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Physical Properties of the Soils of Agricultural Watersheds 1 and 13 which Control Moisture, Storage, and Transport: Final Report on Project 12, Agricultural Watershed Studies, Task C, Canadian Section, Activity 1

International Reference Group on Great Lakes Pollution from Land Use Activities

Canada. Department of Agriculture. Land Resource Research Institute

G. C. Topp

INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

INTERNATIONAL JOINT COMMISSION

PHYSICAL PROPERTIES OF THE SOILS OF AGRICULTURAL WATERSHEDS WHICH CONTROL MOISTURE STORAGE AND TRANSPORT

PHYSICAL PROPERTIES OF THE SOILS

OF AGRICULTURAL WATERSHEDS 1 and 13 WHICH

CONTROL MOISTURE STORAGE AND TRANSPORT

FINAL REPORT ON PROJECT 12

AGRICULTURAL WATERSHED STUDIES

TASK C (Canadian Section - Activity 1)

International Reference Group on Great Lakes

Pollution from Land Use Activities

International Joint Commission

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The study discussed herein was carried out as part of the efforts of the International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG), an organization of the International Joint Commission (IJC), established under the Canada-U.S. Great Lakes Quality Agreement of 1972. Findings and conclusions are those of the author and do not necessarily reflect the views of the Reference Group or its recommendations to the Commission.

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- Messrs. Craig Miller, John Donihee and Doug McLean in Harrow by conducting the field work on the watersheds.
- Messrs. Walter Zebchuk, Keith Wires, Pierre Gonin, and Mrs. Marilyn Leuty in Ottawa for laboratory work and calculations on the data.
- Mr. J.L. Davis for invaluable advice and assistance during infiltration experiments.

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SUMMARY

The objectives of this study were two-fold. Firstly, to make in situ and associated laboratory measurements of soil physical properties (hydraulic conductivity, bulk density and the desorption water capacity relationship) which govern the storage and transmission of water solutions. Secondly, to characterize or represent these soil properties so that they may be applied in the nitrogen and water transport simulation program of D.R. Cameron et al. (Project 13). It was assumed that the hydraulic conductivity was the major property controlling transmission of water and a number of attempts were made to measure this in both watersheds. In Watershed AG-13 the air-entry permeameter measured hydraulic conductivity above the water table and temporarily installed piezometers were used below. In Watershed AG-1 the crust-top permeameter was used in conjunction with the air-entry permeameter to determine hydraulic conductivity. The water storage properties of the soil in both watersheds were measured from soil cores taken to the laboratory. In Watershed AG-1 the shrinking and cracking of the clay soil meant that cracks played an important role in the transmission of water. Infiltration experiments were conducted to assess when soil cracks conduct water.

In general the air entry permeameter and piezometer techniques used in Watershed AG-13 have given consistent and reproducible hydraulic conductivity data. Likewise the desorption water capacity relationships complemented the hydraulic conductivity trends. The changes in soil water properties with location in the watershed were related to the different soil series mapped. The tables and figures displaying these data represent a first step analysis and evaluation of them as tools for characterizing the water storage and flow processes operative in the soil of the watershed. The next step in the characterization process depends on the use of these data in the water transport model used in Project 13 (Nitrogen Transport - D.R. Cameron et al. 1977).

The data presented for Watershed AG-1 can be used as estimates or limits for the hydraulic conductivity. The desorption water capacity relationships showing a higher degree of consistency can perhaps be used directly for characterizing the soil. The degree to which these soil properties for Watershed AG-1 adequately represent how the soil responds depends on their use and testing in the model of Project 13 (D.R. Cameron et al. 1977).

The data obtained in Watershed AG-1 have a number of limitations for their use in characterizing the water storage and transmission properties of the soil. Measurements of water flow in the clay soils were difficult and time consuming and too few data were often obtained. The data obtained were mainly for the surface soil because the sub-soil usually remained too wet for measurement except in the latter part of the summer. The cracking of the clay soil and the resultant bi-modal (in-crack and inter-crack) flow system was virtually impossible to characterize adequately. However, the infiltration experiments on the cracked soil showed that water infiltrating the cracks can be detected and thus a start was made at showing the role of cracks during infiltration.

The results of this project cannot be related directly to PLUARG objectives except in a very general way. This project was intended to provide data to the nitrogen model of Project 13 (D.R. Cameron et al.). The majority of the data obtained in Watershed AG-13 has been evaluated and used in the water transport model of Project 13. Much of the data from Watershed AG-1, however, has only recently been reduced to useable and interpreted form. As a result they have not been incorporated or applied in Project 13. Thus the objectives of providing data to Project 13 has not been met in this respect.

The results of measurements on Watershed AG-1 indicate that cracks are indeed very important to the movement of water in the clay soil. In this case rainfall rates in excess of 1 mm/hr after 1 cm has fallen will contribute to flow in cracks. Any pollutant appearing in the rain or at the soil surface could be carried to the cracks. The volume of cracks and the interconnectivity between cracks and/or with the sub-surface drainage network was not assessed. Additional information from related studies would need to be collected to determine whether cracks in clay soils are a significant source of pollutants to surface waters. The scope of this project did not include its assessment relative to PLUARG objectives except by way of Project 13.

INTRODUCTION

The objectives of this study were two-fold. Firstly, to make in situ and associated laboratory measurements of soil physical properties (hydraulic conductivity, bulk density and the desorption water capacity relationship) which govern the storage and transmission of water solutions. Secondly, to characterize or represent these soil properties so that they may be applied in the nitrogen and water transport simulation program of D.R. Cameron et al. (Project 13). The wide variation in soil properties in the two watersheds meant that different field measurement methods were used in each watershed. It was assumed that the hydraulic conductivity was the major property controlling transmission of water and a number of attempts were made to measure this in both watersheds. In Watershed AG-1 the shrinking and cracking of the clay soil meant that cracks played an important role in the transmission of water and additional measurements were necessary. The water storage properties were measured in the laboratory.

DATA COLLECTION METHODS

(a) Field Locations

The sites for field measurements were chosen in conjunction with the choice of plots for Projects 13 (D.R. Cameron et al.) and 14 (R.W. Gillham, personal communication). Two watersheds (AG-1 tile-drained Brookston clay and AG-13 Berrien sandy loam) were studied. Three sites were located in each watershed and numbered 1 through 6 as designated on Figures 12-1, 12-2. The sites in Watershed AG-13 were on (1) potato-ryegrass (green manure) rotation, (2) tobacco-wheat (green manure) rotation and (3) bean (soybeans 1975, green snap beans 1976) crops. In Watershed AG-1 the sites were on (4) winter wheat (not underdrained in 1975), corn 1976 (after installing underdrains), (5) corn 1975, soybeans 1976, (6) soybeans (not studied in 1976).

(b) Measurements of Hydraulic Conductivity

In Watershed AG-13 two methods were used for in situ measurement of saturated hydraulic conductivity. The air-entry permeameter (Topp and Binns 1976) was used during both field seasons for measurements above the water table. The depths at which measurements were made were 7.5

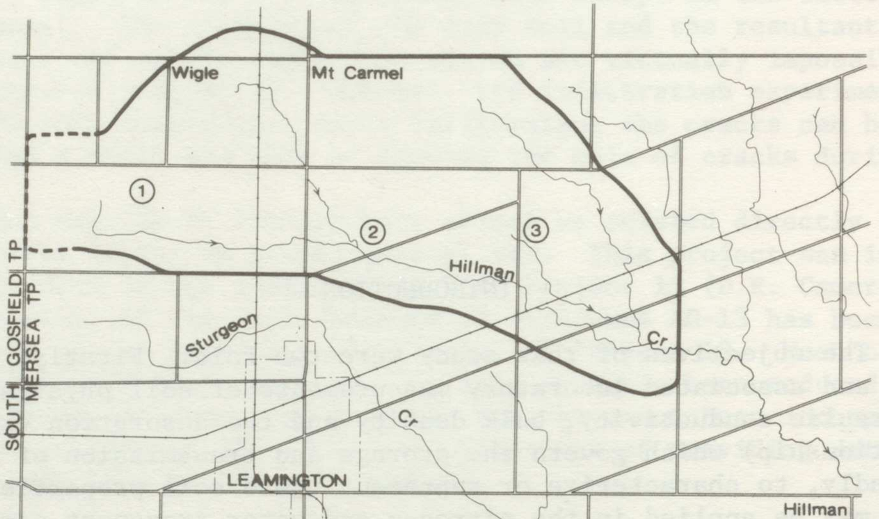


Fig. 12-1: Location of sites for permeameter and piezometer measurements, and core samplings in Watershed AG-13 as indicated by the numbered circles.

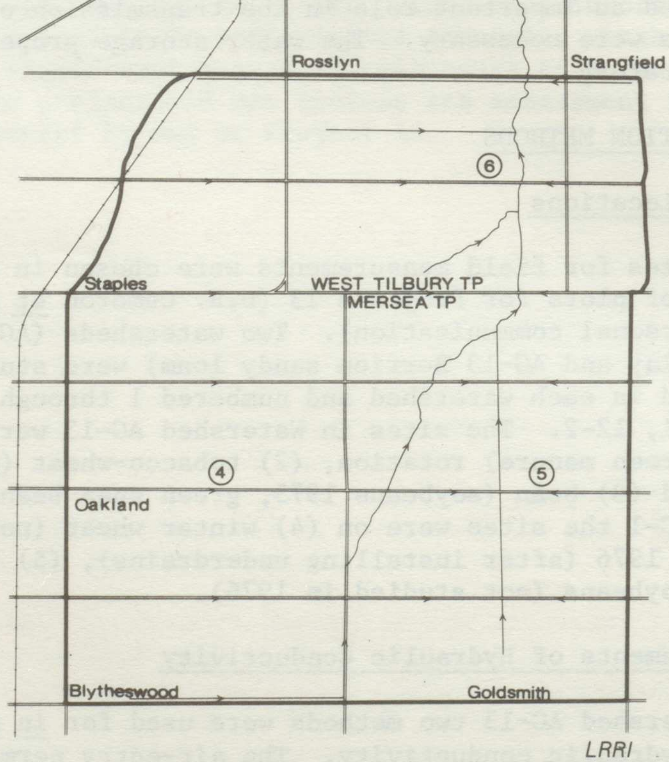


Fig. 12-2: Location of sites for permeameter measurements, core samplings and infiltration trials in Watershed AG-1 as indicated by the numbered circles.

cm, 35 cm, and below 60 cm but above the water table. The air-entry permeameter (AEP) measured the rate of flow of water into the soil until the wetting front reached a predetermined depth. Through the application of Darcy's law one obtained the hydraulic conductivity of the wetted soil.

Temporarily inserted peizometers were used to measure hydraulic conductivity below the water table during May and June 1976. This technique has been described by Boersma (1965). The piezometer diameter was 2 cm and was inserted directly with a tapered tip by hand-driving. The length of the "screened well point" tip was either 2.5 or 10 cm. Measurements with the piezometers were made from a depth of 100 cm to 150 cm. The rate of flow of water through the soil surrounding the piezometer tip was measured by recording the rate of rise or fall of water in the piezometer tube in relation to the pressure head and level governed by the water table. Calculations applying Darcy's law to this flow in cylindrical geometry yielded hydraulic conductivity of the soil surrounding the piezometer tip.

In Watershed AG-1 the air-entry permeameter was used and the results confirmed by comparison with the crust-top permeameter (CTP) as described by Bouma and Denning (1972). In the CTP procedure the rate of flow of water through an applied plaster crust into a soil pedestal gave a measure of the hydraulic conductivity immediately below the crust. The crust acted as a resistance to water flow and the steady flow in the soil took place at water contents less than saturation (i.e. at slightly negative pressure heads).

The measurement of hydraulic conductivity in the clay soil was extremely difficult and the number of data were very limited. The permeameters required that the soil not be saturated for satisfactory determinations. However, the Brookston clay soil begins cracking very soon after desataration commences. Thus a very short period in early summer before the soil begins to crack is all that is available for measurements with the AEP. The CTP although applicable in cracked soil is very time consuming. Consequently, measurments were made principally in the cultivated zone (0-20 cm) with only a selected number being made below that; from 30 to 68 cm at site #4, and from 24 to 50 cm at site #5.

(c) Measurements of Desorption Water Capacity Relationships

Following measurements of hydraulic conductivity with both permeameters (AEP and CTP) a core of soil 7.6 cm diameter and 7.6 cm long was taken by a hand operated device. Each core was taken from within the soil contained in the permeameter cylinder. Several soil cores were also taken in watershed AG-13 at depths to correspond to those of the piezometer measurements. The soil cores were carefully enclosed in plastic bags before being shipped to Ottawa for determination of the soil-water desorption curves. The method used was based on that reported by Stakman et al. (1969) but improved for these measurements (Topp and Zebchuk 1978). The principle of the method was to establish good hydraulic contact between one end surface of the soil core and a saturated porous medium set at a particular pressure head. After sufficient time had elapsed for the soil to come to equilibrium the soil was weighed and the procedure repeated at a lower pressure head. The range of pressure heads used was 0 to -500 cm of water. In addition, the soil was sieved after drying and a portion used to measure the 15-bar water content.

(d) An Assessment of the Role of Soil Cracks during Infiltration of Water

In Watershed AG-1 the development of cracks in the soil as dehydration occurred each summer was believed to be important in the transport of nutrients from at or near the soil surface into cracks. Under conditions of sufficient rain these nutrients could then be available for transport to the tile-drain network. This latter hypothesis was not checked because the role of cracks in the transport of water and nutrients is not easily assessed nor understood. However a simple experiment was undertaken which attempted to show when water was beginning to flow in the cracks as a result of a simulated rainfall.

The experiment consisted of three infiltration trials at each of site #4 (corn) and site #5 (soybeans) in mid-August 1976 after cracks were well established. The infiltration trials took place within a 76 cm diameter region enclosed by a galvanized steel ring which was hammered 4 cm into the soil leaving 6 cm above the soil. The profile of water content with depth was determined at four locations in each ring. The time domain reflectometry method (TDR) described by Davis et al. (1976) was applied to pairs of parallel rods separated by 5 cm and installed vertically in the soil. Each such pair of rods constituted a parallel transmission line and was so constructed as to give water contents over the depth intervals 0 to 10 cm, 10 to 30 cm, 30 to 60 cm and 60 to 110 cm. In this technique a fast rise-time step-signal is transmitted down the transmission line and reflected back. The time of travel of this signal along the transmission line depends on the dielectric constant of the soils, which in turn depends on the soil-water content. The measured dielectric constants are converted to water content using the calibration information from Davis et al. (1976).

The four transmission lines in each infiltration ring were placed as follows: one in the soil cracks, one near the soil crack (about 5 cm away), and two in the uncracked portion of the soil body. Measurements of soil-water content vs depth were taken once before any infiltration, five times during infiltration and up to three times after termination of infiltration.

The simulated rainfall was applied according to a half cycle of a sine function with time where a total of 2.5 cm of water was applied over a four hour period. The rate of application is shown in Figure 12-3. This pattern and amount approximated a once in five year precipitation event. The water was applied in measured volume increments which corresponded to 15 minute time intervals. The simulated rainfall was applied in a fine spray from a hand sprayer. The initial increment of 200 ml contained KCl in solution and the Cl- ion was used as a tracer to identify where nutrients may be concentrated. Soil samples were taken at the end of the experiment for determing the pattern of Cl- movement, for bulk density and for gravimetric water contents.

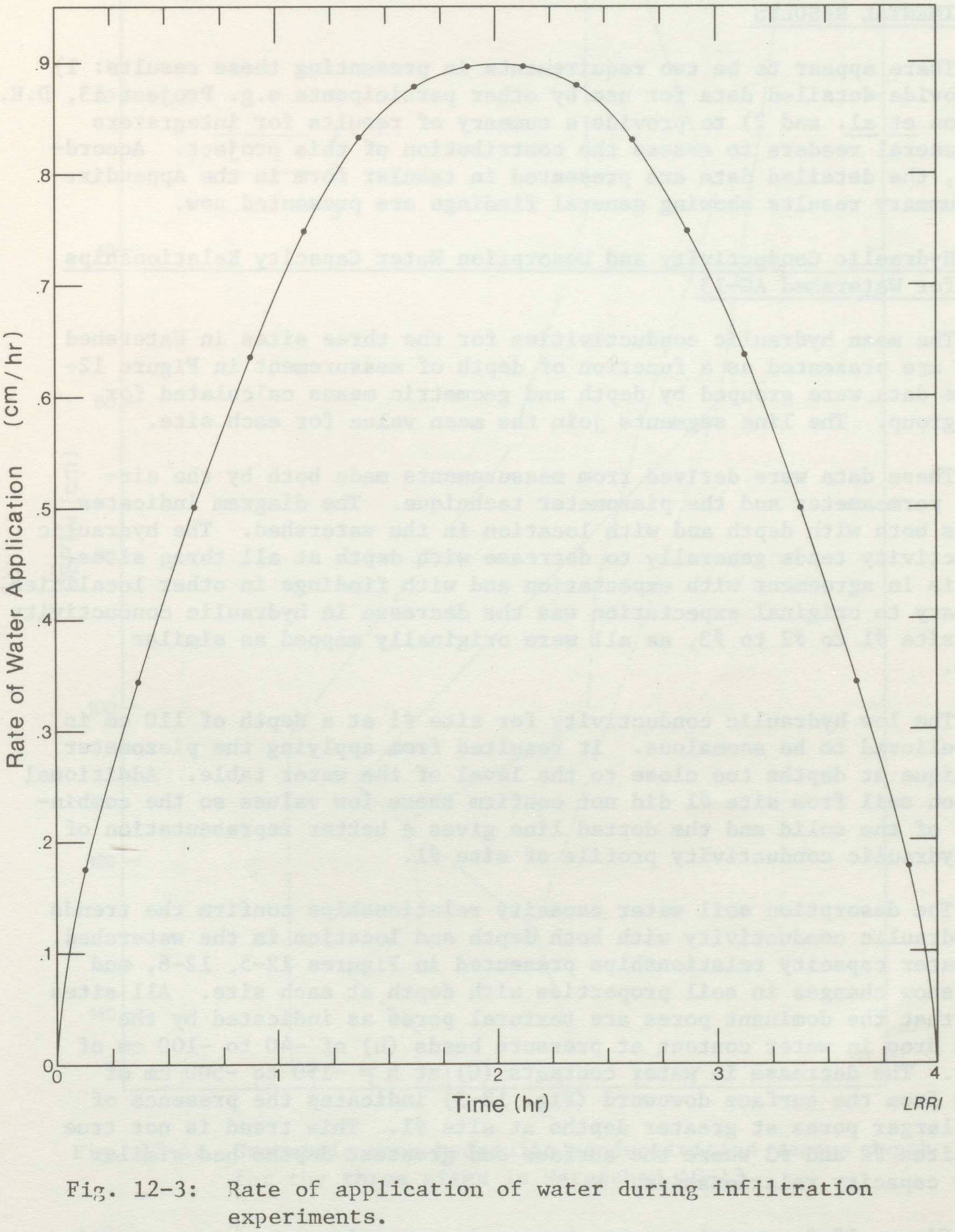


Fig. 12-3: Rate of application of water during infiltration experiments.

As a check on the results of this experiment it was possible to estimate when water would begin to reach the cracks in two other ways: 1) by observing when free water appeared on the soil surface during infiltration 2) through use of previously measured hydraulic conductivities, initial water contents and assumptions concerning depth of penetration of wetting fronts.

EXPERIMENTAL RESULTS

There appear to be two requirements in presenting these results: 1) to provide detailed data for use by other participants e.g. Project 13, D.R. Cameron et al. and 2) to provide a summary of results for integrators and general readers to assess the contribution of this project. Accordingly, the detailed data are presented in tabular form in the Appendix. The summary results showing general findings are presented now.

(a) Hydraulic Conductivity and Desorption Water Capacity Relationships for Watershed AG-13

The mean hydraulic conductivities for the three sites in Watershed AG-13 are presented as a function of depth of measurement in Figure 12-4. The data were grouped by depth and geometric means calculated for each group. The line segments join the mean value for each site.

These data were derived from measurements made both by the air-entry permeameter and the piezometer technique. The diagram indicates trends both with depth and with location in the watershed. The hydraulic conductivity tends generally to decrease with depth at all three sites. This is in agreement with expectation and with findings in other localities. Contrary to original expectation was the decrease in hydraulic conductivity from site #1 to #2 to #3, as all were originally mapped as similar soils.

The low hydraulic conductivity for site #1 at a depth of 110 cm is now believed to be anomalous. It resulted from applying the piezometer technique at depths too close to the level of the water table. Additional data on soil from site #1 did not confirm these low values so the combination of the solid and the dotted line gives a better representation of the hydraulic conductivity profile of site #1.

The desorption soil water capacity relationships confirm the trends of hydraulic conductivity with both depth and location in the watershed. The water capacity relationships presented in Figures 12-5, 12-6, and 12-7 show changes in soil properties with depth at each site. All sites show that the dominant pores are textural pores as indicated by the rapid drop in water content at pressure heads (h) of -40 to -100 cm of water. The decrease in water contents (θ) at h = -150 to -500 cm of water from the surface downward (Fig. 12-5) indicates the presence of more larger pores at greater depths at site #1. This trend is not true for sites #2 and #3 where the surface and greatest depths had similar water capacity relationships.

Figure 12-8 summarizes the changes in pore sizes or water retention properties with depth and with location in the watershed. The degree of

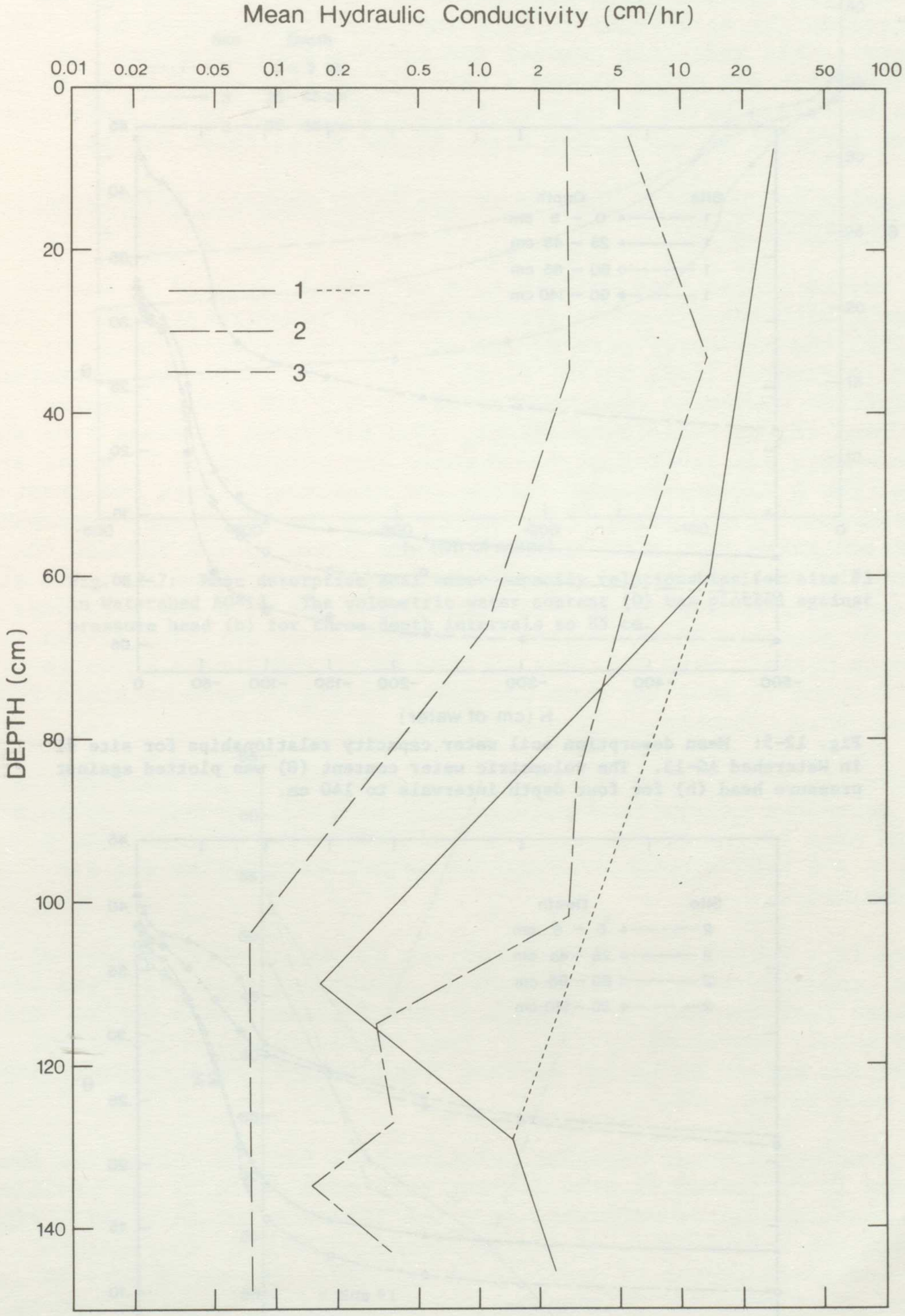


Fig. 12-4: Geometric mean hydraulic conductivities versus depth for the three sites in Watershed AG-13.

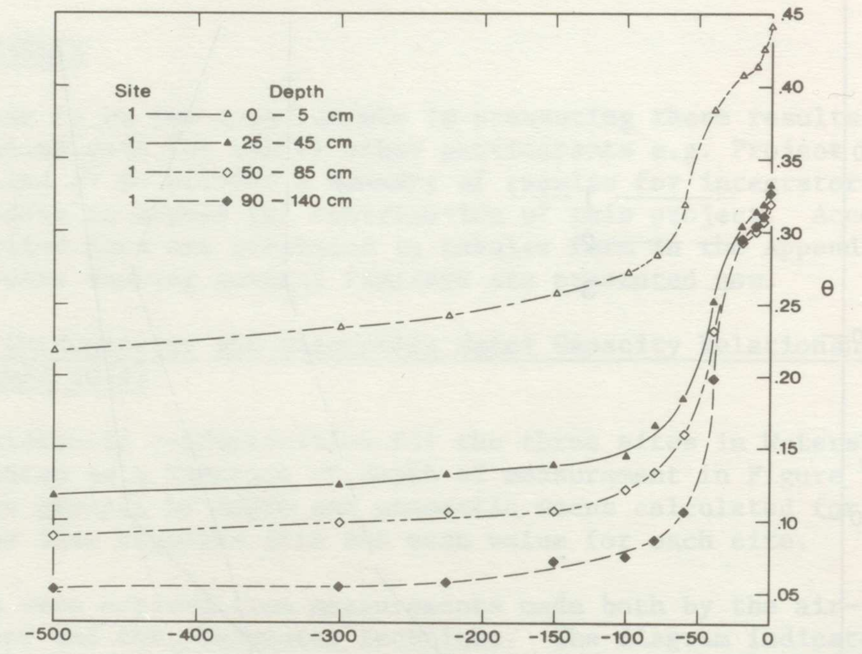


Fig. 12-5: Mean desorption soil water capacity relationships for site #1 in Watershed AG-13. The volumetric water content (θ) was plotted against pressure head (h) for four depth intervals to 140 cm.

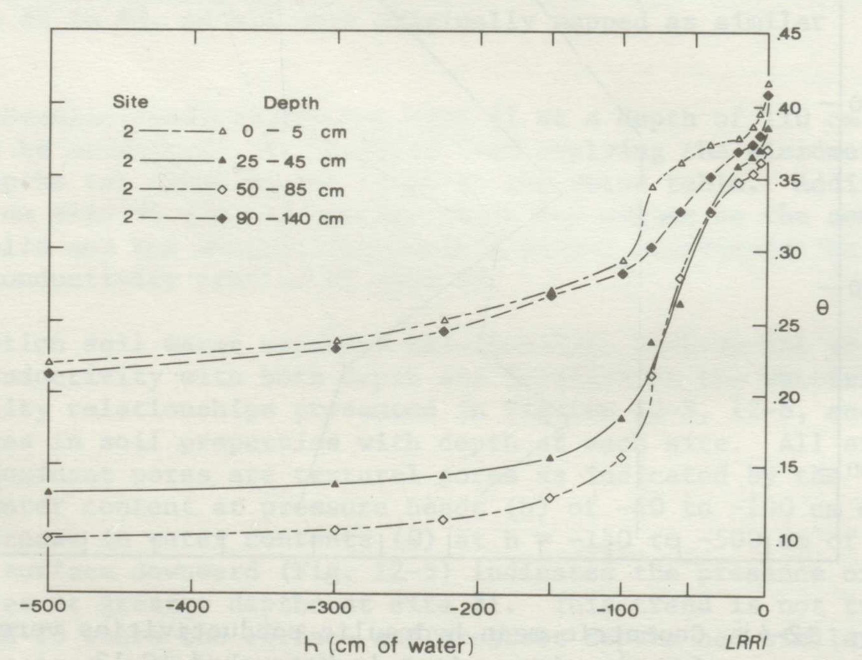


Fig. 12-6: Mean desorption soil water capacity relationships for site #2 in Watershed AG-13. The volumetric water content (θ) was plotted against pressure head (h) for four depth intervals to 140 cm.

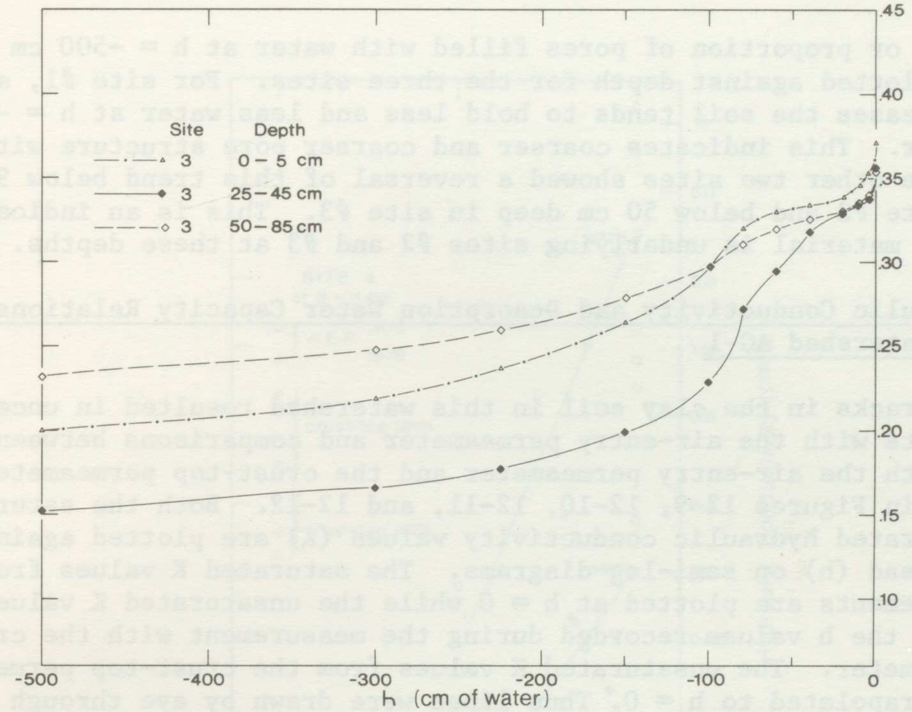


Fig. 12-7: Mean desorption soil water capacity relationships for site #3 in Watershed AG-13. The volumetric water content (θ) was plotted against pressure head (h) for three depth intervals to 85 cm.

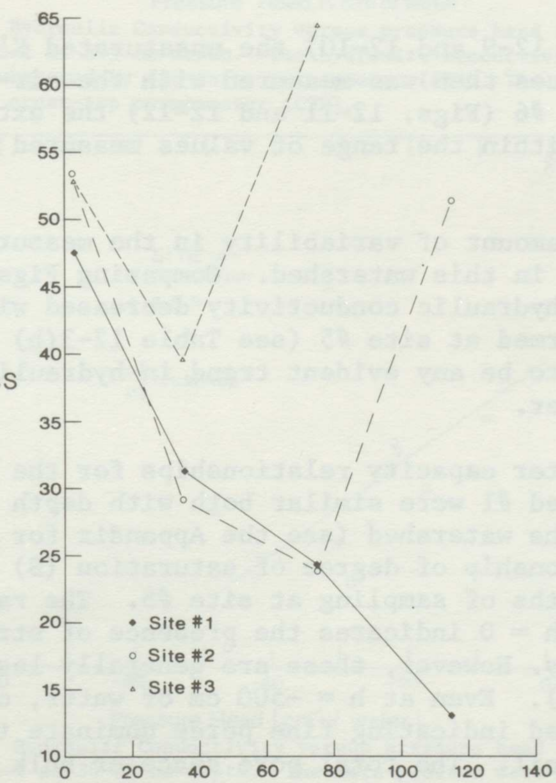


Fig. 12-8: Saturation percentage of soils when dried to h = -500 cm of water for various depths and the three sites of Watershed AG-13.

saturation or proportion of pores filled with water at h = -500 cm of water is plotted against depth for the three sites. For site #1, as depth increases the soil tends to hold less and less water at h = -500 cm of water. This indicates coarser and coarser pore structure with depth. The other two sites showed a reversal of this trend below 90 cm deep in site #2 and below 50 cm deep in site #3. This is an indication that finer material is underlying sites #2 and #3 at these depths.

(b) Hydraulic Conductivity and Desorption Water Capacity Relationships for Watershed AG-1

The cracks in the clay soil in this watershed resulted in uncertain measurements with the air-entry permeameter and comparisons between the results with the air-entry permeameter and the crust-top permeameter are presented in Figures 12-9, 12-10, 12-11, and 12-12. Both the saturated and unsaturated hydraulic conductivity values (K) are plotted against pressure head (h) on semi-log diagrams. The saturated K values from the AEP measurements are plotted at h = 0 while the unsaturated K values are plotted at the h values recorded during the measurement with the crust-top permeameter. The unsaturated K values from the crust-top permeameter can be extrapolated to h = 0. Thus lines were drawn by eye through the data points to estimate a saturated K to compare with those from the air entry permeameter measurements. In Figure 12-9 the 1975 and 1976 data tended to be separate so individual lines were drawn for each season. Data by both methods were obtained at site #4 at the depths shown in Figures 12-9 and 12-10. The data for sites #5 and #6 were obtained from the surface only (Figures 12-11 and 12-12).

In site #4 (Figs. 12-9 and 12-10) the unsaturated K's extrapolate to lower saturated values than was measured with the air-entry permeameter. Whereas in site #5 and #6 (Figs. 12-11 and 12-12) the extrapolated K values at h = 0 fall within the range of values measured by the air-entry permeameter.

There is a large amount of variability in the measured values of hydraulic conductivity in this watershed. Comparing Figs. 12-9 and 12-10 indicates that the hydraulic conductivity decreased with depth. This trend was barely confirmed at site #5 (see Table 12-3(b) - Appendix). There does not appear to be any evident trend in hydraulic conductivity from one site to another.

The desorption water capacity relationships for the soils from the three sites in Watershed #1 were similar both with depth in the profile and with location in the watershed (see the Appendix for details). Fig. 12-13 shows the relationship of degree of saturation (S) to pressure head (h) for three depths of sampling at site #5. The rapid drop in saturation at or near h = 0 indicates the presence of structural pores which drain very easily. However, these are generally less than 10% of the pore space (S >90%). Even at h = -500 cm of water, over 80% of the pores remain waterfilled indicating fine pores dominate the water capacity relationship in this soil. The total pore space or bulk density of the soil (see appendix) was determined at h = -500 cm of water. The fact that S is >100% at h = 0 indicated that the soil was shrinking during drainage to h = -500 cm of water.

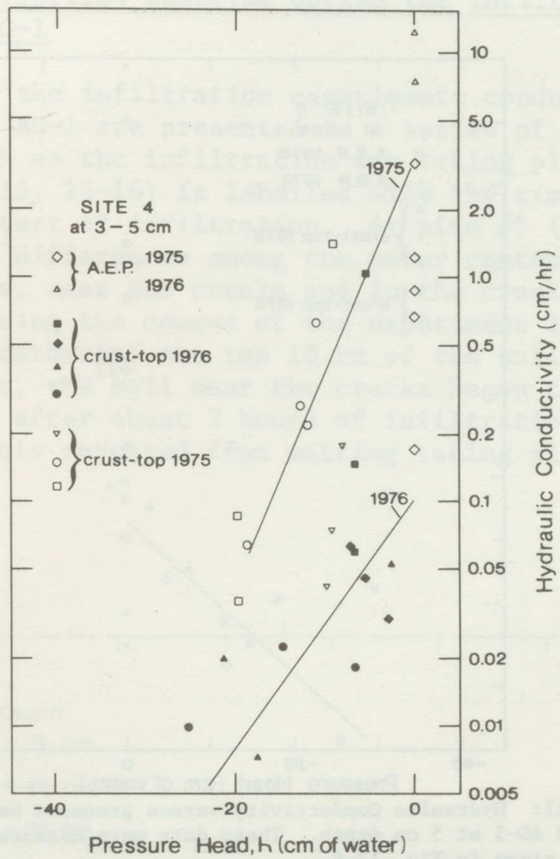


Fig. 12-9: Hydraulic Conductivity versus pressure head for site #4 in Watershed AG-1 at 3-5 cm depth. The hydraulic conductivities plotted at h = 0 were measured by air-entry permeameter (AEP). The other data were obtained by crust-top permeameter (CTP).

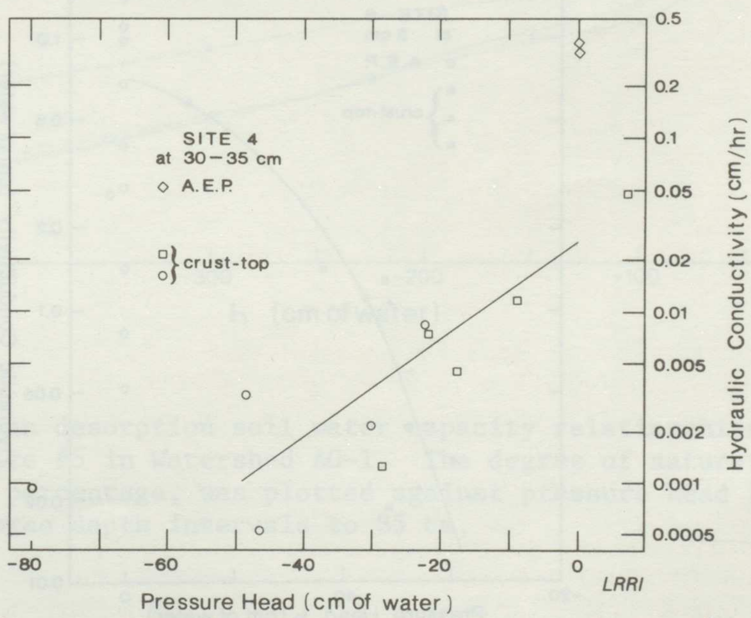


Fig. 12-10: Hydraulic Conductivity versus pressure head for site #4 in Watershed AG-1 at 30-35 cm depth. The data plotted were measured by two types of permeameter as in Fig. 12-9.

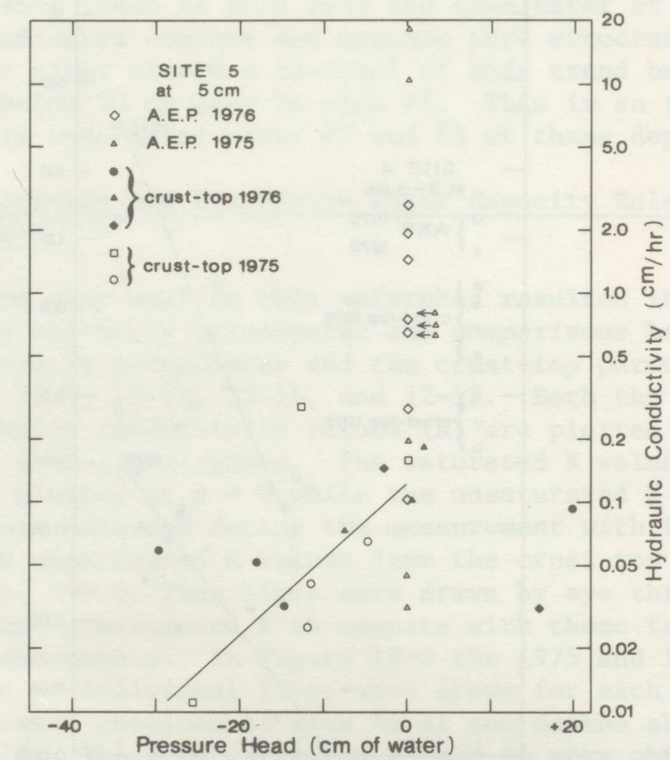


Fig. 12-11: Hydraulic Conductivity versus pressure head for site #5 in Watershed AG-1 at 5 cm depth. These data were measured in the same way as those given in Fig. 12-9.

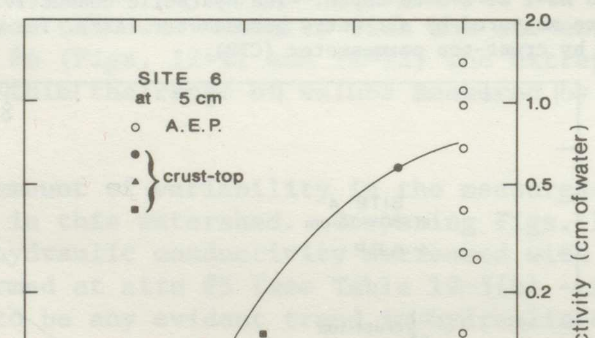


Fig. 12-12: Hydraulic Conductivity versus pressure head for site #6 in Watershed AG-1 at 5 cm depth. These data were measured in the same way as those given in Fig. 12-9.

(c) Water Content Profiles observed during the Infiltration Experiments in Watershed AG-1

The results of the infiltration experiments conducted at sites #4 and #5 in Watershed AG-1 are presented as a series of profiles of water content versus depth as the infiltration was taking place. Each curve (Figures 12-14, 12-15, 12-16) is labelled with the time, in hours, elapsed since the start of infiltration. At site #5 (soybeans crop) there were definite differences among the water content profiles measured away from the cracks, near the cracks and in the cracks. Figure 12-14(a) shows that during the course of the experiment infiltration only changed the water content of the top 10 cm of the soil well away from the cracks. However, the soil near the cracks began to change water content below 10 cm after about 2 hours of infiltration (Figure 12-14(b)). This probably resulted from wetting taking place horizontally

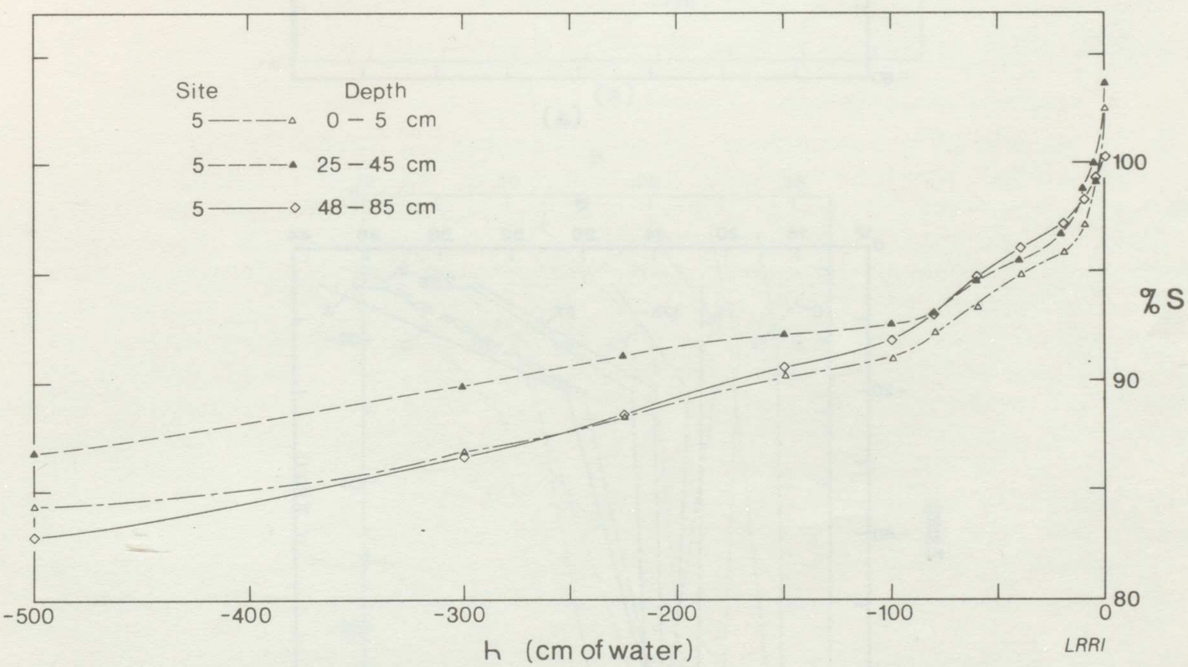
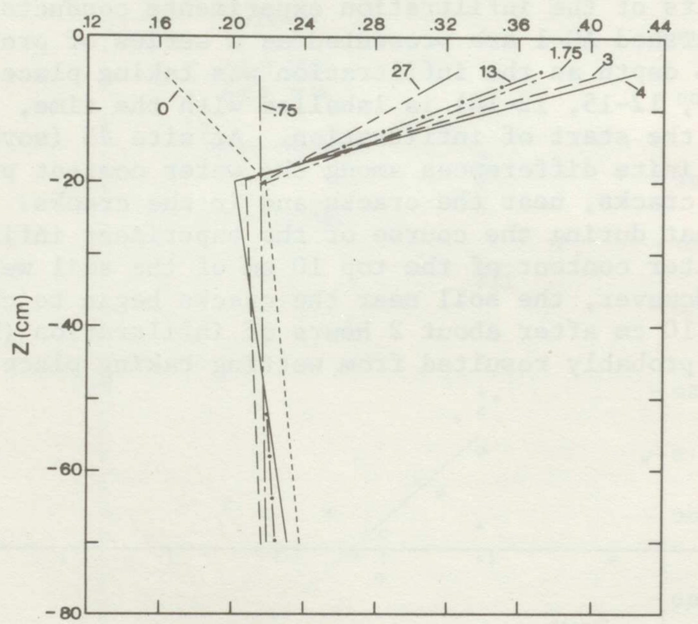
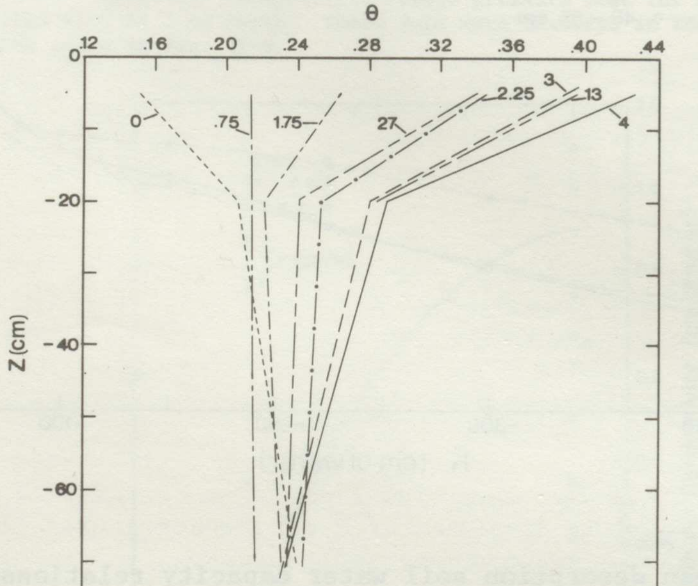


Fig. 12-13: Mean desorption soil water capacity relationships for site #5 in Watershed AG-1. The degree of saturation, as a percentage, was plotted against pressure head (h) for three depth intervals to 85 cm.



(a)



(b)

Fig. 12-14: Volumetric water content (θ) versus depth (Z) profiles obtained during infiltration at site #5 in Watershed AG-1. The parameter labelling each line is the time, in hours, from the beginning of infiltration.
(a) The data points plotted at Z = -5, -20, -70 are means of three measurements made in soil away from cracks.
(b) similar to (a) except measurements were made about 5 cm from cracks.

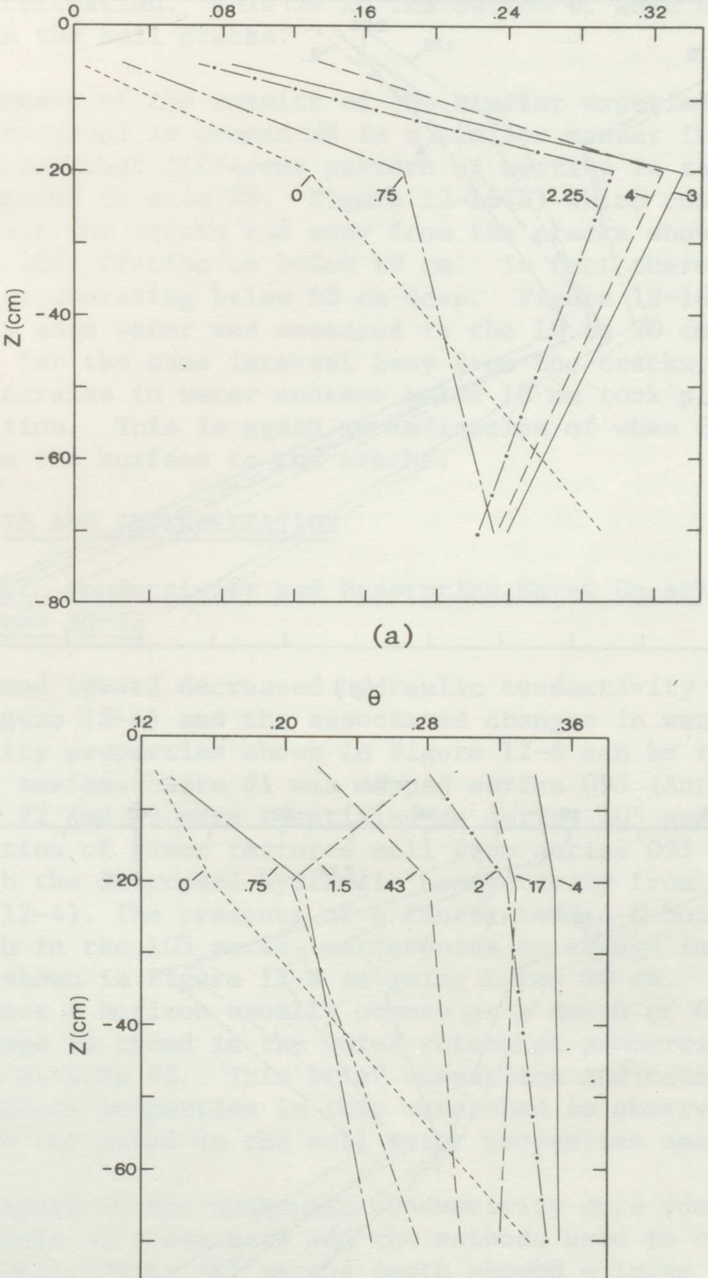
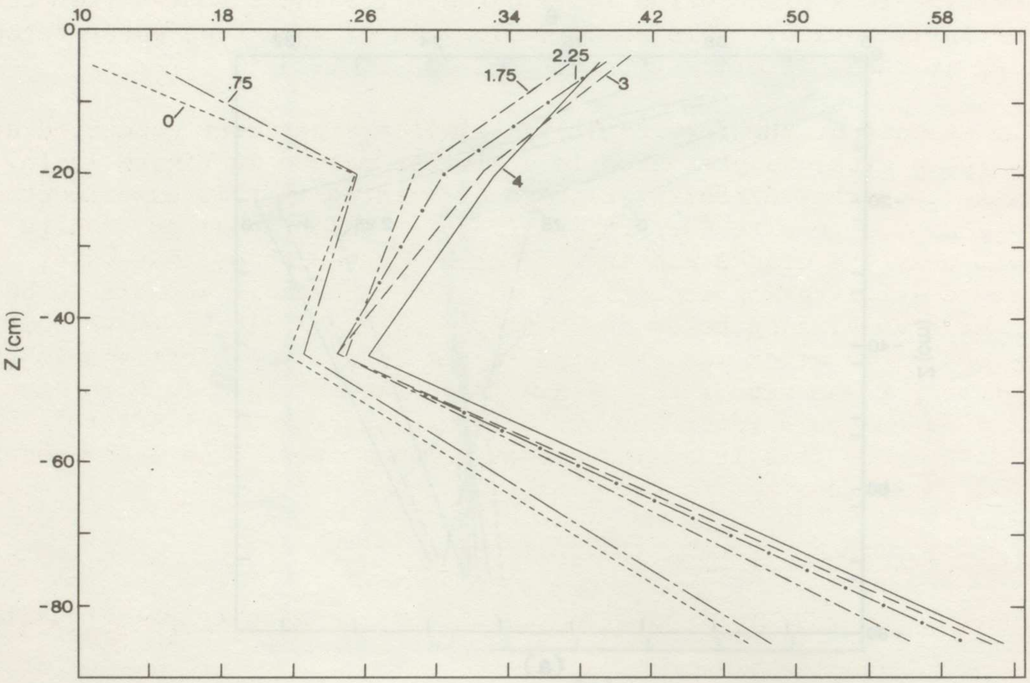
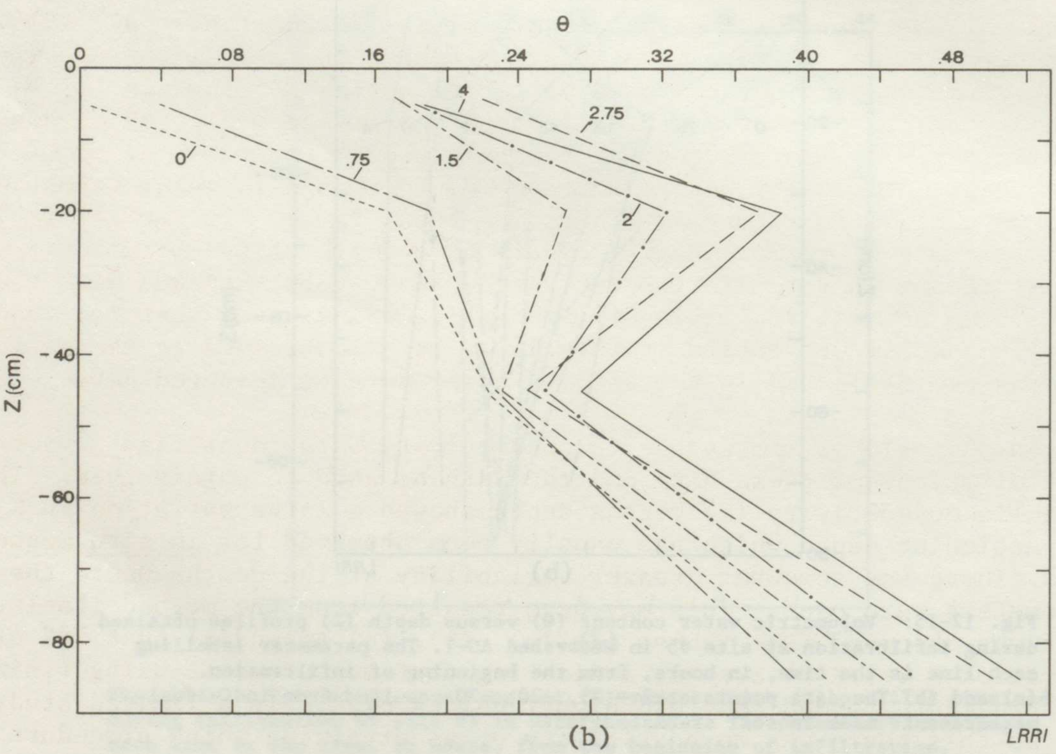


Fig. 12-15: Volumetric water content (θ) versus depth (Z) profiles obtained during infiltration at site #5 in Watershed AG-1. The parameter labelling each line is the time, in hours, from the beginning of infiltration. (a) and (b) The data points at Z = -5, -20, -70 resulted from individual measurements made in soil cracks.



(a)



(b)

Fig. 12-16: Volumetric water content (θ) versus depth (Z) profiles obtained during infiltration at site #4 in Watershed AG-1. The parameter labelling each line is the time, in hours, from the beginning of infiltration.
(a) The data points plotted at Z = -5, -20, -45, -85 are means of six measurements made in soil away from cracks.
(b) similar to (a) except measurements were made about 5 cm from cracks.

from the crack. The water contents profiles measured in the cracks (Figure 12-15) showed no consistent pattern. Figure 12-15(b) shows that rapid wetting took place below 10 cm between 1.5 and 2 hours after the start of infiltration. This is an indication of when free water began appearing in the soil cracks.

The summary of the results of the similar experiment conducted at site #4 (corn crop) is presented in a similar manner in Figure 12-16. There was a somewhat different pattern of wetting in this experiment at site #4 compared to site #5. Figure 12-16(a) which combines results from both near the cracks and away from the cracks shows that water tends to be infiltrating to below 10 cm. In fact there appears to be some water accumulating below 60 cm deep. Figure 12-16(b) shows that considerably more water was measured in the 10 to 30 cm interval in the cracks than for the same interval away from the cracks. In both cases the major increase in water content below 10 cm took place after 1.5 hrs of infiltration. This is again an indication of when free water began flowing from the surface to the cracks.

DATA ANALYSIS AND INTERPRETATION

(a) Hydraulic Conductivity and Desorption Water Capacity Relationships Watershed AG-13

The trend toward decreased hydraulic conductivity from site #1 to site #3 (Figure 12-4) and the associated changes in water retention or water capacity properties shown in Figure 12-8 can be related to currently mapped soil series. Site #1 was mapped series 095 (Acton et al. 1978). While sites #2 and #3 were identified as series 105 and 115, respectively. The observation of finer textured soil from series 095 through 115 concurs with the decreased hydraulic conductivity from site #1 through #3 (Figure 12-4). The presence of a finely bedded C horizon at or below 100 cm depth in the 105 series corresponds to change in water retention properties shown in Figure 12-8 in going below 90 cm. In the 115 series the calcareous C horizon usually occurs at a depth of 60-90 cm. A similar change in trend in the water retention properties was measured below 50 cm at site #3. This brief comparison indicates that the changes in morphological properties in this watershed as observed by the soil surveyor are reflected in the soil water properties measured here.

An analysis of the hydraulic conductivity data identified some of the limitations of these data and the methods used to obtain them. The hydraulic conductivity (K) versus depth showed a large variation in K at any particular depth which has usually been observed for in situ measurements. There was somewhat greater variability at the depths where the piezometers were used. This may have resulted from the method itself, as it was observed (see Tables 12-2(a), (b), (c) Appendix) that 78% of the ratios K (r)/K(f) are >1, indicating that measurements using rising head procedure tended to yield higher values of K. In a limited study such as this there was no possibility of ascertaining which procedure gave the more representative values. As a result all were used to calculate mean values at each depth.

The ratios K (10)/K(2.5) showed a wide range of values from 0.1 to 49 with 70% being >1. This was an indication that the hydraulic conductivity in the horizontal direction was greater than that in the vertical direction. This was the expected result since the soils showed evidence of horizontal layering. However, with the wide variation in the ratios and the limited number of data points it was impossible to determine a quantitative relationship between horizontal and vertical hydraulic conductivities.

In general it was not possible to make measurements at the same depth with both the permeameter and piezometer methods to check one against the other. However, the data showed generally good consistency between the methods. All three sites showed a trend for decreasing K with depth.

From Figure 12-4 where mean hydraulic conductivities are plotted against depth for the three sites, one can observe that the hydraulic conductivity at all depths decreases from site 1 to 3 by about a factor of 10 with site 2 being between. If one ignores the anomalous low point as discussed in the Results section and uses the dotted line in Fig. 12-4, there is no crossing of the mean lines at any depth.

The amount of water held at h = -500 was progressively less with increasing depth within the soil at site #1. This indicated that with increased depth a higher proportion of the pore space is made up of larger pores (Fig. 12-8). This presumably would contribute to a higher saturated hydraulic conductivity with depth which is contrary to what was observed. The values for hydraulic conductivity measured by the University of Waterloo (Project 14, personal communication) at greater depths were at the high end of the range of our measured values at site #1. Thus there appears to be some cause to question the low values obtained at site #1 by our piezometer technique. Perhaps the method of insertion by pushing in the 2.5 cm diameter pipe behind a tapered point increased the density of soil surrounding the well-point (tip) and resulted in low values of hydraulic conductivity.

The desorption water capacity relationships from sites #2 and #3 (Figs. 12-6, 12-7) indicated that the soils at greater depth in these sites retain increased amounts of water at h = -500. At site #2 the 90 to 140 cm depth retains water similar to the surface soil while the two intermediate depths retain less. The intermediate depths at both sites #1 and #2 had similar water capacity relationships. In Figure 12-7 it can be seen that the 50-85 cm depth is retaining even more water than the surface soil does at h = -500. From these observations one would expect the hydraulic conductivity to decrease with depth in response to the changes in pore size distribution as indicated by the desorption water capacity relationships.

In general the techniques used in Watershed AG-13 have given consistent and reproducible data on the major soil-water properties i.e. saturated hydraulic conductivity and desorption water capacity relationship. The tables and figures displaying these data represent a first step analysis and evaluation of the data as tools for characterizing the storage and flow processes operative in the soil of the watershed. The next step in the characterization process depends on the use of these data in applications to the water transport model used in Project 13 (Nitrogen Transport - D.R. Cameron <u>et</u> <u>al</u>.).

b) Hydraulic Conductivity and Desorption Water Capacity Relationships Watershed AG-1

In Watershed AG-1, the difficulties of making measurements in clay soil made it impossible to make sufficient measurements to characterize adequately the soil-water properties. Both the hydraulic conductivity and the desorption water capacity relationships were similar from site to site. The data from the air entry permeameter (AEP) showed greater apparent variability than data from the crust-top permeameter. This probably resulted from soil cracks which would affect the saturated K considerably more than the unsaturated K. In 1975 some AEP measurements were made after the soil was visibly cracked as a result of drying while in 1976 every effort was made to make AEP measurements in the clay soil before cracks had appeared. In Fig. 12-11 where sufficient data exist to allow comparison, the 1976 K(AEP) values show less range of variation - .1 to 2.6 cm/hr as opposed to .31 to 18 cm/hr for 1975.

For site #4 (Fig. 12-9) there was higher hydraulic conductivity measured by both CTP and AEP in 1975 as compared to equivalent measurements made in 1976 at the soil surface. The only explanation available for this is the fact that in 1975 Site 4 was cropped to winter wheat and in 1976 it was under corn. Such results of higher hydraulic conductivity would result from improved structure in the clay soil. There were no associated observations made to confirm this hypothesis. However, if it is true this substantiates the observations of farmers of clay soils that following winter wheat the soil is much more easily cultivated than following spring grains.

The tendancy to decreased K with depth (Fig. 12-10, and Table 12-3(b)) was substantiated by analysis of the desorption water capacity relationships from site #4 and #5. The desorption water capacity relationships for site #4 showed that more of the pore space in the surface soil is as larger pores and that resulted in the higher saturated hydraulic conductivity as compared to that measured in the subsoil. At site #5 desorption water capacity relationships were similar and the hydraulic conductivities of the surface and subsoil were found to be similar at 0.663 cm/hr and 0.563 cm/hr, respectively (Table 12-3(b)).

Watershed AG-1 was found to be principally series 176 (Acton et al. 1978) or the Brookston series in Essex County survey. Comparisons of series 176 descriptions with our own field observations showed that all our sites were similar to series 176. Thus the lack of difference from site to site which we have measured can be attributed the similar morphological features as observed by soil survey.

The above discussed data have a number of limitations in use for characterizing the water storage and transmission properties of Watershed #1. Those which are obvious are: 1) because measurements of flow in clay soils are difficult and time consuming too few data were often obtained; 2) the wetness of the clay soil below the surface except for a very short period in the latter part of summer meant that few data were obtained below the surface; 3) the cracking of clay soils and the resultant bi-modal (in-crack and inter-crack) flow system was virtually impossible to characterize adequately. The infiltration experiment discussed in the next section has attempted to overcome some of the limitations of this third problem.

At best, then, the data presented here can be used as estimates or limits for the hydraulic conductivity. The desorption water capacity relationship showing a higher degree of consistency can perhaps be used more directly. The degree to which these soil properties as measured in Watershed AG-1 adequately represent how the soil responds depends on their use and testing in models such as for Project 13 (D.R. Cameron et al.)

(c) The Role of Soil Cracks during Infiltration Experiments

The water content profiles were measured during the infiltration experiment in order to determine if possible, when water began flowing in the soil cracks. This discussion will compare different ways of estimating when water began entering cracks.

From the water content profiles (Figs. 12-14, 12-15, and 12-16) it is possible to estimate when water was likely to enter the cracks. From Fig. 12-14(a) where only the top 10 cm of soil shows water content changes, it is possible to estimate whether the water added and the measured water content changes are equal. During the period 1.75 to 3 hrs the added water would cause a 0.1 change in water content. However Fig. 12-14(a) shows only a 0.03 change. Thus it is probable that water not accounted for within the soil was entering cracks after about 1.75 hrs of infiltration. Referring to Fig. 12-14(b) one can observe that rapid wetting of the -10 to -30 cm level took place near the cracks after 1.75 hrs. The data obtained within the cracks as shown in Figs. 12-15(a) and (b) indicated that wetting of the -10 to -30 cm level had occurred prior to the 2.25 hrs and 2 hrs, respectively. Thus for the infiltration experiments in the soybean field, the water content profiles indicated that water began entering the soil cracks after 1.75 to 2.25 hrs of infiltration or after 1 cm depth of water had been sprinkled on the soil.

During the experiments the surface of the soil was observed for the presence of free water. The times of occurrence of free water at the surface were 1.25, 1.75, and 2.25 hrs. It is worth noting that the ring showing free water at 1.25 hrs was one in which water was detected below -30 cm at 1.5 hrs. The transmission lines gave a reliable measure of when water entered soil cracks.

Having measured hydraulic conductivity as discussed earlier, and by making assumptions about how the initial infiltration takes place it was possible to estimate when the applied "rainfall" rate exceeds the infiltrability of the soil. At the beginning of the experiment it was observed that a 1 to 2 cm layer of aggregated soil material covered the surface of much less structured soil. Therefore it was assumed this material wetted to 85% of saturation and its hydraulic conductivity did not limit its rate of wetting. From initial measured values of water content and density it was found that this surface layer absorbed .81 cm of the initial applied "rain". We chose a saturated hydraulic conductivity of 0.12 cm/hr from Fig. 12-11 as the maximum infiltration rate for soil between the cracks. When the applied rate exceeded this value we concluded that water would begin entering cracks. The initial .81 cm was added during the first 1.5 hrs and the rate of addition of water from 1.5 to 1.75 hrs was 0.88 cm/hr which was in excess of 0.12 cm/hr. Therefore this procedure has predicted that water should begin to enter cracks between 1.5 and 1.75 hrs after infiltration started. This is in excellent agreement with the observations of the soil surface during the experiments and with the data recorded by the transmission lines method.

Although the transmission line data for site #4 (corn) were not as consistent it is possible to analyze Fig. 12-16 in a way similar to that used for Figs. 12-14, 10 and 12-15 and arrive at the time when water appeared in the cracks. This analysis gave a time of 1.5 to 1.75 hrs. The observations of the surface soil during experiments gave 1.75 and 2 hrs for two of the rings while the third never showed free water at the surface. The calculations using the hydraulic conductivity, initial water contents, and bulk density yielded 1.75 hrs as the time when the "rainfall" rate exceeded the infiltrability of the soil in site #4. The results from the corn plot were more variable but the three types of observations gave similar estimates of when water began flowing in the cracks.

For the purposes of quantitative estimates of the amount of rainfall which enter soil cracks, the use of hydraulic conductivity values, initial water contents, bulk density and assumptions about the initial infiltration between cracks has the greatest potential. However, the measurement of hydraulic conductivity is laborious and time consuming. The method of observing the soil surface during the rainfall is at best qualitative and its use depends on the condition of the soil surface. The electrical measurements using transmission lines both in cracks and away from cracks has potential for quantitative estimates. However, the causes of problems encountered in the experiments at site #4 (corn) must be understood and corrected.

RELATIONSHIPS OF PROJECT RESULTS TO PLUARG OBJECTIVES

The results of this project cannot be related directly to PLUARG objectives except in a very general way. This project was intended to provide input information to the nitrogen model of Project 13 (D.R. Cameron et al.). The majority of the data obtained from Watershed AG-13 has been evaluated and used where applicable in the water transport part of the model in Project 13. The fact one project was to provide input to the next and the fact that the termination dates of both projects were coincident has meant that some of the later available information on soil-water phenomena in Watershed AG-1 have not been applied by way of Project 13. The results of measurements on Watershed AG-1 indicate that cracks are indeed very important to the movement of water in clay soil. In this case rainfall rates in excess of 1 mm/hr after 1 cm has fallen will contribute to flow in cracks. When nitrates occur at the soil surface these could be carried into the crack with the infiltrating rainfall. Information not availabe is the storage volume of cracks and the interconnectivity between cracks and/or with the under-drainage network. Therefore this study was not complete enough to answer the question whether this is a significant source of pollutants to the surface waters. Information from field plot studies, (Project 13), and other measurements on tile drain experiments (Bolton et al. 1970, Bolton and Hore 1976) should be assembled as a subsequent analysis.

The questions of "extent of contributions to unit area seasonal loadings and degree of transmission to boundary waters" are beyond the scope and objectives of this project but depend on pulling together a number of other projects that bear on the question.

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APPENDIX

The hydraulic conductivity data and desorption water capacity data have been assembled in this appendix to provide direct access for anyone pursuing further studies such as Project 13. The Hydraulic Conductivity are presented in Tables 12-1 through 12-4. Table 12-5 is the desorption water capacity data.

(a) Hydraulic Conductivity

The air-entry permeameter results for sites #1, 2, 3 of Watershed AG-13 are presented in Tables 12-1(a), (b), (c), respectively. In addition to hydraulic conductivity, these tables include depth to the midpoint of each measurement, water contents both before and after AEP measurement, the air-entry value and the number of the soil core taken from within the same soil.

The data from the piezometer measurements are given in Tables 12-2(a), (b), (c) for Sites #1, 2, 3, respectively. In addition to a code number for each measurement these tables include depth of measurement, depth to water table, length of piezometer tip, direction of flow during measurement, the hydraulic conductivity. The last two columns give various ratios of hydraulic conductivity values. K(r)/K(f) was used to assess the consistency between data obtained when water was flowing into the piezometer with that obtained during outflow from the piezometer. K(10)/K(2.5) was used to determine if the hydraulic conductivity in the horizontal direction exceeded that in the vertical direction.

The code nos. beginning with 4 in Table 12-2(a) represent measurements taken near piezometer nest H9 of Project 14. Those beginning with 5 were taken near their pieozmeter nest H10. The measurements from Project 14 at H9 at 510 cm depth gave a hydraulic conductivity of 23.8 cm/hr while two measurements at H10 gave 36 cm/hr at 300 cm depth and 4.32 cm/hr at 450 cm.

Tables 12-3(a), (b), (c) give results of air-entry permeameter measurements in Watershed #1. The information given is similar to that included in tables 12-1(a), (b), (c). In Tables 12-3 the (a), (b), (c) refer to site 4, 5, 6 respectively. The unsaturated hydraulic conductivity values obtained from the crust-top permeameter are presented in Table 12-4. In column 4 are the pressure heads as measured by tensiometers and registered on mercury manometers and in column 5 are the corresponding measured unsaturated hydraulic conductivities.

(b) Desorption Water Capacity Relationships

The desorption water capacity data obtained on the soil cores are presented in Tables 12-5(a) through (f). These data are for soils from the six sites in both Watersheds AG-13 and AG-1 and the tables include water contents measured by the method of Topp and Zebchuk (1978), plus pressure plate determinations of the 15-bar water content, and bulk density of the soil core dried to -500 cm of water. The data have been grouped by depth. The arithmetic means and standard deviations of each depth have been calculated and are given in these Tables also.

Table 12-1(a) Hydraulic Conductivity, water contents, air entry value, and depth for measurements in Watershed #13 at Site #1.

Depth (cm)	θ_i*	θ_f*	A.E.V.* (cm of water)	K* (cm/hr)	Core No.
7.5	.086	.242	20.5	146	---
7.5	.097	.229	22.0	83.0	---
7.5	.104	.297	18.0	40.8	---
7.5	.116	.299	16.5	34.7	---
7.5	.112	.233	19.0	12.0	---
7.5	.114	.257	17.0	8.9	---
7.5	.115	.256	5.5	16.8	---
7.5	.115	.296	----	75.5	---
7.5	.121	.268	18.0	23.0	---
7.5	.122	.271	15.0	24.8	---
7.5	.132	.295	27.5	14.0	---
7.5	.076	.208	18.0	13.3	---
7.5	.070	.231	8.0	27.8	---
7.5	.090	.249	4.0	29.0	---
7.5	.098	.213	2.5	29.0	---
31.5	.085	.148	10.5	5.30	472
35.5	.077	.145	11.0	5.96	473
34.5	.147	.221	21.5	4.60	---
34.5	.072	.227	12.0	62.0	478
33.5	.093	.186	----	47.1	---
37.5	.101	.261	9.5	42.8	467
38.5	.087	.201	----	12.9	---
39.5	.082	.227	20.5	15.0	477
41.5	.074	.232	16.5	15.0	476
42.5	.114	.205	8.0	18.0	474
42.5	.079	.223	11.0	59.5	---
46.0	.110	.198	2.5	20.0	475
7.5	.09	.24	-16.7	29.0	
7.5	.10	.24	-12.5	32.2	
7.5	.11	.25	-16.7	47.8	
7.5	.10	.23	-20.4	16.9	732
7.5	.11	.24	-20.4	55.5	
7.5	.10	.24	-14.8	18.4	
35.5	.08	.18	-6.5	9.31	
35.5	.10	.21	-6.3	30.9	737
37.5	.11	.21	-6.4	14.1	733
37.5	.10	.23	-13.4	31.0	734
38.5	.06		-11.1	15.7	
41.5			-12.7	27.8	
58.5	.10	.19	-3.8	11.7	735
60.5	.08	.18	-15.3	12.5	520
61.5			-11.1	17.6	

*θ_i = water content by weight before A.E.P. measurement
θ_f = water content by weight after A.E.P. measurement
A.E.V. = Air Entry Value
K = saturated hydraulic conductivity by A.E.P.

Table 12-1(b) Hydraulic Conductivity, water contents, air entry values and depth for measurements in Watershed #13 at Site #2.

Depth (cm)	θ_i*	θ_f*	A.E.V.* (cm of water)	K* (cm/hr)	Core No.
7.5	.201	.321	15.0	9.39	---
7.5	.188	.260	12.0	1.68	405
7.5	.151	.316	20.0	38.7	409
7.5	.145	.302	21.0	20.3	410
5.0	.145	.217	17.5	5.96	444
5.0	.139	.260	15.5	11.2	445
5.0	.151	.275	25.5	4.7	421
5.0	.142	.285	8.5	7.8	422
5.0	.138	.295	33.5	9.35	426
6.5	.147	.240	23.5	8.8	425
5.0	.142	.267	25.0	12.6	440
5.0	.145	.215	28.0	3.78	441
29.0	.112	.244	5.0	15.8	424
30.0	.163	.256	18.0	18.0	442
31.0	.133	.238	20.0	12.9	443
31.5	.136	.261	10.5	28.0	406
32.0	.127	.235	11.0	18.7	423
32.0	.168	.215	10.5	7.22	---
32.5	.147	.230	18.5	25.9	411
34.0	.112	.232	18.5	25.1	---
35.5	.134	.238	9.0	35.4	412
36.0	.113	.234	20.0	12.7	446
37.5	.144	.248	9.5	15.0	407
38.0	.157	.241	13.0	11.3	427
64.0	.168	.208	29.5	4.24	---
69.5	.195	.231	29.5	6.06	408
87.0	.120	.235	13.0	7.4	485
89.5	.105	.227	22.0	9.4	484
100.5	.098	.222	8.0	8.9	522
102.5	.105	.230	11.0	8.2	---
7.5	.15	.26	-21.6	9.46	
7.5	.13	.25	-10.4	2.76	706
7.5	.16	.24	-34.5	1.22	710
7.5	.14	.24	-30.9	3.04	
7.5	.15	.24	-17.4	2.50	
7.5	.15	.24	-13.3	3.35	
7.5	.12	.27	-28.5	3.19	
7.5	.16	.26	-21.8	1.95	
28.5	.14	.22	- 9.0	13.1	707
28.5	.12	.23	-14.5	19.1	
32.5	.14	.16	- 7.9	2.66	711
32.5	.14	.26	-13.6	17.5	727
34.5	.15	.18	- 9.3	6.63	713
35.5	.14	.23	- 6.6	10.7	
35.5	.16	.24	-11.8	5.35	
39.5	.15	.25	-19.2	7.38	
64.5	.20	.21	-18.9	3.89	
64.5	.16	.22	-28.3	5.72	
80.5	.21	.21		2.09	709

*θ_i - water content by weight before A.E.P. measurement
θ_f - water content by weight after A.E.P. measurement
A.E.V. - air entry value
K - saturated hydraulic conductivity by AEP

Table 12-1(c) Hydraulic Conductivity, water contents, air entry values and depth for measurements in Watershed #13 at Site #3.

Depth (cm)	θ_i^*	θ_f^*	A.E.V.*	K* (cm/hr)	Core No.
5	.108	.239	24.5	12.6	----
5	.103	.202	24.0	5.75	402
5	.144	.255	29.5	3.44	----
5	.142	.208	24.0	5.02	----
5	.154	.248	19.9	4.49	----
5	.150	.211	23.0	1.23	418
5	.140	.258	21.5	6.87	----
5	.130	.261	13.0	9.31	419
5	.148	.254	23.5	3.8	428
5	.144	.247	14.5	1.50	429
5	.144	.197	32.5	3.12	432
5	.145	.230	17.0	2.04	433
5	.136	.191	17.5	1.90	438
7.5	.116	.313	29.0	2.51	----
30	.183	.210	11.0	1.98	----
31	.131	.209	7.5	6.41	415
32	.143	.206	23.5	3.59	401
32.5	.134	.212	19.5	5.84	403
32	.172	.197	13.5	0.89	439
33	.118	.187	21.5	5.10	430
34	.139	.218	10.0	5.2	435
35	.164	.205	13.0	1.35	463
36	.174	.252	13.0	1.39	462
36	.126	.206	11.5	7.98	434
36.5	.193	.225	10.5	1.06	----
38	.163	.163	14.5	11.4	431
61	.190	.203	17.0	0.70	437
62	.197	.230	13.0	0.53	436
62	.188	.197	21.5	0.67	464
63	.184	.207	28.5	0.66	465
65	.160	.212	3.5	2.10	486
65	.155	.207	5.0	1.10	487
70	.203	.199	21.0	0.47	404
78	.175	.217	15.5	2.20	480
83.5	.176	.201	16.0	1.40	482
7.5	.15	.28	-30.7	1.44	
7.5	.14	.31	-27.6	1.59	
7.5	.16	.30	-18.0	3.85	
7.5	.15	.26	-10.4	3.13	
7.5	.17	.23		5.18	509
7.5	.16	.23		0.730	511
7.5	.13	.22	-29.0	0.670	
7.5	.16	.30	-34.5	1.69	
33.5	.17	.19	-13.7	1.10	499
33.5	.15	.20	-19.8	9.23	700
38.0	.16	.23		3.31	508
38.5	.17	.21	-27.6	0.565	495
58.5	.20	.23	-13.4	5.17	701

*θ_i - water content by weight before AEP measurement
θ_f - water content by weight after AEP measurement
A.E.V. - air entry value
K - saturated hydraulic conductivity by AEP

Table 12-2 (a) Hydraulic Conductivity, depth of measurements, and depth to watertable in Watershed # 13 at Site #1.

Code No.	Z* (cm)	X* (cm)	h_c^* (cm)	f or r*	K* (cm/hr)	K(r)*/K(f)	K(10)*/K(2.5)
3.1.1	83	43	10	f	.124		
1.1.1.	104	44	2.5	f	.447		
1.2.2.	111	66	10	f	.0183		
2.1.1.	111	100	2.5	f	.254		1.27
2.1.2	111	100	10	f	.323		
3.4.1.	127	92	2.5	f	.420		
3.4.2.	127	92	10	f	.220		.524
3.3.1.	130	84	2.5	f	.812		
2.2.1.	131	101	2.5	f	.617		
1.3.1	145	93	2.5	f	3.24		
1.3.2.	145	93	10	f	.348		.107
2.3.1.	145	89	2.5	f	.172		
3.2.1.	147	97	10	r	19.0	1.24	
3.2.1.	147	97	10	f	15.3		
- - -							
4.1.1.	125	110	2.5	f	3.66		
4.1.2.	125	110	10	f	6.02		1.64
4.2.1.	136	112	2.5	f	.729		5.71
4.2.2.	136	112	10	f	4.16		
4.2.2.	136	112	10	r	2.61	.627	
4.3.1.	145	105	2.5	f	.263		
4.3.1.	145	105	2.5	r	1.42	5.40	
4.3.2.	145	105	10	f	.729		1.76
4.3.2.	145	105	10	r	2.50	3.43	2.77
4.4.2.	156	122	10	f	2.83		
4.4.2.	156	122	10	r	34.7	12.3	
- - -							
5.1.1.	124	61	2.5	f	.369		
5.1.1.	124	61	2.5	r	2.33	6.31	
5.1.2.	124	61	10	f	1.50	7.87	4.07
5.1.2.	124	61	10	r	11.8		5.06
5.2.1.	131	58	2.5	f	.0681		
5.2.1.	131	58	2.5	r	3.31	48.6	
5.2.2.	131	58	10	f	3.35		49.2
5.2.2.	131	58	10	r	10.5	3.13	3.17
5.3.1.	144	64	2.5	f	.248	11.0	
5.3.1.	144	64	2.5	r	2.73		
5.3.2.	144	64	10	f	11.2	.932	45.2
5.3.2.	144	64	10	r	10.44		3.82

*Z - depth of measurement
X - depth of water table
f - falling head, r - rising head
h_c - lenght of piezometer tip (wellpoint)
f or r - direction of flow during measurement
K - saturated hydraulic conductivity
K(r)/K(f) - ratio of conductivites for rising vs falling head measurement
K(10)/K(2.5) - ratio of conductivities with length of piezometer tip 10 cm vs 2.5 cm

Table 12-2(b) Hydraulic conductivity, depth of measurement, and depth to water table. Watershed #13 at Site #2.

Code No.	Z* (cm)	X* (cm)	h_c^* (cm)	f or r*	K* (cm/hr)	K(r)*/K(f)	K(10)*/K (2.5)
4.1.1.	100	70	3	f	0.423		
4.1.2.	100	70	10	f	4.89		11.6
4.1.2.	100	70	10	r	4.25	.869	
6.1.1.	103	61	2.5	f	.484		
6.1.2.	103	61	10	f	4.97		10.3
3.1.1.	104	68	2.5	f	1.90		
3.1.2.	104	68	10	f	3.31		1.74
. . . .							
5.1.1.	113	68	2.5	f	.294		
. . . .							
4.2.2.	114		10	f	.0723		
3.2.1.	118	68	2.5	f	0.415		
3.2.2.	118	68	10	r	1.06		
1.1.1.	126	92	2.5	f	.189		
1.1.2.	126	92	10	f	1.20		6.35
1.1.2.	126	92	10	r	1.14	.950	
2.1.1.	128	99	2.5	f	.275	1.15	
2.1.1.	128	99	2.5	r	.316	1.15	
2.1.2.	128	99	10	r	1.03	21.4	3.25
2.1.2.	128	99	10	f	.0482		.175
5.2.1.	135	88	2.5	f	.0648		
5.2.2.	135	88	10	f	.140		2.16
1.2.2.	135	102	10	f	.204		
1.2.2.	135	102	10	r	.665	3.26	
2.2.1.	136	109	2.5	f	.118		
2.2.1.	136	109	2.5	r	.369	3.13	
2.2.2.	136	109	10	f	.0291		.247
4.3.1.	143	87	2.5	r	.132		
4.3.2.	143	87	10	r	.266		2.02
2.3.1.	145	98	2.5	f	.591		
2.3.1.	145	98	2.5	r	1.37	2.32	
2.3.2.	145	98	10	r	.421	3.66	.367
2.3.2.	145	98	10	f	.115		.175
1.3.1.	146	99	2.5	r	1.22		

* As in Table 12-2 (a)

Table 12-2 (c) Hydraulic conductivity, depth of measurement, and depth to watertable Watershed #13 at Site #3.

Code No.	Z* (cm)	X* (cm)	h_c* (cm)	f or r*	K* (cm/hr)	K(r)* / K(f)	K(10)* / K(2.5)
2.1.1.	114	93	2.5	f	.129		
2.1.1.	114	93	10	f	.0431		.334
1.1.2.	133	122	10	r	.00751		
3.2.2.	136	109	10	r	.126	.933	
3.2.2.	136	109	10	f	.135		
2.3.2.	145	95	10	f	.0401		
1.3.1.	145	125	2.5	f	.00851		
1.2.1.	146	101	10	r	.604		
2.4.1.	147	82	2.5	r	.664	2.12	
2.4.1.	147	82	2.5	f	.313		
2.4.2.	147	82	10	f	.201		.642
4.1.1.	148	114	2.5	f	.0309		
4.1.2.	148	114	10	f	.0497		1.61
4.1.2.	148	114	10	r	.917	18.5	
2.4.1.	150	103	10	r	.101		
4.2.2.	156	110	10	f	.00587		
4.2.2.	156	110	10	r	.0204	3.48	

* As in Table 12-2 (a)

Table 12-3 (a) Hydraulic conductivity, water contents, air-entry value and depth of measurements in Watershed #1 at Site #4.

Depth (cm)	θ_i^*	θ_f^*	A.E.V.* (cm of water)	K* (cm/hr)	Core No.
2.5	.278	.324	-3.0	12.3	—
2.5	.295	—	-1.0	7.58	416
5	.29	.43	-15.4	1.24	—
5	.27	.46	-29.8	0.171	521
5	.27	.34	-20.6	0.686	524
5	.25	.43	-26.3	0.888	—
5	.24	.42	-25.3	3.23	523
30	.29	.31	-21.3	0.357	498
35	.26	.27	-1.5	0.330	704
68	.25	.29	—	0.74	526

(b) Watershed #1 at Site #5.

Depth (cm)	θ_i^*	θ_f^*	A.E.V.* (cm of water)	K* (cm/hr)	Core No.
2.5	.19	.30	-8.8	1.46	—
2.5	—	—	-29.4	2.65	743
5	.27	.31	-15.0	0.101	—
5	.23	.34	-15.2	0.75	714
5	.22	.34	-30.0	0.28	—
5	.26	.31	-29.5	1.91	—
5	.25	.33	-13.8	0.649	717
24.5	—	—	-20.9	0.252	744
26.5	.19	.20	-12.6	0.478	751
29.0	.27	.28	-17.1	0.251	726
29.5	—	—	-16.3	0.586	747
32	.25	.30	-34.5	0.504	721
34.5	—	—	-2.4	1.54	740
35	.24	.28	-7.1	1.17	729
46.5	.18	.20	—	0.478	741
47.5	.19	.24	—	0.65	749
50	.24	.28	—	0.606	730
2.5	.252	.291	0	0.045	447
2.5	.222	.250	0	0.032	448
2.5	.303	.348	0	0.20	449
2.5	.293	.357	44.5	0.81	—
2.5	.295	.330	25.0	0.64	453
5.0	.301	.334	36.5	0.71	450
5.0	.265	.369	26.5	10.4	—
5.0	.271	.350	12.5	18.6	452
32.5	.266	—	14.0	0.72	—

(c) Watershed #1 at Site #6.

Depth (cm)	θ_i^*	θ_f^*	A.E.V.* (cm of water)	K* (cm/hr)	Core No.
2.5	.246	.302	31.5	0.081	454
2.5	.222	.329	17.0	0.97	455
2.5	.245	.298	27.5	0.051	—
2.5	.268	.306	35.5	0.28	456
2.5	.282	.346	31.5	1.10	458
2.5	.258	.354	0	1.39	—
2.5	.238	.351	0	0.40	—
2.5	.206	.311	17.5	0.28	460
2.5	.222	.289	25.0	0.14	—
2.5	.144	.300	17.5	0.676	—

* θ_i - water content by weight before AEP determination.

θ_f - water content by weight after AEP determination.

A.E.P. - air-entry value

K - hydraulic conductivity

Table 12-4(a) - Hydraulic conductivity (K) measured with crust-top permeameter in Watershed No. 1.

Site No. & Rep. No.	Year & Crop	Depth (cm)	Pressure Head (cm of water)	K (cm/hr)	Core No.
4-1	1975 wheat	5	-7.7	0.18	468
			-9.1	0.076	
			-9.8	0.043	
4-2	1975 wheat	5	-11.0	0.63	469
			-12.0	0.22	
			-12.9	0.27	
			-18.8	0.064	
4-3	1975 wheat	5	-9.0	1.41	470
			-19.9	0.087	
			-19.9	.036	
4-1	1976 corn	3	-5.3	1.04	764
			-6.7	.149	
			-6.8	.060	
4-2	1976 corn	3	-3	.030	763
			-5.6	.0452	
			-7.0	.063	
4-3	1976 corn	3	-2.7	.0529	775
			-17.6	.00732	
			-21.3	.020	
4-4	1976 corn	3	-6.7	.0182	770
			-14.8	.0226	
			-25.2	.00978	
4-5	1976 corn	33	7.1	.0489	772
			-8.9	.0115	
			-17.4	.00447	
			-21.8	.00738	
			-28.6	.00124	
4-6	1976 corn	33	-22.2	.0084	771
			-30.2	.00215	
			-46.5	.000521	
			-48.6	.00328	
			-80.	.000954	

Table 12-4(b) - Hydraulic conductivity (K) measured with crust-top permeameter in Watershed No. 1.

Site No. & Rep. No.	Year & Crop	Depth (cm)	Pressure Head (cm of water)	K (cm/hr)	Core No.
5-1	1975 corn	5	0	0.160	489
			-12.9	0.287	
			-25.8	0.011	
5-2	1975 corn	5	-4.8	0.065	488
			-11.6	0.041	
			-11.8	0.025	
5-1	19/6	3	19.8	0.0936	525
			-14.9	0.0342	
			-18.	0.0516	
			-30.9	0.0588	
5-2	1976 soybeans	3	2.0	0.184	742
			0.5	0.100	
			-7.5	0.073	
5-3	1976 soybeans	3	15.9	0.0305	745
			-2.8	0.146	
6-1	1975 soybeans	5	-2.8	0.59	451
			-11.1	0.11	
			-13.6	0.036	
			-15.2	0.028	
6-2	1975 soybeans	5	-12.2	0.105	461
			-13.2	0.059	
			-13.5	0.022	
6-3	1975 soybeans	5	-9.1	0.14	466
			-12.0	0.13	
			-12.1	0.019	

Table 12-5 (a) Desorption water storage capacity of soil cores from Watershed # 13 at Site #1

Core	Depth (cm)	0	-5	-10	-20	-40	-60	-80	-100	-150	-225	-300	-500	-1500	Bulk Density (gm/cm³)
		Volumetric water contents at pressure heads of (cm of water)													
732	4	.403	.389	.379	.371	.345	.240	.198	.187	.171	.161	.156	.145	.039	1.59
720	4	.481	.462	.449	.446	.424	.398	.369	.357	.344	.322	.312	.291	.088	1.28
Mean	0-5	.442	.426	.414	.408	.384	.319	.284	.272	.258	.242	.234	.218	.064	1.44
STD.DEV.		.055	.051	.049	.054	.055	.111	.120	.120	.121	.113	.110	.103	.034	.23
472	28	.247	.230	.225	.223	.208	.184	.175	.158	.157	.153	.150	.144	0	1.82
478	31	.315	.297	.288	.282	.189	.135	.104	.094	.091	.084	.079	.077	.036	1.71
473	32	.274	.253	.254	.234	.215	.190	.179	.159	.158	.154	.151	.144	.062	1.79
477	36	.329	.314	.312	.299	.238	.157	.136	.118	.108	.098	.094	.088	.047	1.63
476	38	.360	.347	.343	.328	.268	.187	.171	.115	.106	.094	.089	.081	.026	1.62
474	39	.315	.299	.291	.284	.260	.202	.191	.168	.160	.149	.143	.131	.041	1.71
475	43	.336	.323	.319	.310	.275	.221	.214	.182	.176	.164	.163	.157	.047	1.62
737	32	.372	.361	.356	.348	.308	.184	.151	.142	.137	.157	.114	.107	.031	1.66
733	34	.364	.352	.346	.338	.267	.200	.177	.165	.149	.135	.127	.117	.040	1.58
734	34	.424	.417	.407	.399	.291	.190	.164	.153	.139	.130	.126	.119	.038	1.54
Mean	25-45	.334	.319	.314	.304	.252	.185	.166	.145	.138	.132	.124	.116	.042	1.67
STD.DEV.		.050	.054	.052	.052	.038	.024	.030	.027	.027	.029	.028	.028	.010	.08
735	55	.314	.3	.293	.285	.225	.168	.144	.133	.117	.119	.111	.096	.031	1.73
520	57	.325	.314	.308	.304	.238	.152	.123	.112	.096	.093	.088	.082	.020	1.64
Mean	49-86	.320	.307	.300	.294	.232	.160	.134	.122	.106	.106	.099	.089	.026	1.68
STD.DEV.		.007	.010	.011	.013	.008	.011	.014	.016	.014	.018	.017	.010	.007	.06
777	89	.368	.356	.354	.346	.267	.077	.057	.049	.045	.037	.035	.032	.010	1.65
773	109	.371	.345	.334	.323	.176	.112	.099	.089	.086	.069	.068	.067	.024	1.46
Mean	88-110	.370	.351	.344	.334	.222	.094	.078	.069	.066	.053	.052	.050		1.56
STD.DEV.		.001	.007	.014	.016	.013	.026	.030	.028	.028	.023	.023	.025		.13
783	124	.273	.242	.234	.227	.153	.092	.071	.056	.051	.036	.032	.029	.041	1.56
779	139	.240	.300	.294	.285	.195	.144	.124	.110	.105	.089	.086	.082	.031	1.59
MEAN	120-140	.232	.271	.264	.256	.174	.118	.098	.083	.078	.062	.059	.056	.036	1.58
STD.DEV.		.011	.041	.042	.041	.030	.037	.037	.038	.038	.038	.08	.038		.03

Table 12-5 (b) Desorption water storage capacity of soil cores from Watershed #13 at Site #2

Core	Depth (cm)	0	-5	-10	-20	-40	-60	-80	-100	-150	-225	-300	-500	-1500	Bulk Density (gm/cm³)
		Volumetric water contents at pressure heads of (cm of water)													
405	4	.406	.393	.380	.373	.372	.362	.345	.286	.268	.251	.237	.222	.053	1.52
409	4	.459	.429	.421	.411	.405	.396	.383	.327	.303	.279	.259	.248	.087	1.52
410	4	.453	.421	.409	.397	.392	.388	.373	.324	.308	.294	.266	.257	.087	1.53
444	4	.412	.393	.380	.370	.365	.331	.317	.253	.234	.222	.214	.198	.069	1.56
445	4	.411	.390	.382	.373	.369	.357	.344	.288	.262	.240	.228	.209	.103	1.58
421	4	.420	.410	.402	.394	.388	.382	.368	.310	.291	.277	.262	.241	.053	1.48
422	4	.435	.414	.404	.396	.392	.387	.373	.325	.308	.289	.270	.251	.059	1.50
426	4	.414	.391	.384	.374	.370	.362	.349	.295	.269	.241	.226	.212	.083	1.57
425	4	.413	.391	.382	.375	.370	.360	.348	.291	.262	.241	.225	.207	.082	1.54
440	4	.420	.400	.391	.383	.378	.349	.332	.267	.246	.229	.218	.199	.081	1.56
441	4	.398	.382	.372	.361	.357	.345	.336	.282	.259	.238	.225	.206	.085	1.60
706	4	.407	.374	.367	.360	.351	.335	.278	.254	.236	.217	.209	.196	.057	1.55
710	4	.364	.352	.346	.341	.337	.334	.324	.302	.286	.259	.247	.225	.060	1.59
Mean	0-5	.416	.395	.386	.378	.373	.361	.344	.293	.272	.252	.237	.221	.074	1.55
STD. DEV.		.024	.021	.020	.019	.019	.022	.028	.025	.026	.025	.021	.022	.016	.03
424	28	.369	.355	.354	.344	.332	.305	.288	.183	.130	.120	.111	.105	.055	1.57
442	29	.424	.402	.408	.383	.354	.251	.239	.204	.189	.170	.163	.156	.074	1.39
443	30	.366	.348	.346	.333	.296	.216	.200	.162	.151	.135	.128	.123	.061	1.48
406	28	.384	.374	.362	.374	.355	.327	.301	.215	.202	.193	.183	.171	.075	1.44
423	31	.374	.358	.357	.354	.299	.238	.220	.151	.121	.115	.108	.101	.034	1.48
411	29	.480	.435	.421	.403	.371	.341	.319	.239	.200	.184	.169	.162	.067	1.46
412	32	.382	.370	.366	.366	.337	.315	.294	.212	.166	.155	.144	.133	.066	1.49
446	35	.417	.403	.392	.376	.329	.223	.211	.174	.163	.150	.147	.141	.073	1.36
407	34	.381	.374	.367	.371	.349	.323	.306	.203	.176	.167	.158	.148	.067	1.43
427	37	.378	.368	.368	.365	.296	.218	.20	.199	.143	.135	.128	.120	.057	1.43
707	25	.385	.372	.366	.361	.295	.214	.175	.158	.146	.133	.131	.129	.052	1.44
711	29	.325	.316	.309	.304	.290	.254	.207	.174	.143	.125	.119	.111	.034	1.71
727	29	.405	.391	.383	.373	.370	.227	.185	.165	.148	.134	.129	.126	.053	1.39
713	31	.340	.320	.315	.312	.303	.246	.181	.140	.110	.090	.085	.079	.026	1.65
Mean	25-45	.386	.370	.365	.358	.327	.264	.238	.184	.156	.143	.136	.129	.057	1.48
STD. DEV.		.037	.032	.031	.027	.030	.047	.053	.028	.028	.028	.027	.026	.016	.10
408	66	.391	.378	.376	.368	.331	.295	.274	.152	.117	.107	.100	.092	.041	1.53
485	86	.387	.382	.372	.367	.343	.264	.166	.118	.092	.078	.071	.072	.029	1.43
484	86	.370	.362	.351	.344	.329	.277	.189	.134	.102	.082	.073	.068	.020	1.55
718	77	.356	.344	.337	.330	.312	.260	.183	.136	.102	.087	.085	.077	.026	1.63
708	79	.363	.358	.350	.345	.329	.295	.229	.197	.175	.154	.147	.136	.056	1.62
709	80	.359	.349	.341	.335	.321	.293	.243	.206	.183	.162	.155	.146	.060	1.62
Mean	60-86	.371	.362	.354	.348	.328	.281	.214	.157	.128	.112	.105	.098	.039	1.56
STD. DEV.		.015	.015	.016	.016	.010	.016	.042	.036	.041	.037	.037	.034	.016	.08
778	109	.389	.357	.350	.341	.336	.332	.328	.323	.317	.295	.281	.281	.098	1.68
784.	109	.458	.435	.430	.427	.386	.331	.269	.227	.208	.190	.184	.178	.026	1.48
Mean	100-110	.424	.396	.390	.384	.361	.332	.298	.275	.262	.242	.232	.230		1.58
STD. DEV.		.049	.055	.056	.061	.035	.000	.041	.068	.078	.073	.068	.073		.14
776	124	.364	.351	.345	.338	.312	.262	.216	.186	.165	.143	.138	.131	.049	1.60
782	124	.421	.38	.377	.374	.372	.370	.369	.367	.363	.344	.329	.291	.123	1.63
780	139	.415	.376	.369	.365	.354	.343	.331	.321	.298	.248	.227	.183	.057	1.55
Mean	120-140	.400	.369	.364	.359	.346	.325	.305	.291	.275	.245	.231	.202	.	1.59
STD. DEV.		.032	.016	.017	.018	.030	.049	.079	.094	.100	.100	.095	.082		.04

Table 12-5(c) Desorption water storage capacity of Soil Cores from Watershed #13 at Site #3

Core	Depth	0	-5	-10	-20	-40	-60	-80	-100	-150	-225	-300	-500	-15000	Bulk Density (gm/cm³)
		Volumetric water contents at pressure heads of (cm of water)													
402	4	.378	.357	.348	.336	.330	.327	.313	.265	.207	.188	.173	.156	.068	1.61
41C	4	.341	.328	.318	.308	.303	.299	.294	.287	.246	.222	.205	.187	.049	1.70
428	4	.399	.380	.376	.369	.366	.365	.358	.355	.326	.285	.259	.233	.100	1.56
429	4	.411	.391	.386	.382	.379	.378	.371	.355	.334	.297	.269	.243	.009	1.54
432	4	.369	.351	.340	.332	.329	.326	.315	.274	.230	.211	.195	.179	.007	1.64
433	4	.364	.352	.346	.341	.337	.324	.310	.259	.205	.186	.172	.156	.067	1.60
438	4	.333	.314	.305	.300	.294	.290	.280	.259	.236	.212	.197	.181	.085	1.70
509	4	.386	.364	.357	.350	.343	.336	.324	.310	.291	.260	.245	.224	.082	1.69
511	4	.361	.342	.336	.331	.325	.323	.318	.320	.303	.277	.263	.247	.084	1.71
Mean	0-5	.371	.353	.346	.339	.334	.330	.320	.298	.264	.238	.220	.201	.079	1.64
STD. DEV.		.025	.024	.025	.026	.026	.028	.029	.038	.050	.042	.039	.036	.016	.06
415	30	.335	.321	.312	.314	.297	.263	.245	.195	.143	.127	.110	.096	.015	1.62
401	31	.371	.358	.353	.343	.335	.298	.265	.182	.129	.116	.107	.098	.050	1.57
403	31	.371	.350	.341	.331	.320	.278	.244	.170	.134	.123	.113	.105	.053	1.57
439	31	.335	.322	.320	.316	.312	.303	.290	.235	.217	.204	.191	.175	.080	1.71
430	32	.332	.319	.318	.313	.309	.296	.278	.234	.204	.177	.158	.138	.057	1.62
435	33	.378	.359	.361	.350	.333	.305	.295	.243	.223	.213	.204	.189	.099	1.60
463	34	.368	.358	.356	.354	.348	.330	.323	.312	.303	.287	.276	.260	.137	1.63
462	35	.367	.355	.353	.350	.345	.328	.318	.305	.290	.271	.262	.243	.101	1.65
434	35	.366	.345	.341	.337	.318	.292	.275	.212	.196	.176	.165	.152	.072	1.60
431	37	.329	.315	.311	.305	.299	.286	.274	.231	.205	.183	.169	.147	.058	1.65
499	31	.333	.313	.310	.305	.293	.282	.268	.250	.227	.191	.177	.168	.074	1.69
700	31	.354	.341	.341	.326	.309	.397	.277	.263	.234	.196	.180	.165	.058	1.64
495	35	.388	.360	.348	.341	.331	.288	.235	.164	.113	.081	.077	.067	.027	1.58
Mean	25-45	.356	.339	.335	.329	.318	.295	.272	.229	.199	.177	.166	.152	.066	1.63
STD. DEV.		.020	.019	.019	.017	.018	.019	.029	.045	.057	.058	.058	.055	.030	.04
701	55	.380	.366	.360	.352	.339	.330	.321	.316	.304	.281	.271	.258	.124	1.72
437	60	.326	.340	.341	.337	.333	.329	.315	.283	.256	.241	.230	.214	.118	1.71
436	61	.371	.332	.332	.332	.329	.325	.317	.295	.274	.262	.251	.234	.132	1.72
464	61	.347	.332	.329	.324	.319	.311	.303	.294	.276	.258	.250	.233	.105	1.70
465	62	.352	.335	.331	.329	.325	.319	.315	.299	.283	.263	.252	.228	.103	1.69
486	64	.376	.361	.353	.347	.339	.327	.313	.298	.276	.251	.235	.218	.117	1.57
487	64	.349	.334	.328	.323	.320	.314	.308	.298	.276	.251	.236	.221	.110	1.65
404	69	.356	.341	.336	.332	.330	.326	.320	.304	.289	.275	.260	.243	.130	1.69
480	77	.348	.335	.328	.321	.315	.307	.298	.289	.272	.252	.239	.228	.110	1.65
482	80	.330	.323	.319	.315	.313	.308	.302	.295	.282	.264	.253	.242	.122	1.71
Mean	49-86	.354	.340	.336	.331	.326	.320	.311	.297	.279	.260	.248	.232	.117	1.68
STD. DEV.		.018	.014	.013	.012	.009	.009	.008	.008	.013	.012	.013	.014	.010	.04

Table 12-5(d) Desorption water storage capacity of soil cores from watershed #1 at Site #4

Core	Depth (cm)	Volumetric water contents at pressure heads of (cm of water): 0	-5	-10	-20	-40	-60	-80	-100	-150	-225	-300	-500	-15000	Bulk Density (gm/cm^3)
416	4	.511	.498	.492	.486	.480	.473	.465	.435	.433	.426	.417	.402	.237	1.32
469	4	.516	.487	.460	.446	.431	.416	.411	.403	.402	.395	.388	.376	.206	1.29
470	4	.541	.513	.456	.441	.430	.414	.410	.412	.411	.407	.402	.394	.214	1.19
521	4	.497	.481	.475	.473	.466	.463	.459	.454	.451	.437	.432	.421	.212	1.50
524	4	.489	.475	.465	.454	.453	.450	.445	.441	.437	.426	.417	.407	.205	1.47
523	4	.538	.520	.511	.482	.471	.465	.456	.450	.449	.436	.431	.430	.222	1.50
763	4	.441	.409	.400	.391	.384	.375	.366	.359	.351	.334	.325	.314	.233	1.36
764	4	.589	.523	.515	.492	.474	.462	.454	.443	.439	.423	.415	.405	.210	1.34
770	4	.526	.491	.477	.455	.436	.427	.421	.415	.408	.395	.387	.379	.191	1.26
775	4	.498	.470	.454	.444	.436	.431	.426	.422	.419	.409	.402	.394	.211	1.34
Mean	0-5	.515	.487	.470	.456	.446	.438	.431	.423	.42	.409	.402	.391	.218	1.36
STD. DEV.		0.39	.033	.033	.029	.028	.030	.030	.028	.029	.030	.031	.030	.013	.10
498	29	.455	.438	.437	.426	.423	.419	.416	.412	.410	.402	.397	.386	.262	1.60
704	34	.435	.426	.422	.417	.415	.409	.404	.401	.400	.397	.392	.378	.233	1.52
771	34	.450	.414	.402	.389	.381	.376	.373	.369	.367	.356	.351	.346	.235	1.47
772	34	.424	.400	.391	.384	.378	.374	.371	.369	.368	.359	.355	.351	.235	1.56
703	33	.431	.423	.422	.421	.418	.416	.413	.411	.410	.404	.398	.390	.243	1.58
Mean	25-45	.439	.420	.415	.407	.403	.399	.395	.392	.391	.384	.379	.370	.248	1.55
STD. DEV.		.013	.014	.018	.021	.021	.022	.022	.021	.021	.024	.024	.020	.015	.06
526	67	.421	.404	.403	.400	.397	.395	.393	.392	.390	.386	.382	.377	.265	1.64

Table 12-5(e) Desorption water storage capacity of soil cores from Watershed #1 at Site #5.

Core	Depth (cm)	0	-5	-10	-20	-40	-60	-80	-100	-150	-225	-300	-500	-15000	Bulk Density (gm/cm³)
		Volumetric water contents at pressure heads of (cm of water)													
447	4	.413	.402	.396	.393	.389	.380	.376	.377	.376	.369	.360	.344	.268	1.55
448	4	.436	.427	.420	.418	.416	.409	.406	.398	.396	.389	.381	.368	.268	1.49
449	4	.472	.456	.451	.449	.445	.433	.428	.422	.421	.414	.408	.397	.292	1.39
453	4	.461	.449	.443	.442	.439	.429	.423	.416	.414	.406	.398	.387	.276	1.44
450	4	.504	.486	.475	.472	.468	.447	.438	.424	.423	.416	.409	.398	.304	1.39
452	4	.519	.497	.490	.486	.474	.455	.448	.421	.417	.407	.398	.383	.256	1.40
489	4	.430	.418	.408	.396	.389	.385	.381	.378	.373	.365	.358	.351	.250	1.47
488	4	.446	.429	.421	.410	.408	.404	.401	.398	.394	.385	.378	.371	.235	1.45
519	4	.461	.454	.431	.428	.425	.422	.419	.415	.411	.402	.396	.387	.184	1.45
525	4	.440	.421	.415	.411	.407	.403	.4	.398	.391	.383	.375	.363	.170	1.51
518	4	.453	.444	.442	.439	.437	.435	.432	.430	.426	.413	.407	.400	.205	1.59
714	4	.44	.425	.422	.417	.411	.411	.406	.404	.402	.393	.385	.374	.189	1.47
717	4	.472	.459	.453	.439	.433	.429	.420	.417	.412	.402	.395	.386	.203	1.40
743	4	.438	.420	.408	.400	.393	.387	.380	.376	.377	.368	.362	.351	.181	1.50
742	4	.499	.473	.434	.427	.423	.416	.409	.404	.401	.393	.386	.375	.186	1.45
745	4	.453	.44	.431	.424	.420	.416	.411	.405	.402	.392	.387	.373	.180	1.47
739	4	.429	.416	.409	.407	.406	.403	.401	.399	.397	.391	.385	.373	.181	1.53
755	4	.467	.451	.444	.439	.434	.427	.42	.413	.409	.401	.393	.380	.176	1.47
Mean	0-5	.457	.443	.433	.428	.423	.416	.411	.405	.402	.394	.387	.367	.233	1.47
STD. DEV.		.028	.026	.025	.025	.025	.021	.020	.016	.016	.015	.016	.016	.046	.05
751	28	.390	.373	.367	.366	.366	.363	.360	.358	.358	.355	.350	.339	.195	1.68
744	26	.380	.370	.367	.365	.364	.361	.357	.355	.354	.348	.343	.330	.188	1.65
726	28	.466	.459	.448	.418	.410	.405	.398	.395	.392	.389	.384	.373	.223	1.48
747	31	.409	.386	.377	.370	.364	.358	.352	.349	.346	.341	.334	.321	.187	1.63
740	36	.388	.370	.362	.357	.351	.348	.340	.338	.336	.330	.325	.314	.196	1.67
729	34	.439	.432	.427	.422	.415	.412	.405	.403	.402	.398	.392	.381	.223	1.51
721	31	.440	.432	.426	.418	.412	.408	.402	.400	.399	.396	.391	.379	.225	1.49
Mean	25-45	.416	.403	.396	.388	.383	.379	.373	.371	.370	.365	.360	.348	.224	1.59
STD. DEV.		.032	.037	.036	.029	.028	.028	.027	.027	.027	.028	.028	.029	.001	.08
749	49	.456	.442	.437	.432	.427	.422	.416	.412	.410	.405	.400	.387	.202	1.46
741	49	.334	.313	.308	.305	.299	.291	.28	.271	.261	.246	.237	.219	.120	1.80
730	49	.446	.439	.437	.433	.430	.429	.427	.425	.423	.417	.409	.397	.235	1.53
748	58	.351	.341	.338	.334	.331	.327	.321	.319	.316	.311	.306	.293	.185	1.72
Mean	48-60	.397	.384	.38	.376	.372	.367	.361	.357	.352	.345	.338	.324	.235	1.63
STD. DEV.		.063	.067	.069	.066	.067	.069	.071	.074	.077	.080	.082	.084		.14

Table 12-5(f) Desorption water storage capacity of soil cores from Watershed #1 at Site #6

Core	Depth (cm)	Volumetric water contents at pressure heads of (cm of water): 0	-5	-10	-20	-40	-60	-80	-100	-150	-225	-300	-500	-15000	Bulk Density (gm/cm^3)
454	4	.461	.446	.441	.440	.438	.430	.424	.426	.424	.419	.412	.401	.305	1.45
455	4	.444	.429	.422	.420	.419	.410	.406	.401	.399	.394	.389	.377	.232	1.46
456	4	.480	.465	.461	.458	.456	.442	.439	.428	.426	.419	.411	.399	.241	1.49
458	4	.466	.445	.439	.441	.439	.426	.413	.405	.404	.398	.393	.381	.231	1.41
460	4	.465	.451	.448	.448	.445	.433	.426	.414	.411	.403	.396	.383	.229	1.42
451	4	.424	.413	.409	.409	.408	.407	.406	.407	.406	.400	.394	.383	.308	1.51
461	4	.435	.418	.412	.408	.408	.401	.398	.399	.396	.391	.386	.376	.235	1.48
466	4	.425	.415	.407	.408	.407	.403	.395	.401	.400	.395	.388	.375	.226	1.49
Mean	0-5	.450	.435	.430	.429	.428	.419	.413	.410	.408	.402	.396	.384	.251	1.46
STD. DEV.		.021	.019	.020	.020	.C19	.016	.015	.012	.012	.011	.C10	.010	.034	.03

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