = 0.130 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
5.0	15.0	0.05
5.0	25.5	0.50
5.0	41.5	4.58
5.0	71.0	1.15
5.0	114.0	0.95
5.0	154.0	0.39
9.5	28.5	14.50
9.5	37.0	0.35
9.5	55.5	0.08
9.5	74.5	0.04
9.5	96.5	**
9.5	121.0	0.01
9.5	154.5	**
15.0	44.5	0.02
15.0	64.5	0.25
15.0	81.5	0.36
15.0	109.5	0.11
15.0	146.0	0.06
19.5	48.0	**
19.5	62.0	**
19.5	100.0	0.33
19.5	139.0	2.07
19.5	157.0	1.57
25.0	53.0	**
25.0	67.0	**
25.0	85.5	0.01
25.0	107.0	0.02
25.0	131.0	3.75
25.0	156.5	2.62
30.0	79.0	0.01
30.0	91.0	**
30.0	104.5	**
30.0	124.5	**
30.0	143.5	0.08
35.0	94.5	**
35.0	118.0	**

** Less than 0.01

TABLE III (Continued)

Column 8

Flux = 1.03 cm/hr Initial θ = 0.125 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
2.0	264.0	0.07
2.0	313.0	0.04
2.0	533.0	**
5.0	54.0	2.18
5.0	74.0	6.31
5.0	100.0	2.23
5.0	137.0	0.59
5.0	182.0	0.21
5.0	240.0	0.09
5.0	302.0	0.04
5.0	389.0	0.02
5.0	514.0	0.02
10.0	84.0	**
10.0	121.0	0.05
10.0	150.0	2.41
10.0	176.0	4.72
10.0	216.0	2.04
10.0	257.0	0.68
10.0	290.0	0.35
10.0	353.0	0.17
10.0	405.0	0.10
10.0	501.0	0.04
15.0	130.0	**
15.0	160.0	0.05
15.0	188.0	0.02
15.0	247.0	0.72
15.0	294.0	2.20
15.0	358.0	0.91
15.0	416.0	0.40
15.0	490.0	0.20
20.0	170.0	**
20.0	226.0	**
20.0	269.0	**
20.0	308.0	1.80
20.0	361.0	**
20.0	427.0	0.18
20.0	497.0	0.29

TABLE III (Continued)

Column 8

Flux = 1.03 cm/hr — Initial 0 = 0.125 cm^3/cm^3

Soil Depth (cm)	Elapsed Time (min)	Solution Conc. ($\mu g/cm^3$)
25.0	275.0	**
25.0	315.0	**
25.0	374.0	**
25.0	439.0	1.49
25.0	511.0	2.18
30.0	281.0	**
30.0	398.0	**
35.0	384.0	**
35.0	481.0	**

** Less than 0.01

TABLE IV

EXPERIMENTAL DATA FROM SOIL SAMPLES

Column 1 — Elapsed Time = 90 Min.

Flux = 18.1 cm/hr (Ponded) — Initial θ = 0.005 cm^3/cm^3

Soil Depth (cm)	Adsorbed Conc. (µg/g)	Solution Conc. (µg/cm^3)
8	0.02	0.02
12	0.02	0.06
16	0.03	0.09
20	0.05	0.15
24	0.07	0.25
28	0.09	0.37
32	0.10	0.51
36	0.14	0.86
40	0.18	1.51
44	0.27	1.87
48	0.35	3.00
52	0.16	3.42
56	0.11	1.62
60	0	0.04
64	0	0.01

TABLE IV (Continued)

Column 2		Elapsed Time = 59 Min
Flux = 29.0 cm/hr (Ponded)		Initial θ = 0.005 cm^3/cm^3
Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. (μg/cm^3)
0	0.22	0.18
4	**	**
7	**	**
10	**	**
13	0.01	**
16	0.02	0.02
19	0.06	0.07
22	0.06	0.13
25	0.05	0.23
28	0.06	0.37
31	0.13	0.35
34	0.12	0.68
37	0.17	0.84
40	0.31	1.51
43	0.34	1.79
46	0.47	2.43
49	0.45	2.69
52	0.27	2.98
55	0.10	1.64
58	**	0.11
61	**	**

** Less than 0.01

TABLE IV (Continued)

Column 3 — Elapsed Time = 266 Min

Flux = 4.89 cm/hr — Initial θ = 0.005 cm^3/cm^3

Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. (μg/cm^3)
0	16.68	38.28
4	0.02	0.05
7	0.01	0.01
10	0.02	**
13	0.03	0.05
16	0.03	0.02
19	0.04	0.11
22	0.05	0.11
25	0.06	0.16
28	0.13	0.31
31	0.08	0.14
34	0.06	0.39
37	0.11	1.12
40	0.22	1.90
43	0.34	1.33
46	0.15	0.98
49	0.02	0.04
52	**	**
55	**	**
58	**	**
61	**	**

** Less than 0.01

TABLE IV (Continued)

Column 4		Elapsed Time = 980 Min
Flux = 1.00 cm/hr		Initial θ = 0.005 cm^3/cm^3
Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. ($μg/cm^3$)
0	18.35	44.20
4	0.15	0.18
7	0.23	0.25
10	0.18	0.58
13	0.05	0.45
16	0.06	0.67
19	0.06	0.60
22	0.12	0.84
25	0.07	0.79
28	0.06	0.99
31	0.22	1.39
34	0.22	1.85
37	0.26	2.07
40	0.12	1.74
43	0.08	0.44
46	**	0.02
49	**	0.01
52	**	**
55	**	**
58	**	**
61	**	**

** Less than 0.01

TABLE IV (Continued)

Column 5		Elapsed Time = 69 Min
Flux = 10.1 cm/hr		Initial 0 = 0.130 cm^3/cm^3
Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. (μg/cm^3)
0	0.32	0.19
4	0.02	0.05
7	0.03	0.07
10	0.04	0.12
13	0.06	0.18
16	0.10	0.30
19	0.14	0.56
22	0.23	0.96
25	0.39	1.14
28	0.49	2.75
31	0.91	3.05
34	1.00	3.52
37	0.51	2.37
40	**	0.16
43	**	0.02
46	**	0.02
49	**	0.01
52	**	**
55	**	0.04
58	**	**
61	**	**

** Less than 0.01

TABLE IV (Continued)

Column 6		Elapsed Time = 62 Min
Flux = 17.6 cm/hr		Initial θ = 0.140 cm^3/cm^3
Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. (μg/cm^3)
0	0.58	0.49
4	0.04	0.06
7	0.04	0.11
10	0.06	0.15
13	0.08	0.25
16	0.10	0.35
19	0.13	0.60
22	0.19	1.05
25	0.25	1.52
28	0.35	2.92
31	0.70	5.28
34	0.91	7.80
37	0.48	4.55
40	**	0.03
43	**	**
46	**	**
49	**	**
52	**	**
55	**	**
58	**	**
61	**	**

** Less than 0.01

TABLE IV (Continued)

Column 7 — Elapsed Time = 161 Min

Flux = 5.16 cm/hr — Initial 0 = 0.130 cm^3/cm^3

Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. (μg/cm^3)
0	10.28	45.69
4	0.07	0.46
7	0.07	0.34
10	--	5.16
13	0.22	0.63
16	--	1.24
19	0.28	13.55
22	**	10.01
25	0.36	6.12
28	0.16	1.52
31	0.05	0.15
34	**	0.02
37	**	**
40	**	**
43	**	**
46	**	**
49	**	**
52	**	**
55	**	**
58	**	**
61	**	**

** Less than 0.01

TABLE IV (Continued)

Column 8		Elapsed Time = 585 Min
Flux = 1.03 cm/hr		Initial 0 = 0.125 cm^3/cm^3
Soil Depth (cm)	Adsorbed Conc. (μg/g)	Solution Conc. ($\mu g/cm^3$)
0	2.63	3.15
4	0.11	0.09
7	0.11	0.17
10	0.03	0.23
13	0.02	0.20
16	0.13	0.15
19	0.06	0.33
22	0.10	0.28
25	0.08	0.37
28	0.02	0.04
31	**	**
34	**	**
37	**	**
40	**	**
43	**	**
46	**	**
49	**	**
52	**	**
55	**	**
58	**	**
61	**	**

** Less than 0.01

TABLE V

EXPERIMENTAL SOIL-WATER CONTENT DATA

COLUMN 1 — BULK DENSITY = 1.530 G/CC — SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
36.51	1.0	31.70	32.28	20.0	26.30	32.24	30.0	44.60
36.87	1.0	38.30	32.62	20.0	27.80	28.38	31.0	17.50
36.76	1.0	46.60	32.97	20.0	30.80	32.84	31.0	40.90
37.49	1.0	58.40	33.01	20.0	33.40	32.56	31.0	50.30
37.23	1.0	72.00	32.78	20.0	45.20	32.31	31.0	56.50
37.71	2.0	20.50	30.63	21.0	8.60	32.54	31.0	62.60
36.17	5.0	32.10	32.85	21.0	40.00	32.59	31.0	75.80
36.24	5.0	37.90	32.52	21.0	49.00	28.29	32.0	18.60
35.73	6.0	36.70	32.84	21.0	57.20	28.39	33.0	19.80
35.27	6.0	47.20	33.05	21.0	60.80	30.06	35.0	24.40
35.66	6.0	59.00	32.75	21.0	74.60	30.52	35.0	25.40
36.32	6.0	72.60	29.14	22.0	9.00	31.90	35.0	29.00
33.71	10.0	2.10	31.88	22.0	9.80	32.17	35.0	34.70
33.75	10.0	22.00	32.79	22.0	10.60	32.22	35.0	69.90
34.49	10.0	26.80	28.26	24.0	10.20	32.40	36.0	36.50
34.44	10.0	31.30	25.67	25.0	11.00	32.27	36.0	41.30
34.27	10.0	32.50	31.01	25.0	12.50	32.23	36.0	50.90
34.43	10.0	45.80	31.20	25.0	13.40	32.33	36.0	63.30
33.28	11.0	2.80	32.96	25.0	23.50	32.59	36.0	76.60
33.83	11.0	39.20	33.00	25.0	28.20	28.57	40.0	29.50
34.09	11.0	47.80	32.97	25.0	33.80	31.29	40.0	35.20
34.33	11.0	57.80	33.09	25.0	70.70	31.78	40.0	44.00
34.06	11.0	59.60	26.61	26.0	12.00	26.13	41.0	29.90
34.21	11.0	73.30	31.18	26.0	14.70	31.26	41.0	41.70
16.70	12.0	2.50	32.08	26.0	37.00	31.84	41.0	51.50
33.01	15.0	22.50	31.80	26.0	40.50	31.57	41.0	55.90
33.06	15.0	27.30	31.57	26.0	49.60	31.74	41.0	63.90
33.20	15.0	32.90	31.85	26.0	61.80	31.57	41.0	77.20
33.64	15.0	71.40	31.93	26.0	75.20	26.35	45.0	35.60
33.59	16.0	6.10	26.05	27.0	13.00	31.31	45.0	69.30
33.70	16.0	37.40	31.14	27.0	15.40	23.95	46.0	36.00
33.24	16.0	39.60	26.23	28.0	14.20	30.73	46.0	42.20
33.73	16.0	48.40	26.52	29.0	15.00	31.59	46.0	52.10
33.45	16.0	60.20	31.1[illegible]	29.0	18.10	32.17	46.0	64.50
33.57	16.0	74.00	26.73	30.0	16.10	32.63	46.0	77.90
32.93	17.0	7.10	31.77	30.0	19.20	30.85	51.0	52.80
29.48	19.0	6.60	32.84	30.0	24.00	30.59	51.0	55.20
29.50	20.0	7.50	32.82	30.0	28.60	31.84	51.0	65.10
32.85	20.0	9.30	32.20	30.0	30.30	32.13	51.0	78.60
32.34	20.0	23.00	32.72	30.0	34.30	0.75	53.0	43.10

TABLE V (CONTINUED)

COLUMN 1 BULK DENSITY = 1.530 G/CC SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
30.27	55.0	68.70	1.26	59.0	54.00	30.22	66.0	80.50
25.61	56.0	53.40	32.26	60.0	90.60	27.46	70.0	81.20
30.98	56.0	65.70	0.87	61.0	54.60	1.21	75.0	82.60
30.95	56.0	79.30	29.40	61.0	66.40	1.65	78.0	89.10
1.26	59.0	54.00	30.73	61.0	79.90			

TABLE V (CONTINUED)

COLUMN 2 BULK DENSITY = 1.522 G/CC SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
22.83	1.0	0.0	33.49	21.0	10.06	33.37	37.0	34.98
38.90	1.0	15.85	33.60	21.0	23.83	33.65	37.0	41.41
39.29	1.0	26.50	33.99	21.0	31.49	34.08	37.0	54.70
39.36	1.0	36.09	34.18	21.0	40.44	0.74	41.0	20.60
39.08	1.0	48.00	33.74	21.0	53.37	0.05	41.0	20.92
37.19	5.0	1.79	1.27	25.0	8.50	7.86	41.0	21.62
37.46	5.0	1.90	0.37	25.0	8.80	19.02	41.0	21.91
37.05	5.0	16.18	0.69	25.0	9.09	26.59	41.0	22.23
36.91	5.0	19.99	9.38	25.0	9.39	30.48	41.0	23.47
37.22	5.0	31.09	30.35	25.0	9.70	31.31	41.0	24.63
37.52	5.0	36.40	32.16	25.0	10.46	31.99	41.0	25.99
37.11	5.0	48.35	33.59	25.0	12.99	33.70	41.0	34.26
34.99	9.0	2.66	33.98	25.0	22.63	33.87	41.0	39.06
35.67	9.0	19.14	34.35	25.0	31.81	34.16	41.0	55.02
35.05	9.0	26.92	33.70	25.0	40.74	1.18	45.0	24.96
35.68	9.0	36.72	34.43	25.0	53.72	7.05	45.0	25.28
34.93	9.0	48.69	0.98	29.0	11.30	17.19	45.0	25.57
20.68	13.0	3.49	0.72	29.0	11.61	30.83	45.0	28.16
34.13	13.0	3.90	3.90	29.0	11.89	32.57	45.0	29.72
34.05	13.0	4.25	24.62	29.0	12.19	33.12	45.0	32.92
34.25	13.0	12.60	32.21	29.0	13.35	33.37	45.0	39.39
33.86	13.0	17.81	34.03	29.0	24.24	33.04	45.0	45.58
34.02	13.0	27.27	33.67	29.0	41.05	33.54	45.0	55.39
34.63	13.0	30.43	34.67	29.0	54.07	0.55	49.0	28.55
34.93	13.0	37.05	0.92	33.0	13.75	5.03	49.0	29.28
33.98	13.0	49.00	0.40	33.0	14.08	27.41	49.0	30.05
1.31	17.0	4.75	0.64	33.0	14.40	30.72	49.0	32.26
32.55	17.0	5.60	1.37	33.0	14.70	31.12	49.0	33.59
33.68	17.0	8.06	19.16	33.0	15.04	32.48	49.0	35.34
33.73	17.0	10.87	29.18	33.0	15.40	32.73	49.0	45.26
34.23	17.0	19.54	31.11	33.0	16.64	32.64	49.0	51.44
34.22	17.0	30.75	33.26	33.0	23.00	1.18	53.0	32.58
33.82	17.0	43.41	33.47	33.0	42.91	3.19	53.0	33.25
34.45	17.0	52.99	34.59	33.0	54.39	25.21	53.0	33.90
0.81	21.0	6.07	0.65	37.0	17.08	28.73	53.0	34.65
0.88	21.0	6.39	0.53	37.0	17.38	29.38	53.0	35.70
1.11	21.0	6.76	26.60	37.0	18.41	31.33	53.0	38.30
14.89	21.0	7.07	29.67	37.0	18.72	32.50	53.0	40.10
30.86	21.0	7.36	32.93	37.0	21.28	32.77	53.0	44.95
32.44	21.0	7.69	34.69	37.0	27.78	33.39	53.0	51.08

TABLE V (CONTINUED)

COLUMN 2 — BULK DENSITY = 1.522 G/CC — SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
1.45	57.0	37.59	30.19	61.0	46.00	32.15	65.0	56.30
27.26	57.0	38.64	30.64	61.0	47.26	2.76	69.0	51.85
29.29	57.0	39.77	31.97	61.0	50.11	15.01	69.0	52.20
30.38	57.0	41.83	32.93	61.0	56.62	24.21	69.0	52.59
31.89	57.0	44.29	1.42	65.0	46.30	29.56	69.0	55.89
33.53	57.0	50.56	0.89	65.0	46.60	30.83	69.0	57.81
2.02	61.0	42.15	1.82	65.0	46.90	10.42	73.0	57.00
7.86	61.0	42.50	19.13	65.0	47.58	23.11	73.0	57.38
27.75	61.0	43.55	28.48	65.0	49.63	26.35	73.0	58.24
28.61	61.0	44.61						

TABLE V (CONTINUED)

COLUMN 3 BULK DENSITY = 1.544 G/CC SOIL THICKNESS = 13.03 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
2.80	1.0	0.50	26.74	5.0	28.05	2.75	13.0	37.90
2.83	1.0	1.00	28.13	5.0	33.13	2.51	13.0	39.72
2.76	1.0	1.60	28.77	5.0	38.47	3.35	13.0	40.25
3.35	1.0	2.20	29.57	5.0	42.57	2.49	13.0	40.86
2.84	1.0	2.90	31.03	5.0	75.23	2.40	13.0	41.37
4.12	1.0	3.45	32.14	5.0	96.03	7.67	13.0	43.17
7.23	1.0	3.96	30.90	5.0	213.35	11.45	13.0	43.69
11.52	1.0	4.52	30.96	5.0	261.55	15.20	13.0	44.20
16.67	1.0	5.34	3.32	9.0	18.60	17.58	13.0	44.73
21.62	1.0	7.05	3.32	9.0	19.73	19.23	13.0	45.25
25.28	1.0	9.17	3.10	9.0	22.05	21.59	13.0	46.44
25.86	1.0	9.70	2.97	9.0	22.57	22.78	13.0	48.15
28.60	1.0	12.21	2.86	9.0	24.52	22.74	13.0	48.70
29.98	1.0	14.55	3.35	9.0	26.37	23.18	13.0	50.70
29.81	1.0	16.88	3.14	9.0	26.93	24.77	13.0	53.50
30.34	1.0	25.18	4.01	9.0	27.50	25.52	13.0	58.97
32.75	1.0	78.80	7.18	9.0	28.64	27.55	13.0	66.40
32.20	1.0	214.00	9.70	9.0	29.22	28.33	13.0	75.82
32.25	1.0	261.00	12.98	9.0	29.80	29.34	13.0	93.02
3.24	5.0	5.95	15.14	9.0	30.33	29.53	13.0	212.02
3.52	5.0	6.40	17.40	9.0	30.84	3.05	17.0	47.01
3.09	5.0	7.85	19.20	9.0	32.00	3.11	17.0	47.57
3.24	5.0	8.55	20.72	9.0	32.57	2.97	17.0	49.95
3.17	5.0	10.46	22.93	9.0	33.70	3.29	17.0	51.32
3.51	5.0	11.04	22.70	9.0	34.85	3.58	17.0	54.20
4.47	5.0	11.64	24.51	9.0	36.65	3.15	17.0	54.77
7.40	5.0	12.77	24.35	9.0	37.20	3.47	17.0	55.30
7.94	5.0	13.35	24.59	9.0	39.08	4.32	17.0	55.92
8.72	5.0	13.99	25.76	9.0	41.95	5.83	17.0	56.45
9.74	5.0	15.17	27.20	9.0	49.33	7.03	17.0	56.98
10.43	5.0	15.72	27.38	9.0	52.70	10.77	17.0	57.70
12.26	5.0	16.30	29.04	9.0	71.10	14.30	17.0	58.20
17.00	5.0	17.45	30.16	9.0	79.41	21.41	17.0	59.64
19.06	5.0	18.01	30.48	9.0	96.60	21.76	17.0	60.18
22.13	5.0	19.16	30.23	9.0	212.70	22.60	17.0	60.75
24.04	5.0	20.33	30.75	9.0	262.16	23.90	17.0	62.60
24.54	5.0	20.91	2.39	13.0	31.42	22.95	17.0	63.18
25.00	5.0	21.48	2.87	13.0	34.26	23.67	17.0	65.02
25.88	5.0	23.70	2.64	13.0	35.43	25.05	17.0	68.72
26.18	5.0	25.75	2.90	13.0	35.95	25.78	17.0	70.52

TABLE V (CONTINUED)

COLUMN 3 BULK DENSITY = 1.544 G/CC SOIL THICKNESS = 13.03 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
27.58	17.0	79.99	14.31	25.0	87.28	29.27	29.0	230.44
28.89	17.0	92.41	18.27	25.0	87.80	1.70	33.0	107.40
29.13	17.0	128.86	20.01	25.0	88.33	2.11	33.0	109.19
30.00	17.0	183.87	20.72	25.0	88.88	3.25	33.0	111.75
29.91	17.0	211.37	21.48	25.0	89.45	1.86	33.0	112.36
30.26	17.0	262.75	22.13	25.0	90.70	1.93	33.0	113.01
2.98	21.0	61.38	23.21	25.0	91.25	1.78	33.0	113.70
2.85	21.0	61.90	24.24	25.0	94.45	2.38	33.0	114.68
2.54	21.0	63.85	26.31	25.0	104.42	3.17	33.0	115.20
2.90	21.0	64.44	26.38	25.0	111.16	6.52	33.0	115.80
3.10	21.0	67.02	26.80	25.0	124.94	13.07	33.0	116.37
2.55	21.0	67.60	27.93	25.0	138.16	17.09	33.0	116.89
3.09	21.0	68.14	27.95	25.0	153.43	19.60	33.0	117.40
2.59	21.0	69.30	28.96	25.0	183.27	20.09	33.0	117.92
2.76	21.0	69.93	29.90	25.0	263.36	20.54	33.0	118.44
7.20	21.0	71.75	2.35	29.0	90.04	21.83	33.0	119.60
12.65	21.0	72.35	2.20	29.0	93.70	21.93	33.0	120.10
17.90	21.0	72.92	2.41	29.0	95.08	22.59	33.0	122.12
19.82	21.0	73.44	2.74	29.0	97.30	25.63	33.0	134.22
20.89	21.0	73.97	2.86	29.0	97.86	26.69	33.0	150.64
21.35	21.0	74.60	2.87	29.0	98.40	27.99	33.0	170.50
22.79	21.0	76.45	2.36	29.0	99.90	27.97	33.0	184.60
23.37	21.0	76.96	5.91	29.0	101.10	28.72	33.0	202.75
24.59	21.0	80.60	11.33	29.0	101.70	28.80	33.0	229.75
25.34	21.0	83.06	15.79	29.0	102.20	29.53	33.0	263.97
25.55	21.0	83.74	18.91	29.0	102.77	1.42	37.0	120.89
26.15	21.0	86.18	20.13	29.0	103.29	1.25	37.0	122.77
27.13	21.0	91.82	20.98	29.0	103.82	0.98	37.0	123.70
27.81	21.0	106.22	21.75	29.0	105.02	1.15	37.0	125.60
28.18	21.0	128.23	22.29	29.0	105.60	1.07	37.0	127.00
27.42	21.0	154.18	23.04	29.0	106.82	0.48	37.0	129.62
29.25	21.0	210.60	22.99	29.0	108.00	7.14	37.0	130.30
2.97	25.0	77.60	23.44	29.0	108.57	11.53	37.0	130.89
2.69	25.0	78.10	23.20	29.0	109.90	14.56	37.0	131.43
2.79	25.0	81.90	24.07	29.0	110.55	17.19	37.0	131.95
2.96	25.0	82.46	25.02	29.0	119.00	18.61	37.0	132.47
2.57	25.0	84.32	25.57	29.0	124.30	19.49	37.0	133.00
2.92	25.0	84.84	27.06	29.0	136.80	19.92	37.0	133.59
3.24	25.0	85.55	27.68	29.0	151.26	20.74	37.0	134.80
9.83	25.0	86.77	27.81	29.0	171.20	21.38	37.0	136.02

TABLE V (CONTINUED)

COLUMN 3 BULK DENSITY = 1.544 G/CC SOIL THICKNESS = 13.03 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
21.92	37.0	137.40	0.73	45.0	157.67	0.96	53.0	182.60
22.42	37.0	139.91	0.94	45.0	158.30	0.97	53.0	186.53
22.30	37.0	140.42	4.56	45.0	159.05	1.00	53.0	187.29
23.22	37.0	142.40	8.23	45.0	159.58	0.92	53.0	187.90
23.69	37.0	144.40	11.79	45.0	160.10	1.27	53.0	188.56
24.47	37.0	148.80	15.74	45.0	160.61	5.55	53.0	189.12
25.29	37.0	155.53	17.76	45.0	161.14	12.23	53.0	189.62
2.99	37.0	169.70	18.61	45.0	161.67	16.03	53.0	190.20
27.09	37.0	179.20	19.55	45.0	162.18	17.60	53.0	190.71
27.67	37.0	194.54	20.70	45.0	163.41	18.48	53.0	191.27
27.64	37.0	202.05	20.47	45.0	163.98	19.07	53.0	191.93
28.55	37.0	229.05	21.68	45.0	165.40	22.71	53.0	197.50
1.24	41.0	135.41	22.41	45.0	167.45	24.22	53.0	206.81
0.95	41.0	138.85	24.09	45.0	176.67	26.24	53.0	223.50
1.02	41.0	141.00	25.24	45.0	179.95	27.22	53.0	233.35
1.07	41.0	141.73	26.20	45.0	193.29	27.72	53.0	239.70
0.95	41.0	143.09	26.90	45.0	200.74	28.59	53.0	255.80
1.04	41.0	143.74	27.88	45.0	226.30	0.72	57.0	196.20
9.97	41.0	144.98	28.33	45.0	242.90	0.98	57.0	198.60
13.79	41.0	145.52	0.90	49.0	166.00	0.79	57.0	199.42
16.84	41.0	146.04	0.80	49.0	168.70	4.93	57.0	203.52
18.60	41.0	146.55	0.24	49.0	168.70	10.36	57.0	204.07
19.26	41.0	147.06	0.58	49.0	172.00	15.01	57.0	205.10
19.75	41.0	147.58	0.50	49.0	172.60	17.69	57.0	205.10
20.50	41.0	148.18	2.14	49.0	173.30	18.20	57.0	205.63
20.96	41.0	149.40	7.10	49.0	173.92	19.27	57.0	206.18
21.55	41.0	150.03	11.92	49.0	174.45	19.93	57.0	207.50
22.24	41.0	152.00	15.61	49.0	175.01	24.06	57.0	222.90
22.88	41.0	154.90	17.23	49.0	175.53	25.46	57.0	232.75
24.71	41.0	162.80	18.23	49.0	176.05	23.32	57.0	238.00
24.94	41.0	164.65	19.45	49.0	177.24	26.44	57.0	247.52
25.04	41.0	166.85	20.30	49.0	178.59	27.51	57.0	255.12
25.75	41.0	177.80	21.46	49.0	180.51	27.44	57.0	260.15
27.51	41.0	193.92	21.95	49.0	181.90	0.27	61.0	209.90
27.31	41.0	201.40	23.38	49.0	185.31	0.79	61.0	214.92
27.99	41.0	228.38	24.02	49.0	192.55	0.70	61.0	216.05
28.91	41.0	243.56	26.01	49.0	209.16	0.51	61.0	216.90
1.57	45.0	152.65	26.73	49.0	225.62	12.59	61.0	218.90
0.98	45.0	156.25	28.20	49.0	240.72	16.53	61.0	219.70
0.94	45.0	156.98	0.87	53.0	181.12	18.14	61.0	220.16

TABLE V (CONTINUED)

COLUMN 3 BULK DENSITY = 1.544 G/CC SOIL THICKNESS = 13.03 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
18.71	61.0	220.72	10.21	65.0	234.05	0.42	69.0	245.60
19.55	61.0	221.25	15.04	65.0	234.55	15.20	69.0	249.68
20.21	61.0	221.80	17.50	65.0	235.10	18.00	69.0	250.26
20.22	61.0	222.30	18.87	65.0	235.60	18.96	69.0	250.78
21.07	61.0	224.20	19.10	65.0	236.20	19.73	69.0	251.30
21.09	61.0	224.70	19.28	65.0	236.78	19.89	69.0	251.80
22.03	61.0	227.05	20.88	65.0	238.65	20.99	69.0	253.03
23.34	61.0	231.25	21.78	65.0	241.40	21.43	69.0	254.30
24.85	61.0	237.40	22.29	65.0	244.35	22.46	69.0	256.50
25.16	61.0	244.97	22.83	65.0	246.25	23.03	69.0	258.60
25.88	61.0	248.35	23.79	65.0	249.00	0.76	73.0	259.20
26.62	61.0	253.65	25.19	65.0	252.42	12.74	73.0	264.76
26.40	61.0	257.29	25.44	65.0	258.04	15.61	73.0	265.32
0.38	65.0	227.68	0.51	69.0	242.18	18.44	73.0	265.87
0.85	65.0	231.90						

TABLE V (CONTINUED)

COLUMN 4 BULK DENSITY = 1.540 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
6.39	0.0	3.50	1.83	3.0	17.90	9.64	5.0	53.95
6.38	0.0	4.90	1.91	3.0	21.45	12.54	5.0	60.40
6.41	0.0	5.95	1.82	3.0	22.55	13.60	5.0	65.60
6.14	0.0	7.05	2.40	3.0	26.25	14.68	5.0	73.75
5.99	0.0	8.10	3.05	3.0	27.35	15.66	5.0	84.00
6.18	0.0	9.15	3.88	3.0	28.40	16.86	5.0	92.45
6.21	0.0	10.20	6.00	3.0	30.80	18.22	5.0	105.05
6.96	0.0	11.25	6.85	3.0	31.90	19.29	5.0	118.00
8.96	0.0	12.35	8.39	3.0	33.05	20.11	5.0	130.95
6.22	1.0	14.00	10.81	3.0	35.55	20.37	5.0	152.10
7.16	1.0	15.05	11.59	3.0	38.00	21.70	5.0	215.95
9.52	1.0	19.00	12.39	3.0	40.45	22.23	5.0	263.70
9.84	1.0	20.10	12.90	3.0	42.90	22.58	5.0	305.55
10.85	1.0	23.90	15.01	3.0	48.60	23.29	5.0	369.20
10.97	1.0	25.00	15.77	3.0	55.20	23.71	5.0	432.20
12.61	1.0	29.60	15.97	3.0	61.55	23.86	5.0	503.80
14.90	1.0	36.75	16.46	3.0	66.90	23.82	5.0	562.30
15.85	1.0	41.65	16.86	3.0	75.05	24.15	5.0	622.10
17.06	1.0	49.75	17.01	3.0	85.30	24.46	5.0	687.00
17.70	1.0	56.45	17.54	3.0	93.65	24.55	5.0	838.40
17.86	1.0	62.90	18.38	3.0	106.50	24.15	5.0	951.15
18.19	1.0	68.35	19.82	3.0	133.65	1.20	9.0	59.20
18.23	1.0	76.20	21.25	3.0	211.70	1.02	9.0	64.20
18.93	1.0	86.60	21.93	3.0	265.00	1.26	9.0	69.70
19.19	1.0	94.90	21.86	3.0	304.45	1.29	9.0	70.90
20.58	1.0	107.70	23.20	3.0	433.50	1.32	9.0	72.00
20.77	1.0	135.00	22.95	3.0	502.70	0.54	9.0	77.45
21.01	1.0	150.50	23.34	3.0	563.50	0.69	9.0	78.55
21.60	1.0	210.05	23.49	3.0	623.40	0.67	9.0	79.75
21.92	1.0	266.35	23.75	3.0	688.40	0.54	9.0	82.50
22.47	1.0	303.35	23.76	3.0	834.40	3.17	9.0	88.15
22.81	1.0	375.30	23.38	3.0	952.35	3.88	9.0	89.50
23.25	1.0	436.50	1.39	5.0	34.35	4.51	9.0	90.60
23.20	1.0	501.60	1.52	5.0	39.20	7.56	9.0	96.35
23.54	1.0	564.90	1.33	5.0	44.10	8.40	9.0	99.00
24.17	1.0	624.75	1.68	5.0	45.20	10.40	9.0	103.50
23.80	1.0	690.00	2.53	5.0	46.25	11.76	9.0	110.70
24.31	1.0	833.20	3.08	5.0	47.45	13.29	9.0	116.80
24.18	1.0	953.55	7.60	5.0	51.00	15.61	9.0	129.80
1.52	3.0	16.80	8.71	5.0	52.85	18.15	9.0	143.90

TABLE V (CONTINUED)

COLUMN 4 — BULK DENSITY = 1.540 G/CC — SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
16.16	9.0	147.40	8.21	13.0	153.60	18.90	17.0	273.30
16.44	9.0	157.10	10.35	13.0	158.60	19.84	17.0	298.60
17.10	9.0	167.00	12.58	13.0	164.70	19.87	17.0	309.30
17.46	9.0	180.22	14.10	13.0	170.35	20.30	17.0	320.10
17.71	9.0	191.05	17.18	13.0	181.80	20.50	17.0	347.70
17.94	9.0	199.40	18.19	13.0	189.50	21.13	17.0	378.50
20.22	9.0	217.80	18.54	13.0	197.70	21.19	17.0	408.40
20.83	9.0	233.35	18.76	13.0	208.20	21.96	17.0	446.00
20.85	9.0	249.50	19.89	13.0	231.79	22.03	17.0	510.10
20.90	9.0	262.45	20.42	13.0	248.24	22.11	17.0	558.70
21.66	9.0	306.70	20.83	13.0	261.15	21.98	17.0	618.30
21.87	9.0	358.80	20.63	13.0	275.10	22.55	17.0	682.45
22.72	9.0	429.30	21.36	13.0	307.80	23.11	17.0	844.30
22.70	9.0	505.00	19.54	13.0	319.40	22.79	17.0	945.55
22.95	9.0	561.15	21.47	13.0	328.00	0.56	21.0	223.60
23.10	9.0	620.85	21.98	13.0	387.90	29.11	21.0	237.15
23.27	9.0	685.25	22.25	13.0	446.80	2.47	21.0	243.50
23.44	9.0	839.80	22.84	13.0	508.95	3.16	21.0	245.70
23.40	9.0	949.95	22.46	13.0	559.90	5.40	21.0	250.90
0.52	13.0	97.60	23.05	13.0	619.60	6.08	21.0	253.90
0.47	13.0	101.85	23.11	13.0	683.70	6.32	21.0	255.40
0.43	13.0	109.15	23.22	13.0	843.05	7.04	21.0	258.60
0.45	13.0	112.00	23.55	13.0	946.80	11.53	21.0	271.65
0.45	13.0	113.35	0.02	17.0	140.35	15.25	21.0	281.10
0.47	13.0	114.70	0.28	17.0	141.55	16.49	21.0	285.00
0.68	13.0	119.25	0.41	17.0	155.30	17.68	21.0	296.90
0.31	13.0	120.60	0.45	17.0	160.70	17.96	21.0	302.20
0.51	13.0	121.90	0.42	17.0	172.75	18.65	21.0	310.40
0.54	13.0	123.20	0.62	17.0	177.10	18.99	21.0	318.50
0.87	13.0	123.40	2.64	17.0	185.00	19.34	21.0	326.20
1.14	13.0	125.60	4.00	17.0	187.50	19.87	21.0	338.00
1.44	13.0	127.00	4.95	17.0	192.90	20.38	21.0	372.50
2.13	13.0	128.30	7.41	17.0	201.50	20.86	21.0	390.30
3.31	13.0	132.20	8.43	17.0	205.90	20.84	21.0	414.60
4.16	13.0	136.40	12.98	17.0	211.10	21.38	21.0	444.40
4.25	13.0	137.90	14.64	17.0	230.05	22.17	21.0	511.35
4.60	13.0	139.00	16.85	17.0	240.40	21.66	21.0	557.40
5.49	13.0	142.75	18.15	17.0	247.00	22.05	21.0	617.05
6.00	13.0	145.10	18.16	17.0	252.45	22.31	21.0	681.15
6.41	13.0	149.00	18.67	17.0	259.90	22.89	21.0	845.60

TABLE V (CONTINUED)

COLUMN 4 BULK DENSITY = 1.540 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
23.09	21.0	944.35	2.77	29.0	364.30	17.82	33.0	455.00
0.42	25.0	257.10	4.34	29.0	367.40	18.26	33.0	463.50
0.28	25.0	270.30	6.05	29.0	371.00	18.87	33.0	471.60
0.43	25.0	279.00	8.10	29.0	376.70	19.27	33.0	490.50
0.44	25.0	286.75	11.47	29.0	380.00	19.56	33.0	495.05
0.61	25.0	291.20	14.96	29.0	383.20	20.02	33.0	517.60
0.55	25.0	294.60	15.69	29.0	386.00	20.42	33.0	532.25
0.53	25.0	300.60	16.76	29.0	392.00	20.39	33.0	550.75
5.68	25.0	311.60	17.52	29.0	396.00	20.85	33.0	609.55
6.12	25.0	313.10	17.56	29.0	402.00	21.67	33.0	677.60
6.89	25.0	314.30	18.93	29.0	411.90	22.32	33.0	732.75
7.11	25.0	317.20	19.29	29.0	424.70	22.48	33.0	853.90
8.69	25.0	321.50	19.96	29.0	439.50	22.82	33.0	940.80
11.30	25.0	324.70	20.33	29.0	451.70	0.94	37.0	453.20
14.08	25.0	329.80	21.33	29.0	516.45	0.80	37.0	460.50
15.41	25.0	332.90	21.46	29.0	552.45	0.71	37.0	465.20
16.89	25.0	339.40	21.93	29.0	614.60	1.01	37.0	469.10
17.74	25.0	345.50	22.32	29.0	678.80	1.81	37.0	475.80
17.98	25.0	350.40	22.71	29.0	763.80	5.47	37.0	480.00
18.56	25.0	357.10	22.62	29.0	798.90	6.61	37.0	481.50
18.86	25.0	365.70	22.84	29.0	852.75	8.29	37.0	482.80
18.96	25.0	374.00	22.99	29.0	942.00	10.22	37.0	484.10
19.73	25.0	381.60	0.96	33.0	384.50	11.87	37.0	485.60
19.62	25.0	394.70	0.72	33.0	393.40	13.46	37.0	487.00
20.47	25.0	416.20	0.70	33.0	403.30	14.65	37.0	488.80
21.09	25.0	440.80	0.64	33.0	406.40	15.64	37.0	491.90
21.65	25.0	512.60	0.80	33.0	410.60	15.98	37.0	493.25
21.74	25.0	553.65	0.51	33.0	413.30	16.70	37.0	496.55
21.98	25.0	615.85	0.95	33.0	417.50	17.16	37.0	500.40
22.42	25.0	680.00	1.20	33.0	419.00	17.63	37.0	506.45
23.14	25.0	851.60	1.59	33.0	421.10	18.60	37.0	515.20
23.14	25.0	943.15	3.27	33.0	422.80	18.45	37.0	518.90
0.76	29.0	315.70	6.27	33.0	426.20	18.95	37.0	523.85
0.49	29.0	331.40	7.35	33.0	428.00	19.08	37.0	529.45
0.78	29.0	340.90	9.16	33.0	430.90	19.80	37.0	548.10
0.67	29.0	344.00	14.45	33.0	435.00	21.17	37.0	607.75
0.66	29.0	352.10	15.82	33.0	438.10	21.98	37.0	676.28
0.49	29.0	355.80	16.33	33.0	442.20	21.89	37.0	714.40
0.79	29.0	360.30	17.26	33.0	447.50	22.64	37.0	797.20
1.57	29.0	363.00	17.53	33.0	450.30	22.28	37.0	861.60

TABLE V (CONTINUED)

COLUMN 4 BULK DENSITY = 1.540 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
23.10	37.0	936.80	0.97	45.0	577.00	1.08	49.0	632.00
0.88	41.0	497.85	0.92	45.0	578.00	0.97	49.0	635.00
1.03	41.0	507.65	1.07	45.0	579.00	1.56	49.0	636.00
0.81	41.0	513.95	1.07	45.0	579.00	1.25	49.0	637.00
0.88	41.0	520.10	1.10	45.0	580.00	1.40	49.0	638.00
0.76	41.0	521.45	1.04	45.0	581.00	1.36	49.0	639.00
0.87	41.0	522.60	0.92	45.0	582.00	2.25	49.0	641.00
0.55	41.0	525.25	1.03	45.0	583.00	3.23	49.0	642.00
0.58	41.0	526.70	1.28	45.0	584.00	4.11	49.0	643.00
0.85	41.0	528.10	1.64	45.0	585.00	5.04	49.0	644.00
0.77	41.0	530.75	1.93	45.0	586.00	6.32	49.0	645.00
2.73	41.0	533.55	2.40	45.0	587.00	2.03	49.0	646.00
3.90	41.0	534.60	2.69	45.0	588.00	7.38	49.0	646.00
5.69	41.0	535.70	3.47	45.0	589.00	8.80	49.0	647.00
8.23	41.0	536.80	5.00	45.0	590.00	9.73	49.0	648.00
10.80	41.0	537.90	7.08	45.0	591.00	10.99	49.0	649.00
12.30	41.0	539.00	8.57	45.0	592.00	11.96	49.0	650.00
13.53	41.0	540.40	10.97	45.0	593.00	12.69	49.0	651.00
14.36	41.0	541.65	12.60	45.0	594.00	13.48	49.0	652.00
14.53	41.0	542.75	13.70	45.0	595.00	14.33	49.0	653.00
15.05	41.0	543.80	14.50	45.0	596.00	14.87	49.0	654.00
15.51	41.0	546.70	14.76	45.0	597.00	15.05	49.0	655.00
16.97	41.0	556.10	14.98	45.0	598.00	15.10	49.0	656.00
18.04	41.0	569.05	15.65	45.0	599.00	15.51	49.0	657.00
19.66	41.0	606.00	15.63	45.0	600.00	15.28	49.0	658.00
20.22	41.0	629.15	15.93	45.0	601.00	15.87	49.0	659.00
21.06	41.0	674.90	16.19	45.0	602.00	15.78	49.0	660.00
21.59	41.0	713.10	16.19	45.0	603.00	15.89	49.0	661.00
22.00	41.0	792.20	16.18	45.0	604.00	16.08	49.0	662.00
22.36	41.0	871.30	18.18	45.0	627.85	15.91	49.0	663.00
22.60	41.0	935.60	18.60	45.0	630.40	16.33	49.0	664.00
0.80	45.0	545.30	19.95	45.0	673.46	17.07	49.0	672.25
0.93	45.0	554.95	20.80	45.0	710.20	18.62	49.0	701.70
0.92	45.0	566.55	21.63	45.0	768.80	19.62	49.0	731.20
0.80	45.0	567.70	21.88	45.0	826.70	20.53	49.0	771.50
1.05	45.0	572.00	22.02	45.0	872.50	20.99	49.0	825.30
0.71	45.0	573.00	22.28	45.0	934.40	21.16	49.0	875.25
0.91	45.0	574.00	1.15	49.0	611.90	21.12	49.0	902.40
0.78	45.0	575.00	0.72	49.0	613.05	21.59	49.0	933.20
0.97	45.0	576.00	0.71	49.0	626.60	0.40	53.0	667.80

TABLE V (CONTINUED)

COLUMN 4 BULK DENSITY = 1.540 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
0.32	53.0	669.45	8.22	57.0	760.50	0.77	65.0	855.45
0.82	53.0	692.00	9.72	57.0	762.30	0.75	65.0	856.75
0.53	53.0	693.00	12.79	57.0	765.70	0.72	65.0	858.05
0.45	53.0	694.00	15.07	57.0	770.20	0.61	65.0	859.35
0.54	53.0	695.00	15.17	57.0	773.70	0.99	65.0	860.40
0.66	53.0	696.00	16.35	57.0	789.10	2.15	65.0	863.05
1.26	53.0	697.00	18.00	57.0	817.80	2.70	65.0	864.20
2.09	53.0	698.00	19.92	57.0	879.00	2.73	65.0	865.30
2.49	53.0	699.00	20.12	57.0	899.70	2.79	65.0	866.40
3.11	53.0	700.00	20.30	57.0	929.60	3.66	65.0	867.70
7.13	53.0	703.30	0.93	59.0	736.30	3.99	65.0	868.80
8.79	53.0	704.50	0.21	61.0	775.00	4.65	65.0	869.90
11.49	53.0	707.00	0.38	61.0	776.20	7.74	65.0	874.00
13.14	53.0	708.70	0.63	61.0	778.50	10.16	65.0	877.75
14.92	53.0	711.70	0.23	61.0	781.30	13.58	65.0	881.50
15.56	53.0	716.00	0.43	61.0	785.40	15.17	65.0	884.15
15.95	53.0	719.70	0.47	61.0	787.80	15.79	65.0	885.15
16.06	53.0	722.60	0.72	61.0	794.10	15.61	65.0	886.15
16.74	53.0	728.30	0.49	61.0	795.50	16.29	65.0	887.15
17.02	53.0	735.00	0.56	61.0	800.60	16.02	65.0	888.15
17.74	53.0	744.00	0.55	61.0	802.00	16.34	65.0	889.15
18.65	53.0	767.30	0.81	61.0	803.50	16.24	65.0	890.15
19.57	53.0	790.70	0.88	61.0	805.50	16.74	65.0	897.10
20.09	53.0	820.90	1.24	61.0	806.70	17.47	65.0	903.80
20.52	53.0	876.45	1.45	61.0	808.00	18.74	65.0	927.25
20.96	53.0	901.00	3.23	61.0	811.90	18.85	65.0	939.50
21.43	53.0	932.05	6.26	61.0	816.50	19.75	65.0	956.65
0.68	57.0	739.90	8.79	61.0	819.30	0.95	69.0	882.75
0.67	57.0	741.10	12.19	61.0	822.30	0.58	69.0	891.85
0.54	57.0	746.00	13.79	61.0	824.00	0.85	69.0	892.85
0.48	57.0	747.00	15.50	61.0	828.40	0.74	69.0	893.85
0.45	57.0	748.00	16.02	61.0	830.00	0.95	69.0	894.85
28.94	57.0	749.00	16.24	61.0	831.50	0.81	69.0	905.00
1.04	57.0	750.00	17.03	61.0	841.30	0.69	69.0	906.00
0.36	57.0	751.00	17.38	61.0	847.75	0.61	69.0	907.00
1.88	57.0	753.00	19.26	61.0	880.25	0.43	69.0	908.00
2.87	57.0	754.20	19.79	61.0	898.40	0.54	69.0	909.00
3.66	57.0	755.30	20.15	61.0	928.45	0.74	69.0	910.00
5.39	57.0	757.00	20.29	61.0	955.50	0.85	69.0	911.00
6.76	57.0	759.00	0.25	65.0	849.05	0.45	69.0	912.00

TABLE V (CONTINUED)

COLUMN 4 BULK DENSITY = 1.540 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
0.69	69.0	913.00	12.08	69.0	938.30	0.36	73.0	969.20
0.59	69.0	914.00	16.23	69.0	948.55	0.15	73.0	970.20
1.01	69.0	915.00	16.62	69.0	957.85	0.40	73.0	971.20
1.04	69.0	916.00	0.51	73.0	959.20	0.07	73.0	972.20
1.37	69.0	917.60	0.70	73.0	960.20	0.37	73.0	973.20
1.99	69.0	919.00	0.65	73.0	961.20	0.60	73.0	974.20
2.33	69.0	920.00	0.41	73.0	962.20	0.79	73.0	975.20
2.86	69.0	921.00	0.37	73.0	963.20	0.96	73.0	976.20
2.76	69.0	922.00	0.38	73.0	964.20	1.17	73.0	977.20
3.15	69.0	923.00	0.43	73.0	965.20	2.31	73.0	978.20
3.49	69.0	924.00	0.55	73.0	966.20	2.55	73.0	979.20
3.63	69.0	925.00	0.26	73.0	967.20	3.58	81.5	813.10
4.08	69.0	926.00	0.36	73.0	968.20	5.22	81.5	815.00
5.97	69.0	930.90						

TABLE V (CONTINUED)

COLUMN 5 BULK DENSITY = 1.539 G/CC SOIL THICKNESS = 13.01 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
12.59	1.0	0.0	33.38	17.0	53.67	35.60	29.0	62.95
37.06	1.0	0.10	17.39	21.0	5.73	14.41	33.0	11.06
38.47	1.0	2.66	25.94	21.0	7.12	14.80	33.0	12.96
37.54	1.0	14.39	30.53	21.0	8.55	16.68	33.0	14.90
37.19	1.0	21.25	31.79	21.0	9.91	19.22	33.0	16.34
37.04	1.0	29.10	32.70	21.0	12.11	22.38	33.0	17.81
36.79	1.0	40.74	32.17	21.0	15.96	26.59	33.0	20.56
36.63	1.0	56.06	31.49	21.0	21.69	28.81	33.0	22.79
27.25	3.0	14.82	32.24	21.0	24.60	31.49	33.0	26.08
32.55	5.0	1.49	32.64	21.0	33.30	34.55	33.0	35.40
19.78	5.0	2.06	32.82	21.0	39.29	35.16	33.0	49.96
32.59	5.0	2.20	32.93	21.0	46.05	35.43	33.0	61.08
5.74	5.0	12.65	32.35	21.0	63.66	13.99	37.0	16.67
33.71	5.0	14.08	14.76	25.0	6.06	9.21	37.0	18.83
17.68	5.0	14.36	14.09	25.0	6.78	17.38	37.0	20.24
33.32	5.0	19.74	15.20	25.0	7.45	20.67	37.0	22.09
32.64	5.0	28.76	17.92	25.0	8.20	24.03	37.0	23.89
33.09	5.0	41.05	21.42	25.0	9.25	27.44	37.0	25.75
33.14	5.0	56.37	28.92	25.0	11.73	27.94	37.0	27.28
32.15	9.0	3.07	31.17	25.0	13.67	30.62	37.0	30.04
32.05	9.0	3.40	33.12	25.0	15.64	32.18	37.0	35.09
33.14	9.0	4.36	33.75	25.0	18.47	32.80	37.0	37.51
32.86	9.0	12.49	34.93	25.0	23.53	34.83	37.0	49.66
33.32	9.0	19.33	35.96	25.0	32.09	34.74	37.0	60.77
32.36	9.0	28.43	35.32	25.0	38.97	14.55	41.0	22.40
33.23	9.0	41.37	35.19	25.0	46.44	15.93	41.0	24.22
32.61	9.0	56.69	36.00	25.0	63.27	17.45	41.0	25.39
30.22	13.0	3.85	14.32	29.0	6.39	19.96	41.0	26.96
31.59	13.0	5.05	13.92	29.0	7.80	22.41	41.0	27.99
32.99	13.0	10.32	15.42	29.0	9.58	25.52	41.0	29.70
32.68	13.0	17.39	16.41	29.0	10.73	26.38	41.0	30.74
32.33	13.0	26.47	17.48	29.0	11.40	29.63	41.0	34.78
32.33	13.0	43.67	22.62	29.0	13.30	31.24	41.0	37.15
32.67	13.0	54.00	26.21	29.0	15.27	34.67	41.0	49.35
27.31	17.0	5.39	29.75	29.0	18.12	35.02	41.0	59.56
33.39	17.0	8.87	31.77	29.0	20.88	14.84	45.0	26.67
33.12	17.0	17.03	33.03	29.0	23.18	17.38	45.0	30.40
32.71	17.0	24.93	34.08	29.0	31.78	19.27	45.0	31.43
32.62	17.0	33.63	34.16	29.0	35.77	20.97	45.0	32.52
32.59	17.0	43.97	35.38	29.0	46.75	23.47	45.0	34.10

TABLE V (CONTINUED)

COLUMN 5 BULK DENSITY = 1.539 G/CC SOIL THICKNESS = 13.01 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
27.12	45.0	36.82	19.95	53.0	43.33	22.09	61.0	54.97
28.49	45.0	38.59	22.35	53.0	44.42	25.59	61.0	57.60
29.49	45.0	40.35	23.46	53.0	45.39	28.11	61.0	60.36
30.95	45.0	42.62	27.09	53.0	47.20	29.02	61.0	62.28
33.16	45.0	49.05	27.65	53.0	48.46	30.36	61.0	65.82
34.35	45.0	59.25	29.43	53.0	50.97	14.47	65.0	52.38
14.55	49.0	31.10	30.87	53.0	52.71	14.42	65.0	54.65
14.42	49.0	32.86	31.44	53.0	55.70	16.75	65.0	57.30
16.16	49.0	34.41	32.55	53.0	58.63	22.27	65.0	60.04
17.77	49.0	36.19	33.45	53.0	67.18	24.86	65.0	61.95
20.64	49.0	37.89	13.11	57.0	43.00	28.17	65.0	65.53
24.07	49.0	40.04	13.08	57.0	45.08	14.04	69.0	57.97
27.28	49.0	42.28	14.97	57.0	47.51	15.72	69.0	61.64
29.06	49.0	44.75	16.46	57.0	48.16	20.65	69.0	64.28
30.05	49.0	45.71	22.01	57.0	50.66	22.72	69.0	65.23
31.08	49.0	48.76	24.14	57.0	51.97	24.48	69.0	66.50
31.86	49.0	51.30	27.69	57.0	55.33	25.45	69.0	67.91
32.31	49.0	53.10	29.26	57.0	58.32	14.51	73.0	64.60
33.35	49.0	58.94	31.20	57.0	62.58	14.12	73.0	64.90
13.14	53.0	36.51	32.77	57.0	66.89	14.62	73.0	66.20
13.38	53.0	38.21	13.42	61.0	47.82	17.16	73.0	67.60
14.09	53.0	39.72	14.25	61.0	50.34	18.73	73.0	68.42
16.49	53.0	41.94	15.11	61.0	51.66	19.26	73.0	68.75

TABLE V (CONTINUED)

COLUMN 6 BULK DENSITY = 1.529 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
13.04	1.0	0.0	20.14	21.0	11.72	30.40	33.0	25.11
13.11	1.0	0.0	22.88	21.0	12.04	34.30	33.0	27.74
33.44	1.0	0.30	24.22	21.0	12.32	37.99	33.0	33.85
39.08	1.0	0.70	25.61	21.0	12.62	16.21	37.0	25.45
11.77	5.0	1.12	26.45	21.0	13.35	17.68	37.0	25.80
15.04	5.0	1.43	34.61	21.0	15.95	18.10	37.0	26.02
25.02	5.0	1.70	35.70	21.0	17.18	19.56	37.0	26.29
28.86	5.0	1.95	21.29	21.0	18.95	21.39	37.0	26.58
34.00	5.0	2.34	13.37	25.0	13.72	22.39	37.0	26.84
37.32	5.0	2.75	13.58	25.0	14.00	23.60	37.0	27.11
40.29	5.0	5.20	14.43	25.0	14.28	24.42	37.0	27.38
13.27	9.0	3.10	15.83	25.0	14.57	27.60	37.0	28.14
17.83	9.0	3.37	17.31	25.0	14.84	28.67	37.0	28.40
24.95	9.0	3.70	19.18	25.0	15.10	28.82	37.0	28.67
28.88	9.0	4.00	20.96	25.0	15.37	35.04	37.0	32.52
31.68	9.0	4.31	22.49	25.0	15.63	15.53	41.0	29.01
32.98	9.0	4.58	26.22	25.0	16.28	16.18	41.0	29.28
33.56	9.0	4.88	27.86	25.0	16.56	16.40	41.0	29.59
40.41	9.0	7.60	28.03	25.0	16.84	19.16	41.0	30.17
15.59	13.0	5.57	35.45	25.0	21.32	20.71	41.0	30.45
20.75	13.0	5.85	15.58	29.0	17.54	22.04	41.0	30.72
23.37	13.0	6.10	15.69	29.0	17.85	22.86	41.0	31.00
27.03	13.0	6.38	16.76	29.0	18.08	24.74	41.0	31.30
28.69	13.0	6.67	17.58	29.0	18.35	25.48	41.0	31.59
30.80	13.0	6.95	19.29	29.0	18.85	27.05	41.0	31.86
31.78	13.0	7.25	21.94	29.0	19.25	26.81	41.0	32.17
37.60	13.0	10.46	24.33	29.0	19.61	29.55	41.0	32.93
13.19	17.0	7.95	26.14	29.0	19.95	28.92	41.0	33.20
15.02	17.0	8.22	30.07	29.0	20.94	30.06	41.0	33.48
17.77	17.0	8.52	31.40	29.0	21.75	33.31	41.0	36.10
20.50	17.0	8.80	34.43	29.0	24.17	36.63	41.0	40.33
23.48	17.0	9.08	17.88	33.0	22.14	20.05	45.0	34.24
25.30	17.0	9.35	19.68	33.0	22.42	21.96	45.0	34.55
27.23	17.0	9.65	20.66	33.0	22.71	22.73	45.0	34.85
28.99	17.0	9.98	22.21	33.0	22.99	24.19	45.0	35.11
35.95	17.0	13.00	24.26	33.0	23.26	25.17	45.0	35.38
39.80	17.0	20.45	25.21	33.0	23.54	26.70	45.0	35.75
13.42	21.0	10.88	26.06	33.0	23.82	28.53	45.0	36.40
15.11	21.0	11.17	28.27	33.0	24.50	29.02	45.0	36.65
17.40	21.0	11.45	28.90	33.0	24.85	29.46	45.0	36.94

TABLE V (CONTINUED)

COLUMN 6 BULK DENSITY = 1.529 G/CC SOIL THICKNESS = 13.10 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
33.56	45.0	39.33	17.15	57.0	44.77	19.53	65.0	53.53
34.54	45.0	40.67	17.78	57.0	45.07	22.48	65.0	54.52
17.46	49.0	37.30	18.23	57.0	45.33	22.46	65.0	54.80
18.23	49.0	37.60	18.78	57.0	45.60	23.51	65.0	55.10
19.36	49.0	37.88	21.82	57.0	46.45	29.05	65.0	57.52
20.53	49.0	38.17	19.86	57.0	46.75	29.87	65.0	57.85
22.23	49.0	38.45	23.97	57.0	47.02	31.66	65.0	59.31
22.33	49.0	38.72	25.01	57.0	47.34	13.10	69.0	47.20
24.01	49.0	39.00	25.72	57.0	47.65	17.12	69.0	55.46
26.18	49.0	39.67	30.29	57.0	48.87	18.35	69.0	55.75
26.71	49.0	39.94	17.27	61.0	48.00	17.63	69.0	56.03
30.01	49.0	41.00	17.74	61.0	48.33	18.23	69.0	56.30
33.08	49.0	43.10	17.90	61.0	48.64	18.05	69.0	56.60
18.09	53.0	41.37	18.08	61.0	48.92	17.97	69.0	56.93
18.93	53.0	41.65	18.85	61.0	49.22	22.03	69.0	58.19
19.69	53.0	41.92	19.41	61.0	49.52	23.20	69.0	58.45
20.36	53.0	42.20	22.97	61.0	50.70	23.39	69.0	58.72
21.57	53.0	42.47	23.85	61.0	51.02	23.60	69.0	59.00
22.61	53.0	42.74	24.83	61.0	51.29	27.07	69.0	60.41
25.80	53.0	43.60	30.45	61.0	53.88	28.02	69.0	60.69
25.80	53.0	43.88	30.86	61.0	54.16	18.76	73.0	59.74
30.52	53.0	46.02	16.86	65.0	51.60	18.47	73.0	60.02
35.55	53.0	50.32	16.89	65.0	51.90	20.15	73.0	61.03
16.73	57.0	44.22	17.24	65.0	52.20	20.36	73.0	61.30
16.74	57.0	44.49	17.72	65.0	52.52	20.63	73.0	61.58
17.15	57.0	44.77	17.72	65.0	52.80			

TABLE V (CONTINUED)

COLUMN 7 BULK DENSITY = 1.537 G/CC SOIL THICKNESS = 13.03 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
11.23	1.0	1.10	16.01	17.0	30.85	29.71	33.0	111.45
11.39	1.0	2.20	19.02	17.0	34.40	31.54	33.0	142.30
11.58	1.0	3.30	23.88	17.0	39.20	12.24	37.0	61.60
12.72	1.0	4.40	30.94	17.0	57.95	12.59	37.0	67.55
22.43	1.0	10.30	32.12	17.0	75.85	13.25	37.0	71.05
30.88	1.0	17.25	32.15	17.0	98.15	14.43	37.0	74.75
34.58	1.0	52.00	32.72	17.0	134.60	15.93	37.0	82.90
36.30	1.0	80.30	14.88	21.0	33.20	21.88	37.0	93.30
36.46	1.0	130.15	15.76	21.0	35.55	27.54	37.0	110.15
12.98	3.0	5.60	17.47	21.0	38.05	30.47	37.0	143.40
14.12	3.0	6.70	23.92	21.0	45.10	13.81	41.0	81.70
12.12	5.0	7.85	29.22	21.0	56.85	14.26	41.0	85.20
15.31	5.0	11.43	31.09	21.0	66.30	15.50	41.0	89.95
21.53	5.0	16.10	30.90	21.0	73.45	16.01	41.0	92.15
25.42	5.0	23.70	31.31	21.0	97.00	25.44	41.0	109.00
26.93	5.0	29.60	31.31	21.0	138.95	27.41	41.0	116.35
28.71	5.0	50.90	13.86	25.0	36.80	29.81	41.0	145.90
33.66	5.0	79.15	14.86	25.0	41.60	13.04	45.0	86.40
34.34	5.0	131.25	15.96	25.0	43.90	13.37	45.0	91.05
11.88	9.0	9.00	17.67	25.0	48.60	14.35	45.0	95.70
12.12	9.0	12.60	20.24	25.0	55.75	15.65	45.0	100.64
12.76	9.0	14.95	23.93	25.0	65.15	19.98	45.0	107.80
16.15	9.0	18.45	26.37	25.0	72.30	23.55	45.0	115.15
20.19	9.0	20.80	30.15	25.0	88.70	29.26	45.0	147.05
26.34	9.0	28.45	33.25	25.0	140.10	14.75	49.0	99.45
29.08	9.0	49.80	13.05	29.0	42.75	14.91	49.0	103.15
33.50	9.0	78.05	13.42	29.0	47.45	14.98	49.0	106.65
33.38	9.0	132.35	15.19	29.0	54.65	18.26	49.0	113.90
10.98	1.0	0.0	18.22	29.0	64.00	20.87	49.0	117.51
12.45	13.0	13.75	20.51	29.0	69.90	28.96	49.0	148.20
13.24	13.0	19.60	27.92	29.0	87.55	15.16	53.0	101.90
13.89	13.0	22.00	30.84	29.0	112.60	14.78	53.0	105.55
16.22	13.0	24.90	32.06	29.0	141.20	17.07	53.0	118.85
19.19	13.0	27.25	12.61	33.0	46.30	19.51	53.0	122.85
23.70	13.0	32.00	12.57	33.0	53.40	28.52	53.0	151.90
27.19	13.0	40.35	13.89	33.0	60.35	13.79	57.0	104.35
31.43	13.0	59.05	14.42	33.0	62.75	14.58	57.0	120.30
33.36	13.0	76.95	15.63	33.0	68.70	14.68	57.0	121.35
33.67	13.0	133.45	22.00	33.0	84.05	15.95	57.0	126.50
13.08	17.0	26.10	26.48	33.0	99.45	17.77	57.0	129.00

TABLE V (CONTINUED)

COLUMN 7 BULK DENSITY = 1.537 G/CC SOIL THICKNESS = 13.03 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
27.16	57.0	153.10	26.08	61.0	154.30	20.41	69.0	156.65
14.45	61.0	124.00	14.36	65.0	125.40	21.91	69.0	159.55
14.57	61.0	127.80	17.62	65.0	144.75	14.31	73.0	150.60
17.19	61.0	136.05	23.90	65.0	155.50	15.69	73.0	157.85
26.08	61.0	154.30	14.38	69.0	137.50			

TABLE V (CONTINUED)

COLUMN 8 BULK DENSITY = 1.532 G/CC SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
10.71	1.0	0.0	14.97	5.0	33.90	12.20	13.0	77.00
10.73	1.0	0.0	14.92	5.0	35.00	12.32	13.0	78.20
11.00	1.0	0.50	16.46	5.0	39.90	12.92	13.0	80.10
10.82	1.0	4.30	17.70	5.0	49.30	14.19	13.0	86.90
10.92	1.0	6.20	17.80	5.0	50.40	14.12	13.0	88.00
10.99	1.0	7.20	19.55	5.0	67.70	16.22	13.0	96.90
10.97	1.0	8.20	20.72	5.0	81.40	16.32	13.0	98.20
11.11	1.0	9.20	20.12	5.0	82.90	17.66	13.0	121.30
11.81	1.0	10.20	24.81	5.0	236.50	19.11	13.0	132.40
13.40	1.0	11.20	24.45	5.0	237.50	23.70	13.0	220.80
14.11	1.0	12.20	24.63	5.0	527.00	23.65	13.0	221.80
14.54	1.0	13.20	24.74	5.0	527.60	25.15	13.0	490.80
15.41	1.0	14.20	11.13	7.0	28.90	24.84	13.0	491.90
16.10	1.0	15.20	10.11	9.0	31.50	11.52	17.0	89.50
17.59	1.0	17.70	10.15	9.0	32.60	11.52	17.0	89.50
18.08	1.0	18.90	10.26	9.0	36.30	11.87	17.0	90.60
19.15	1.0	23.90	10.44	9.0	41.10	11.52	17.0	91.90
20.28	1.0	30.10	10.54	9.0	42.20	11.92	17.0	92.90
20.56	1.0	37.50	10.75	9.0	45.00	12.32	17.0	100.20
21.02	1.0	38.60	10.93	9.0	46.00	12.69	17.0	104.10
21.63	1.0	51.90	11.21	9.0	48.00	13.03	17.0	106.53
21.90	1.0	52.90	12.49	9.0	54.30	14.55	17.0	115.50
22.66	1.0	69.00	12.35	9.0	55.30	15.12	17.0	119.70
23.45	1.0	84.40	12.86	9.0	56.30	15.11	17.0	123.10
23.36	1.0	85.50	14.03	9.0	60.70	15.82	17.0	131.10
25.35	1.0	241.80	14.30	9.0	61.80	17.63	17.0	142.50
25.25	1.0	243.00	16.02	9.0	71.90	17.52	17.0	148.60
25.41	1.0	525.50	16.16	9.0	72.90	22.05	17.0	218.50
25.78	1.0	526.10	16.17	9.0	73.90	22.12	17.0	219.60
10.66	3.0	0.0	16.44	9.0	74.90	24.82	17.0	431.40
10.95	3.0	2.00	18.47	9.0	94.70	24.79	17.0	432.50
9.09	3.0	3.10	18.37	9.0	95.70	10.38	21.0	101.60
12.99	3.0	16.50	21.07	9.0	133.90	12.43	21.0	108.00
14.48	3.0	20.10	23.97	9.0	229.60	12.70	21.0	112.25
14.79	3.0	21.30	23.71	9.0	288.50	12.96	21.0	117.00
16.11	3.0	25.20	24.37	9.0	493.40	13.02	21.0	124.10
16.90	3.0	43.60	24.46	9.0	494.60	13.69	21.0	129.65
11.35	5.0	22.50	11.21	13.0	57.70	13.95	21.0	135.25
12.52	5.0	26.40	11.12	13.0	58.80	14.28	21.0	136.40
13.01	5.0	27.70	11.34	13.0	70.40	14.45	21.0	140.00

TABLE V (CONTINUED)

COLUMN 8 BULK DENSITY = 1.532 G/CC SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
15.38	21.0	147.30	15.34	29.0	204.60	20.83	33.0	311.20
17.03	21.0	162.00	15.75	29.0	205.70	23.42	33.0	382.10
20.40	21.0	213.30	17.53	29.0	233.90	24.55	33.0	547.60
23.53	21.0	275.10	17.72	29.0	235.10	12.38	37.0	178.15
23.25	21.0	276.10	19.96	29.0	263.30	12.63	37.0	179.25
24.29	21.0	415.10	19.86	29.0	264.30	12.59	37.0	181.60
24.36	21.0	416.40	24.05	29.0	388.00	12.76	37.0	182.60
25.30	21.0	555.40	23.90	29.0	389.00	12.81	37.0	183.60
11.78	25.0	118.30	24.59	29.0	552.50	12.78	37.0	184.60
11.85	25.0	125.80	12.71	33.0	165.50	12.58	37.0	185.60
11.71	25.0	126.85	12.78	33.0	167.90	12.64	37.0	189.10
12.07	25.0	137.70	13.16	33.0	171.45	12.70	37.0	190.25
12.11	25.0	141.20	13.22	33.0	173.65	12.14	37.0	191.30
11.77	25.0	144.70	12.77	33.0	174.90	12.57	37.0	192.40
12.31	25.0	146.05	13.01	33.0	175.95	12.65	37.0	193.55
12.93	25.0	150.00	13.10	33.0	177.01	12.47	37.0	194.65
12.95	25.0	151.10	12.50	33.0	180.45	12.99	37.0	199.10
12.90	25.0	153.80	13.67	33.0	195.80	14.37	37.0	247.40
13.02	25.0	155.00	13.68	33.0	196.90	14.78	37.0	248.50
13.19	25.0	156.10	13.94	33.0	197.95	14.67	37.0	249.90
13.12	25.0	157.20	13.72	33.0	200.30	14.97	37.0	255.80
13.45	25.0	158.30	13.98	33.0	201.30	14.96	37.0	256.80
13.53	25.0	160.70	13.84	33.0	202.30	15.87	37.0	261.70
17.80	25.0	211.10	14.03	33.0	207.60	15.79	37.0	266.30
17.88	25.0	212.10	14.51	33.0	208.80	15.70	37.0	267.60
21.58	25.0	220.60	14.46	33.0	214.60	12.91	37.0	277.00
21.14	25.0	269.60	14.57	33.0	216.60	16.68	37.0	280.82
23.66	25.0	407.00	15.17	33.0	223.30	16.41	37.0	281.80
23.59	25.0	408.00	15.28	33.0	224.70	17.86	37.0	306.10
24.36	25.0	554.60	15.80	33.0	231.10	19.67	37.0	326.50
12.16	29.0	128.20	15.87	33.0	232.50	22.07	37.0	373.60
12.42	29.0	138.85	15.95	33.0	239.10	24.10	37.0	545.20
12.10	29.0	152.45	16.24	33.0	240.10	13.48	41.0	186.75
12.61	29.0	155.50	16.54	33.0	244.70	13.57	41.0	187.75
12.82	29.0	163.20	16.61	33.0	246.80	15.35	41.0	278.30
12.79	29.0	164.30	17.32	33.0	258.20	15.52	41.0	279.30
12.47	29.0	166.70	17.33	33.0	259.20	15.98	41.0	285.00
13.13	29.0	169.20	18.30	33.0	272.10	15.68	41.0	286.00
13.21	29.0	170.30	18.48	33.0	273.10	15.88	41.0	290.40
13.37	29.0	172.70	20.92	33.0	310.20	16.11	41.0	291.40

TABLE V (CONTINUED)

COLUMN 8 BULK DENSITY = 1.532 G/CC SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
16.34	41.0	299.20	15.72	49.0	370.70	16.68	57.0	385.40
16.36	41.0	300.20	18.01	49.0	370.70	17.37	57.0	400.00
17.07	41.0	307.70	18.31	49.0	371.70	17.16	57.0	400.00
16.46	41.0	308.70	19.27	49.0	391.00	17.97	57.0	409.70
17.37	41.0	312.90	19.54	49.0	392.00	18.09	57.0	410.80
17.08	41.0	313.90	21.21	49.0	422.90	18.21	57.0	418.00
18.07	41.0	325.00	21.41	49.0	424.00	18.34	57.0	419.10
18.81	41.0	340.80	22.92	49.0	484.40	19.51	57.0	429.90
19.04	41.0	341.80	23.63	49.0	539.80	19.87	57.0	435.70
20.73	41.0	366.00	15.25	53.0	331.20	19.75	57.0	441.80
24.08	41.0	522.50	15.42	53.0	332.20	20.02	57.0	443.10
24.24	41.0	544.50	15.51	53.0	338.60	20.86	57.0	451.00
15.56	45.0	287.40	16.02	53.0	348.20	20.66	57.0	452.00
15.34	45.0	288.70	16.04	53.0	350.00	20.64	57.0	453.00
15.58	45.0	293.00	16.97	53.0	361.70	20.87	57.0	454.00
15.55	45.0	294.00	16.51	53.0	362.70	20.53	57.0	455.00
15.54	45.0	302.00	16.83	53.0	368.20	20.95	57.0	456.00
15.58	45.0	303.00	14.28	53.0	369.20	21.04	57.0	457.00
16.35	45.0	315.60	16.87	53.0	379.30	20.97	57.0	458.00
16.48	45.0	316.60	17.03	53.0	380.30	21.31	57.0	459.00
16.95	45.0	318.90	18.19	53.0	393.80	21.03	57.0	460.00
17.59	45.0	333.80	18.11	53.0	394.80	21.13	57.0	461.00
17.72	45.0	343.40	18.51	53.0	403.30	21.12	57.0	462.00
17.89	45.0	344.40	18.14	53.0	404.30	21.27	57.0	463.00
19.60	45.0	364.60	19.24	53.0	412.10	21.55	57.0	464.00
21.45	45.0	396.80	19.57	53.0	413.20	21.71	57.0	465.00
21.48	45.0	397.80	19.66	53.0	420.40	20.72	57.0	466.00
23.95	45.0	481.70	19.55	53.0	421.50	21.25	57.0	467.00
23.88	45.0	483.10	20.84	53.0	434.10	21.49	57.0	468.00
24.68	45.0	543.50	22.55	53.0	475.80	22.56	57.0	486.80
14.81	49.0	296.20	22.48	53.0	477.40	22.77	57.0	501.80
14.33	49.0	297.20	23.17	53.0	504.90	22.71	57.0	503.20
15.58	49.0	322.50	23.74	53.0	539.00	23.79	57.0	538.00
15.67	49.0	328.60	15.91	57.0	351.40	17.41	61.0	425.50
15.63	49.0	329.60	15.35	57.0	352.50	17.69	61.0	428.30
16.17	49.0	335.60	11.56	57.0	357.40	18.27	61.0	436.90
16.34	49.0	336.60	15.71	57.0	359.30	18.42	61.0	437.90
16.72	49.0	346.90	16.38	57.0	375.20	18.40	61.0	438.90
16.76	49.0	354.40	16.41	57.0	377.20	18.52	61.0	439.90
17.06	49.0	355.40	16.40	57.0	384.40	18.81	61.0	444.40

TABLE V (CONTINUED)

COLUMN 8 BULK DENSITY = 1.532 G/CC SOIL THICKNESS = 13.07 CM

THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)	THETA (%)	DEPTH (CM)	ELAPSED TIME (MIN)
18.93	61.0	445.40	23.78	65.0	578.30	21.59	77.0	580.30
18.98	61.0	446.40	20.40	69.0	510.00	15.17	81.0	517.60
18.87	61.0	447.40	20.23	69.0	511.00	15.34	81.0	528.70
19.32	61.0	448.40	21.92	69.0	534.50	15.46	81.0	529.60
19.12	61.0	449.40	21.75	69.0	540.70	17.11	81.0	556.40
20.58	61.0	469.40	23.08	69.0	577.70	18.96	81.0	575.60
20.80	61.0	471.00	18.90	73.0	512.30	18.68	81.0	581.00
20.99	61.0	478.90	17.30	73.0	513.80	19.41	81.0	581.00
20.89	61.0	480.20	18.59	73.0	515.20	13.88	85.0	518.90
21.37	61.0	485.60	19.14	73.0	522.90	14.96	85.0	557.80
21.89	61.0	496.10	18.83	73.0	523.60	12.72	85.0	574.90
21.74	61.0	497.20	19.59	73.0	531.60	16.53	85.0	581.70
22.00	61.0	50[illegible].70	20.16	73.0	532.50	14.58	89.0	520.30
22.46	61.0	508.40	20.75	73.0	548.70	14.96	89.0	560.10
23.16	61.0	536.90	21.00	73.0	549.70	14.81	89.0	574.20
24.25	61.0	579.00	20.85	73.0	550.30	15.55	89.0	582.40
20.36	65.0	488.10	21.47	73.0	562.90	15.07	93.0	521.50
20.61	65.0	489.20	22.58	73.0	577.10	15.17	93.0	569.30
21.22	65.0	499.10	22.16	73.0	579.70	15.96	93.0	569.80
20.87	65.0	500.40	16.82	77.0	516.40	14.89	93.0	570.30
22.55	65.0	535.40	17.19	77.0	524.30	14.93	93.0	570.80
22.53	65.0	542.80	18.31	77.0	530.50	15.36	93.0	583.10
23.78	65.0	578.30	19.81	77.0	551.40			

TABLE VI

INITIAL SOIL-WATER CONTENT DATA

Column 5		Bulk Density = 1.54 g/cm^3	
Theta (%)	Depth (cm)	Theta (%)	Depth (cm)
15.32	0.0	13.62	45.0
13.38	1.0	13.08	47.0
11.68	3.0	13.06	49.0
11.69	5.0	13.03	51.0
12.46	7.0	12.62	53.0
13.08	9.0	12.45	55.0
13.76	11.0	12.57	57.0
14.35	13.0	13.02	59.0
14.80	15.0	13.36	61.0
14.54	17.0	13.43	63.0
14.99	19.0	13.89	65.0
15.90	21.0	13.94	67.0
15.51	23.0	13.78	69.0
14.52	25.0	13.73	71.0
14.67	27.0	13.64	73.0
14.24	29.0	13.13	75.0
13.80	31.0	13.29	77.0
13.98	33.0	13.14	79.0
13.81	35.0	12.93	81.0
13.53	37.0	12.28	83.0
13.39	39.0	12.60	85.0
13.40	41.0	12.03	87.0
13.63	43.0	11.69	91.0

TABLE VI (Continued)

Column 6		Bulk Density = 1.53 g/cm^3	
Theta (%)	Depth (cm)	Theta (%)	Depth (cm)
11.85	1.0	14.76	49.0
11.94	5.0	15.20	53.0
12.07	9.0	15.49	57.0
12.51	13.0	16.29	61.0
12.52	17.0	15.28	65.0
12.79	21.0	16.67	69.0
13.10	25.0	16.96	73.0
13.87	29.0	17.80	77.0
13.55	33.0	18.47	81.0
13.90	37.0	19.07	85.0
13.93	41.0	19.83	89.0
14.69	45.0	22.01	93.0

TABLE VI (Continued)

Column 7		Bulk Density = 1.54 g/cm^3	
Theta (%)	Depth (cm)	Theta (%)	Depth (cm)
10.04	0.0	12.57	43.0
12.60	1.0	12.72	45.0
10.95	3.0	12.46	47.0
10.73	5.0	13.81	49.0
10.95	7.0	13.95	51.0
11.37	9.0	14.39	53.0
12.06	11.0	13.88	55.0
12.68	13.0	13.22	57.0
13.03	15.0	13.21	59.0
12.95	17.0	13.94	63.0
13.51	19.0	14.02	65.0
13.89	21.0	13.61	67.0
13.27	23.0	13.79	69.0
13.29	25.0	14.00	71.0
13.31	27.0	13.64	73.0
12.30	29.0	13.63	75.0
12.55	31.0	13.80	77.0
12.34	33.0	13.37	79.0
12.29	35.0	13.93	81.0
12.15	37.0	13.90	83.0
12.47	39.0	14.16	85.0
12.66	41.0	14.67	87.0

TABLE VI (Continued)

Column 8		Bulk Density = 1.53 g/cm^3	
Theta (%)	Depth (cm)	Theta (%)	Depth (cm)
9.82	1.0	13.96	49.0
10.06	5.0	14.15	53.0
9.54	9.0	14.64	57.0
10.39	13.0	14.48	61.0
10.52	17.0	15.01	65.0
11.58	21.0	15.10	69.0
11.63	25.0	14.49	73.0
12.25	29.0	14.57	77.0
12.43	33.0	14.07	81.0
12.29	37.0	13.91	85.0
13.37	41.0	14.17	89.0
14.15	45.0	14.77	93.0

VITA

Alvin Lynn Wood

Candidate for the Degree of

Master of Science

Thesis: MEASURED AND CALCULATED DISTRIBUTIONS OF FLUOMETURON AND WATER DURING INFILTRATION

Major Field: Agronomy

Biographical:

Personal Data: Born in Sulphur, Oklahoma, December 24, 1947, the son of Loy and Olive Belle Wood.

Education: Graduated from Vanoss High School, Vanoss, Oklahoma in 1965; attended Murray State College, Tishomingo, Oklahoma 1965-1967; received Bachelor of Science degree, with a major in Agronomy, from Oklahoma State University, Stillwater, Oklahoma, in May, 1969; completed the requirements for the Master of Science degree at Oklahoma State University in May, 1974, with a major in Agronomy.

Professional Experience: Graduate research assistant, Oklahoma State University, 1970-1972; Research technician, Department of Agronomy, Oklahoma State University, 1972-1974.