An infiltration study on Montana soils
by George A Reichman

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree Of Master of Science in Soils
Montana State University


Abstract:
Infiltration rates were measured in the field on 21 soil types located in eight different irrigated farming districts in Montana during the summer of 1950. The infiltration rates of the soils of similar parent material were found to be related to rainfall.

Different average infiltration values were found for the different soil types, even though the variability among replicate determinations was high. The data fits the formula: accumulated infiltration = b(time)^a.

For surface soils the infiltration rates were directly proportional to the clay content and inversely proportional to the sand content. The surface infiltration rate decreased between the spring and fall measurements. The data show a tendency for the infiltration to be directly proportional to the ground cover of each crop.

Lateral movement of water after passing the metal ring was about 2/3 as rapid as vertical movement. The relationship between volume weight and infiltration on soils of similar parent material appeared to follow the form: log infiltration rate = 5.7((1/volume weight)-.714). No relationship between the initial moisture content and infiltration was found.

According to the disturbed sample data, the surface rates of the sandy loams exceeded the subsurface rates, while the reverse was true of the silt loams. The permeabilities of saturated undisturbed cores was related to the field infiltration rates. The pore space drained at low tensions decreased between spring and fall and parallels the infiltration change.

It is concluded that the unbuffered ring will measure relative infiltration values that may be corrected by a mathematical treatment to approximate true infiltration values. Attempts to relate laboratory techniques and field observations on infiltration were only moderately successful.

1498.a

AN INFILTRATION STUDY

ON MONTANA SOILS

by

George A. Reichman

A THESIS

Submitted to the Graduate Faculty

in

partial fulfillment of the requirements

for the degree of

Master of Science in Soils

at

Montana State College

Approved:

A. H. Post
Head, Major Department

K. C. Hide
Chairman, Examining Committee

J. A. Nelson
Dean, Graduate Division

Bozeman, Montana
June, 1954

## ACKNOWLEDGEMENT

The writer is indebted to the U. S. Bureau of Reclamation for providing funds for the field portion of the study. Acknowledgement is due to Mr. O. W. Monson for supervising the field aspects of the study and for advice in the interpretation of the data.

The writer also wishes to acknowledge the assistance of Dr. J. C. Hide, whose advice and guidance throughout the course of study were gratefully appreciated. The cooperation of the Montana State Experiment Station personnel and the land owners was also appreciated. The writer also wishes to thank Dr. A. H. Post, Dr. W. E. Larson and other persons who contributed time, equipment and advice.

TABLE OF CONTENTS

# LISTING OF TABLES

## Context Tables



## Appendix Tables

Page

# LISTING OF FIGURES

Context Figures — Page

## Appendix Figures

Page

Page

Page

ABSTRACT

Infiltration rates were measured in the field on 21 soil types located in eight different irrigated farming districts in Montana during the summer of 1950. The infiltration rates of the soils of similar parent material were found to be related to rainfall.

Different average infiltration values were found for the different soil types, even though the variability among replicate determinations was high. The data fits the formula: accumulated infiltration $= b(\text{time})^a$. For surface soils the infiltration rates were directly proportional to the clay content and inversely proportional to the sand content. The surface infiltration rate decreased between the spring and fall measurements. The data show a tendency for the infiltration to be directly proportional to the ground cover of each crop.

Lateral movement of water after passing the metal ring was about 2/3 as rapid as vertical movement. The relationship between volume weight and infiltration on soils of similar parent material appeared to follow the form: $\log \text{infiltration rate} = 5.7 \left(\frac{1}{\text{volume weight}} - .714\right)$. No relationship between the initial moisture content and infiltration was found.

According to the disturbed sample data, the surface rates of the sandy loams exceeded the subsurface rates, while the reverse was true of the silt loams. The permeabilities of saturated undisturbed cores was related to the field infiltration rates. The pore space drained at low tensions decreased between spring and fall and parallels the infiltration change.

It is concluded that the unbuffered ring will measure relative infiltration values that may be corrected by a mathematical treatment to approximate true infiltration values. Attempts to relate laboratory techniques and field observations on infiltration were only moderately successful.

# INTRODUCTION

An important characteristic of soil is the rate at which it will absorb water from rains, runoff or flood irrigation. With a knowledge of infiltration rates it is possible to devise soil management practices which will minimize erosion and flood hazards and contribute to efficient water use.

The measurements of infiltration that have been made previously are limited in scope, quantity and usefulness. An infiltration study was undertaken to collect data representing an extensive part of Montana, and to measure the variability encountered at each location.

Additional objectives were: (1) to obtain a measure of the reliability of an unbuffered ring procedure for measuring field infiltration and (2) to evaluate laboratory techniques in relation to field techniques.

Soils were selected to represent dominant types in the important irrigated valleys. A location was chosen that represented each soil type, and the infiltration rate was determined. Other physical properties were measured and the cropping history recorded.

On the soils conveniently located near Bozeman, additional samplings were taken for supplemental laboratory tests. These tests included permeability measurements, determinations of volume weight and pore size distribution of the soils.

## LITERATURE REVIEW

Water and air movement into the soil have been recognized as important physical properties. Baver (2) cites studies of these soils properties extending back about a century.

Free, et al., (15) determined relative water infiltration values on sixty-eight different soil types. The range in values was from .05-5.00 inches per hour. Other workers who have made water infiltration studies on various soil types include Lewis (19) and Musgrave (22). Duley and Kelly (12) determined that at the end of 1.5 hours the infiltration rates on clay loam, sandy loam, silt loam and silty clay loam had a range from 0.16"/hour to 0.33"/hour.

Auten (1) compared the infiltration rates of surface soils to the rates of subsurface soils and found that under forest cover the subsoil was the slower, whereas on cultivated fields he did not find differences.

Lewis (19) found that his infiltration data could be expressed by an equation of the form $I = bt^a$, where "I" is accumulated infiltration, "t" is elapsed time, "a" and "b" are coefficients. According to Phillips (26) this equation was first used by Kostiakov. Lewis points out that the first differential of this equation is the form used to calculate the rate of infiltration at any desired time. This results in the form $i = abt^{a-1}$ in which i is rate in inches per minute, t is minutes from start of infiltration, and a and b have the same values as in the original equation. This analysis compliments Free, et al., (15) who found that the infiltration rate at one interval was a good estimate of the infiltration rate at any other interval.

The influence of season on infiltration rates is mentioned by Beutner, et. al., (3) who connected lower rates with cooler months. Horton (16) gives the following reasons for differences in seasonal infiltration: (1) cultivation increases infiltration rates, (2) active soil fauna help to increase the infiltration rate and (3) the infiltration rate on sandy soils follows the temperature closely.

Forest litter or other soil cover will prevent clogging soil pores with suspended silt in runoff water according to Lowdermilk (21). Lewis and Powers (20) observed a much greater intake of water into native sod than into eroded, tilled land. Musgrave and Free (23) observed that dense vegetation prevents the sealing of the surface that occurs on bare fallow or desurfaced soil as water is repeatedly applied.

To determine the extent of lateral water movement in soils, Free, et al., (15) made several types of determinations. Soil samples were taken outward from 4 feet by 6 feet plots which were sprinkled by a rain similator. While Free's data is not specific with regard to the elapsed time during which lateral movement was measured, it is evident that a movement of at least 12 inches beyond the wetted area was encountered. Movement did not at either depth extend out 36 inches during the time of observation.

Tensiometers were set at plot center and 6 inches and 30 inches from the side of the plot and the time between flooding and rapid drop of instrument reading was recorded. The tensiometers 30 inches from the plot at a depth of 7 inches recorded increased moisture content about 1 hour after water was applied to the plot. In highly permeable Honeoye soil using a tube infiltration technique, Free, et al., (15) state, "water about 8 inches below the tube was found to have spread laterally about 40 inches".

Lewis (19) found infiltration rates for 1/6 A. plots were comparable to infiltration rates for 18 inch rings. The rate of infiltration into a tube set 7 feet into the soil was as rapid as those set only 3 or 4 inches. In neither study did lateral movement seriously influence the accuracy of the determination. When a six inch ring was surrounded by a buffer strip within an 18 inch ring and both set 3 inches into the soil, the rate was greater from the buffer strip than from the center ring. Lewis measured no difference in rates when both rings were set 6 inches into the soil.

Extremes in initial moisture content affected the infiltration rate of Chehalis loam as measured by Lewis (19). Free, et al., (15) list initial moisture content among those variables they did not measure. Musgrave and Free (23) suggest that there may be a moisture content below which the infiltration rate is little affected by the initial moisture percentage.

Nelson and Baver (24) measured mixtures with known pore space arrangements constructed from sand separates and state that percolation varied directly with the amount and inversely with the size of pores. Musgrave and Free (23) came to the conclusion that increasing the pore space by cultivation increased the rate of infiltration. The data of Free, et al., (15) show a significant correlation between non-capillary porosity and infiltration.

Several types of equipment have been used in the field to measure infiltration. Simple rings set only a few inches in the soil have been used by Evanko (13), Kirby (17) and Auten (1). Others have added a buffer strip of water outside this type of ring. Free, et al., (15) and Musgrave (22) are among those who have forced tubes into the soil 6 inches or more to confine the infiltering water. A rain-similator or sprinkler type of equipment has been used by Horton (16), Duley and Kelly (12), Free et al., (15) and others.

To make possible precise descriptions of various phases of water movement studies in soils Richards (26) has presented a series of technical definitions, among which were these: Infiltration (soil). The downward entry of water into the soil. Infiltration capacity or infiltration rate (soil). The maximum rate at which a soil, in a given condition, at a given time, can absorb rain, or will absorb water impounded on the surface at a shallow depth when adequate precautions are taken regarding border and fringe effects. Permeability (soil). (1) Qualitative. The quality or state of a porous medium relating to the readiness with which such a medium conducts or transmits fluids. (2) Quantitative. The specific property designating the rate or readiness with which a porous medium transmits fluid under standard conditions.

The soils that were studied had been surveyed and mapped and the descriptions of these soils can be found in the following references: (4), (6), (7), (8), (9), (10), (11), and (25).

## MATERIALS AND METHODS

Field infiltration studies were made on important soil types as selected from soil survey maps for several widely distributed irrigated areas of Montana. Data was obtained on thirty-three sites comprising 21 soil types.

The equipment for determining field infiltration consisted of a ring to impound water on the surface of the soil and a supply of water. The ring was constructed of one eighth inch sheet iron about nine inches in diameter and six inches high. Metal grips were welded to the sides of the ring to aid in setting. A scale was painted on the inside of the ring to facilitate measuring the depth of the water. Two rings had large saw-like teeth while the other two had smooth sharpened edges. The soil condition determined which type of ring could be most easily set.

The small size of the ring made for high variability among measurements had already been found by Free, et al., (15). However, for this survey type of information ready mobility of equipment was essential. This necessitated hauling water to the field in a barrel and consequently the size of ring used had to be such that the barrel provided adequate water to complete a measurement. Local canals were the usual source of water. At each site a ring was set into the soil sufficiently deep to retain water. A cheese cloth and wood barrier was used to prevent disturbance of the surface soil while water was being added to the ring. Water was poured into the ring to a depth of approximately two and one-half inches. The infiltration rate was determined by recording the time required for half inch increments of water to be taken into the soil.

Water was added as required to keep the water surface between $\frac{1}{2}$ and $2\frac{1}{2}$ inches about ground level. The observations were recorded for at least three hours or until at least 12 inches of water had entered the soil.

At each site four replications were secured by setting rings on the soil surface, taking precautions to prevent soil disturbance. In addition the soil was removed from two sites to a depth of 4 to 6 inches to determine subsurface infiltration. The soil was carefully removed to approximately the desired depth with a hand shovel so that the exposed surfaces consisted mostly of aggregate surfaces exposed along natural lines of weakness between macrostructural units. This surface was left slightly rough to insure against a glazed condition. The ring was set into this surface with a minimum of movement and any clods loosened in this operation were removed. Infiltration rates were determined on these subsurface sites as outlined above for surface soils.

For volume weight determinations, samples of know volume were secured by driving a calibrated 3 inch tube into the soil to the appropriate depth. No attempt was made to retain the natural structure in the sample when it was removed from the tube but the entire sample was packaged and taken to the laboratory. After drying and weighing, the volume weight of the soil was calculated. The volume weight samples for the 0-3 and 3-6 inch depths were secured within about 12 inches of each infiltration site. At the sites where subsurface infiltration rates were determined two additional volume weight samples were taken representing depths of 6-9 and 9-12 inches.

At each surface infiltration site moisture samples were secured to represent the 0-6 inch layer. A 6-12 inch moisture sample was also taken where subsurface infiltrations were determined.

For laboratory studies a distrubed sample of soil was secured in the autumn from each infiltration site in the vicinity of Bozeman, representing the 0-6 and 6-12 inch layers. On each sample the relative permeability was determined using Fireman's (14) method. A second part of the sample was used to determine the pore space distribution on the pressure plate apparatus at tensions of 10, 20, 60, 100, 345, and 1000 cm. of water. The method has been described by Richards and Fireman (28). Similarly undisturbed cores were collected from each Bozeman site to represent the 0-6 and 6-12 inch layers. Uhland and O'Neals (30) method was used to take the samples and to determine initial and saturated permeability and the corresponding non-capillary pore space in addition to the volume weight of the samples.

Statistical analysis used for table VI was according to methods described by Snedecor (29).

# EXPERIMENTAL RESULTS

## Field Studies

The general location of the infiltration sites and the dates on which field observations were made are presented in table I. This table also lists the figures which present supplemental data for each general location of sampling sites.

Table I. Summary of different sampling sites, approximate dates of infiltration measurements and figure numbers providing detailed data.

| Location | Dates of Measurement | Figures Providing Detailed Data |
|---|---|---|
| Bozeman | June 15 - July 8, 1950 | 11 - 20 |
| do | Sept. 28 - Oct. 16, 1950 | 21 - 26 |
| Corvallis | Aug. 14, - 15, 1950 | 27 - 28 |
| Ronan | Aug. 8 - 10, 1950 | 29 - 30 |
| Creston | July 31 - Aug. 3, 1950 | 31 - 33 |
| Conrad | Aug. 28 - 30, 1950 | 34 - 35 |
| Chinook | Aug. 24 - 26, 1950 | 36 - 37 |
| Fairfield | Aug. 31 - Sept. 8, 1950 | 38 - 39 |
| Miles City | July 12 - 20, 1950 | 40 - 43 |

The legal description of each location is listed in table VII of the appendix.

Infiltration data on the soils near Bozeman were secured early in the season on the sites represented by figures 11-20. A second set of data which was obtained in the fall is presented in figures 21-26, from sites adjacent to those used to obtain the data for figures 11-16.

The infiltration data from pasture or native range near the sites represented by figures 13-15 is presented in figures 18-20.

Additional infiltration data was collected from the other areas in the state during the summer season and is presented in figures 27-43.

Infiltration is one of the most variable properties of the soil and considerable variation occurs in the different replications of the data at each site. However, the infiltration rates for soils in the Bozeman area appeared to vary through a greater range than did infiltration rates for the other soil areas investigated. Subsurface samples appeared to be about as variable as surface samples.

Table VIII, appendix, presents the average rate of infiltration over the first two hour period in inches per hour. In three cases one value varied excessively from the other values and was ignored in calculating averages. A value was ignored when it either exceeded by four times or was less than one quarter of the average of the other three values. The soil types on which the average is calculated from three values are Bozeman silt loam, Huffine silt loam and Creston silt loam.

Reference to figures 11 to 43 shows essentially two parts to the infiltration rate curves. During the first few minutes of the determination, the infiltration rate changes rapidly with time. While this conditioning period differs for the different sites, it does not ordinarily exceed the first 15 minutes of the observation. After this initial period the relationship between time and cumulative infiltration approaches a straight line. Since this latter portion of the curve for the different replications at a site differ in slope it is apparent that the soils differ in properties which contribute to the sustained infiltration rate.

The variation associated with distances of 10 miles and 200 miles respectively was insignificant in the data from Manhattan very fine sandy loam (figures 16, 17, and 26) and Havre silt loam (figures 37 and 41).

The data for four soils in which all replications had infiltration rates exceeding five inches per hour are graphed in figures 31, 32, 33 and 38. In figures 14, 18, 19, 27, 29, 30, 31, and 39, the data for each replication of the surface soils at the site shows infiltration rates exceeding that of any subsoil infiltration rate at that site. In figures 20, 22, 25, 28, 34, 36, 40, 42, and 43, the reverse is true; whereas, in the other 16 sites the data for surface soils and subsoils overlap.

The data from four replications were selected to study the applicability of Kostiakov's (26) equation, $I = b\ t^{a}$, to the infiltration values obtained in this study. The curves of this equation were fitted by trial and error to the selected data and presented in figures 1-4.

The infiltration data in figure 1 from Havre silt loam was selected as the slowest and is compared to the curve of the formula $I = .0737t^{.7}$. The low infiltration rate is indicated by the low value of coefficient "b". Similarly the high infiltration rate of Huffine silt loam and the high value of coefficient "b" are shown by figure 2.

Figure 3 is a comparison between the infiltration curve of Bozeman silt loam, on which the infiltration rate changed most rapidly with time, and the curve of the equation $I = .6t^{.58}$. The infiltration data for Manhattan very fine sandy loam fits the curve of the formula $I = .187t^{.8}$ as shown in figure 4. In this figure the change in rate of infiltration with time is the lowest encountered in the study. In the equation, the

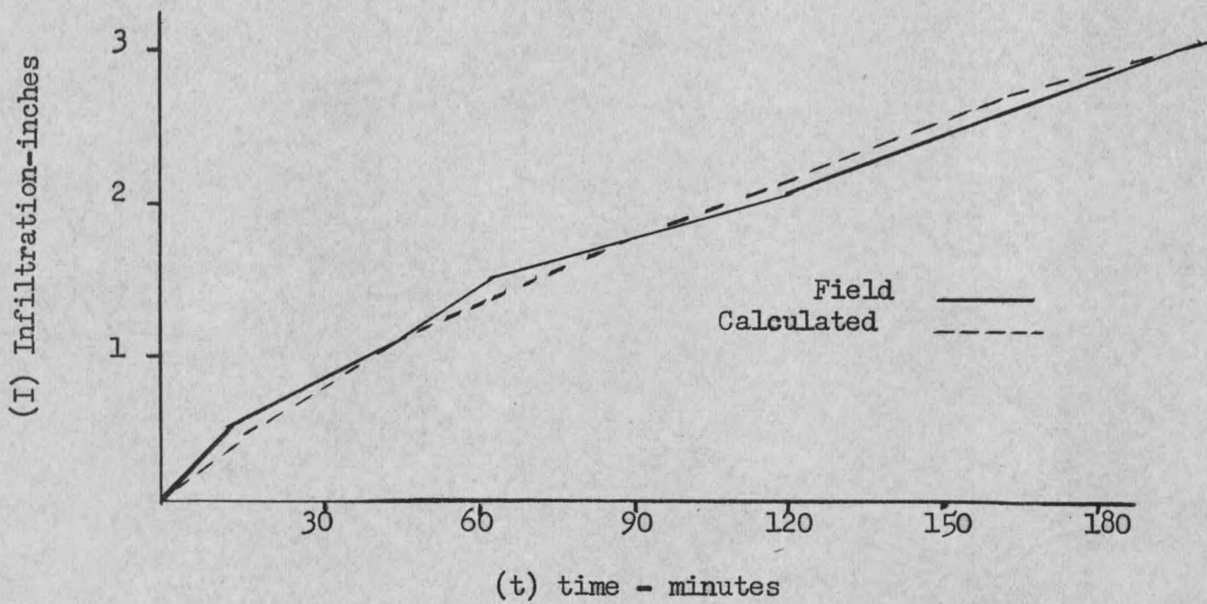


Figure 1. - Comparison of infiltration curve on Havre silt loam and curve of formula $I = .0737t^{.7}$.

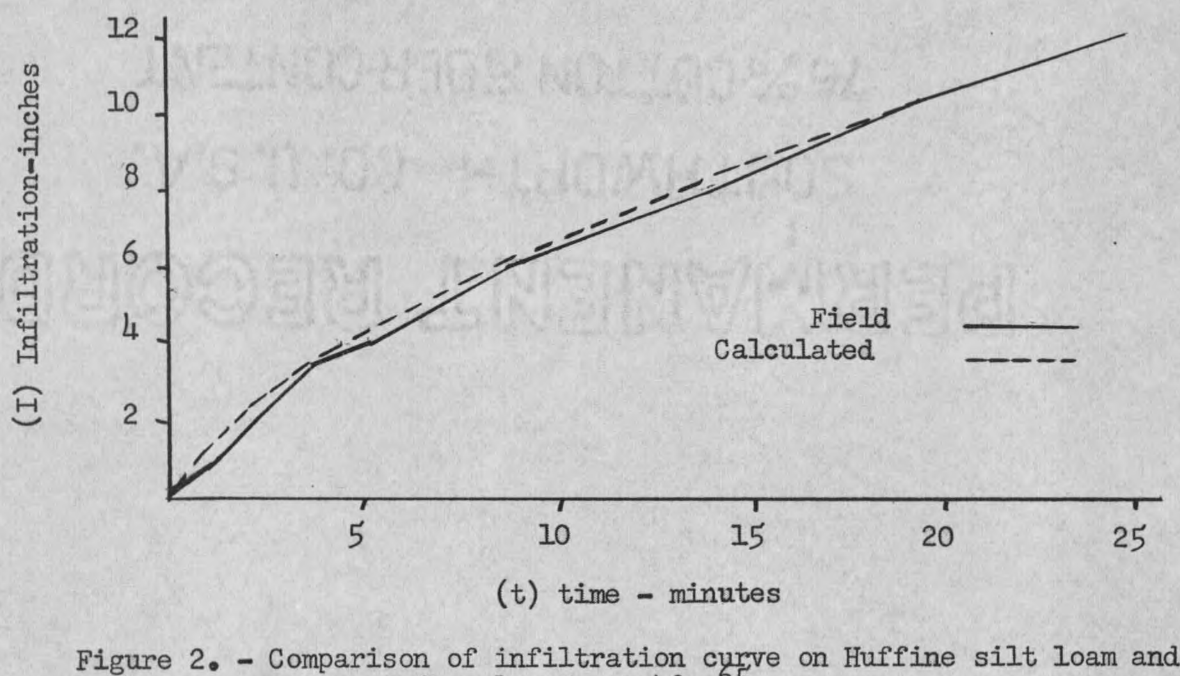


Figure 2. - Comparison of infiltration curve on Huffine silt loam and curve of forumla $I = 1.48t^{.65}$.

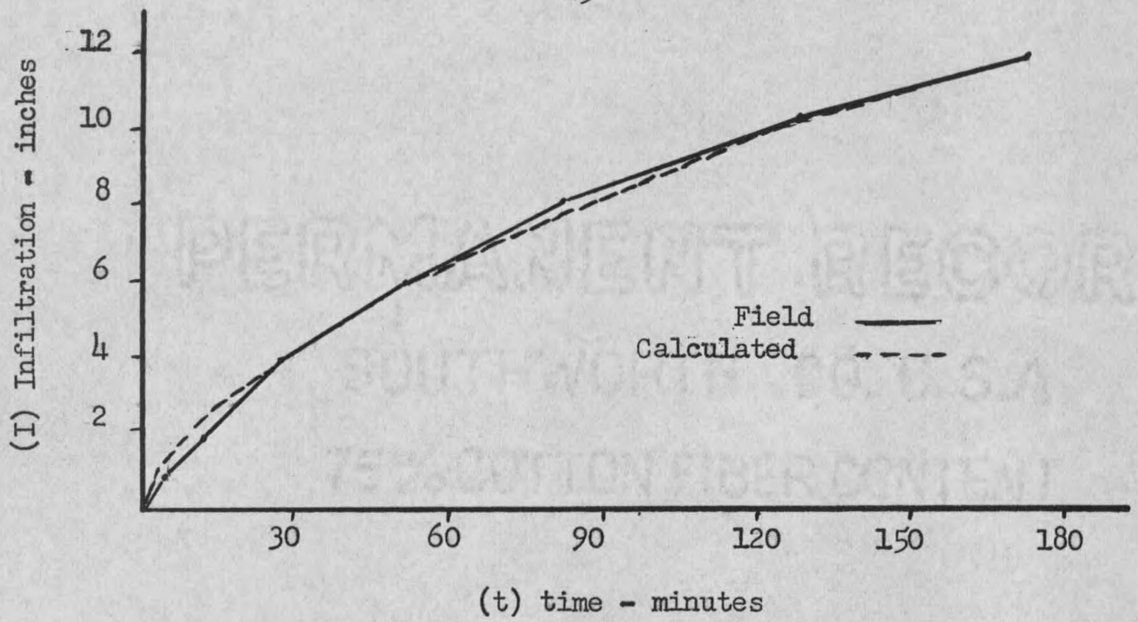


Figure 3. Comparison of infiltration curve on Bozeman silt loam and curve of formula $I = .6t^{.58}$.

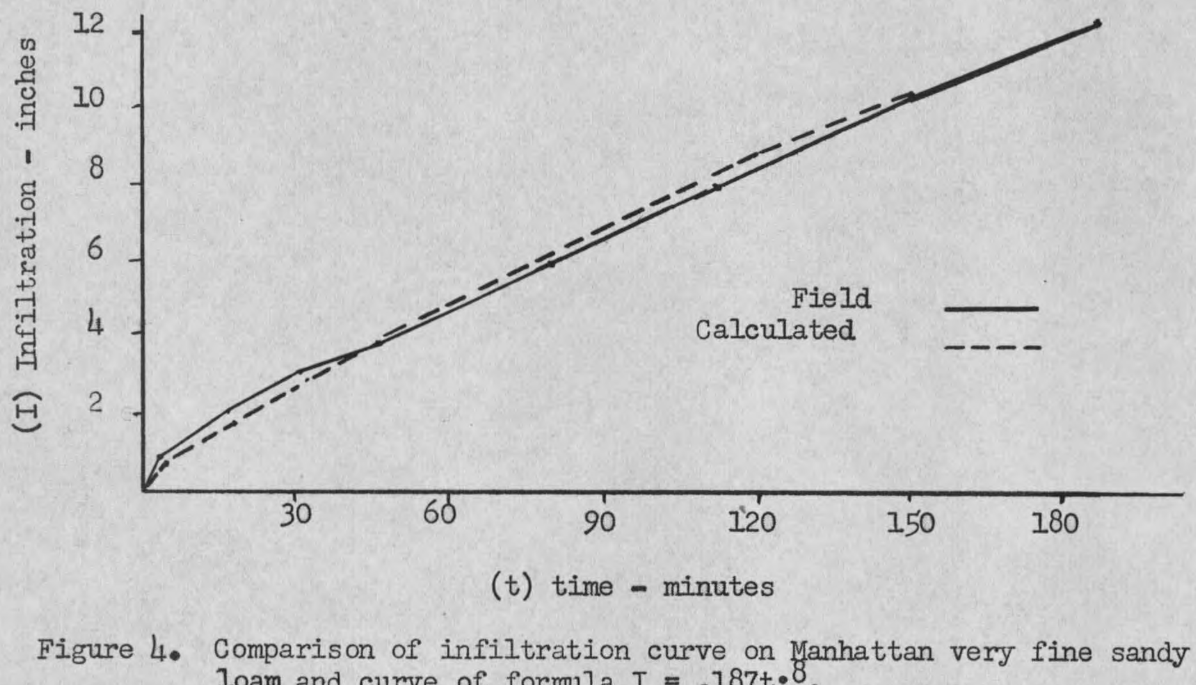


Figure 4. Comparison of infiltration curve on Manhattan very fine sandy loam and curve of formula $I = .187t^{.8}$.

change in infiltration rate is characterized by the value "a" and a value of 1.00 would result in a straight line.

The minimum value measured was .25"/hour and the minimum average value for any soil was .62"/hour. The infiltration sites selected on Pondera silt loam (figure 34), Hamilton silt loam (figure 28) and Scobey loam (figure 35) apparently had been packed by hay equipment. Havre fine sandy loam (figure 36) and Havre silt loam (figure 37 and 41) had infiltration rates below 1½"/hour. The rate for Havre very fine sandy loam (figure 40) was only 1.62"/hour, therefore all the infiltration rates measured on Havre soils were slow to moderate according to Uhlands (30) terminology. In contrast, soils with infiltration rates over 9 inches per hour are Huffine silt loam (figures 15 and 20), Creston silt loam (figure 32) and Burnt Fork loam (figure 27). The remaining soils, comprising 70 per cent of the sites, had infiltration rates ranging from 1½ inches to 9 inches per hour.

The pore space of a soil is influenced by the texture, so the average infiltration values for each soil in each textural group was combined in table IX, appendix. To summarize this data, the average for each textural group is given in table II.

Table II. Infiltration rates of soils differing in texture.

| Soil Texture | Surface Rate | Subsurface Rate |
|---|---|---|
| Sandy Loams | 3.47"/hour | 2.94"/hour |
| Loams | 4.33 " | 1.87 " |
| Silt Loams | 6.81 " | 7.16 " |
| Silty Clay Loam* | 7.00 " | 9.75 " |

*One site

The average values of the several textures ranks the soils according to sand and clay content. The infiltration was directly proportional to the clay and inversely proportional to the sand content. This fact indicates that in the soils under study the soil structure rather than the soil texture had the greater effect on the infiltration rate.

A comparison between the infiltration rates obtained from the Bozeman soils in the spring and adjacent sites in the fall are tabulated in table III.

Table III. The infiltration rates measured in the spring and fall on adjacent sites, in inches per hour.

| Soil Type | Surface | | Subsurface | |
|---|---|---|---|---|
| | Spring | Fall | Spring | Fall |
| Amsterdam very fine sandy loam | 3.31 | 2.50 | 4.38 | 2.62 |
| Amsterdam silt loam | 2.56 | .62 | 1.25 | 3.75 |
| Bozeman silt loam | 5.38 | 4.12 | 5.00 | 3.88 |
| Bozeman silt loam (brown phase) | 6.00 | 2.75 | 1.38 | 2.12 |
| Huffine silt loam | 27.00 | 3.25 | 21.12 | 34.50 |
| Manhattan very fine sandy loam | 3.38 | 2.34 | 2.88 | 3.00 |

The infiltration rates for surface soils decreased from spring to fall, but for subsoils no consistent seasonal change of rate was observed.

The infiltration rates measured on dryland sites were comparable to the intermediate rates measured on irrigated fields.

The infiltration data for the soils near Bozeman are related to the rainfall as shown in table IV.

Table IV. Annual rainfall, maximum anticipated storm intensity and average infiltration rate for Bozeman sites.

| Soil Type | Annual Rainfall | Rate of rainfall in in/hr. from most intense storm anticipated in 100 yrs. in | | Inches of infiltration of water into soil in | | |
|---|---|---|---|---|---|---|
| | | | | Initial | | After 2 hrs. |
| | | 5 min. | 10 min. | 5min. | 10min. | Infiltration |
| Bozeman silt loam | 18.08 | 6.0 | 4.32 | 14.4 | 12.0 | 4.12 |
| Huffine silt loam | 17.98 | | | 36.0 | 24.0 | 3.25 |
| Bozeman silt loam (brown phase) | 13.12* | 5.88 | 4.20 | 6.0 | 4.8 | 2.75 |
| Amsterdam silt loam | 10.64 | | | 2.4 | 1.7 | .62 |
| Amsterdam very fine sandy loam | 10.72 | | | 6.0 | 4.2 | 2.50 |
| Manhattan very fine sandy loam | 10.52* | 5.76 | 4.08 | 6.0 | 5.4 | 2.34 |

*Estimated from U. S. Geol. data

The annual rainfall data presented in table IV was provided by U. S. Geological Survey (31). While this information covers the rainfall for a period of only two years it agrees well with the long time averages at Bozeman and Belgrade. These data were chosen in preference to other data because they were collected at locations near the infiltration sites involved.

The expected storm intensity was interpolated from charts showing the intensity-frequency pattern of storms throughout the United States drawn by Yarnell (32).

The infiltration rates, the intensity of storms and the annual rainfall each decreased to the westward from Bozeman silt loam to Manhattan very fine sandy loam.

The soils studied near Bozeman were formed from loessial material which is quite similar in characteristics throughout the area, although there is a tendency for the parent material to become coarser toward the west. With decreasing rainfall toward the west, the great soil group to which the soils belong changes progressively from Chernozem to the Brown group. This change is associated with a decrease in the infiltration rate which is probably associated with the structural development and stability in the different profiles. The infiltration characteristics of the different profiles appear to be related to the rainfall.

By intercepting raindrops and thus reducing the puddling of the surface soil, it is generally recognized that vegatative cover prevents sealing of the soil and a consequent reduction in the infiltration rate.

A record was kept of the plant growth present at the time infiltration was measured, and the rates associated with each crop are listed in table X in the appendix. The average infiltration values are listed in table V. The data shows that differences in both the surface and subsurface infiltration rates under different crops are comparable. The infiltration rates measured under potatoes were highly variable and probably influenced by the cultivation pattern. There appears to be a general relationship between the amount of protective plant cover on the soil and the infiltration rate.

Table V. Infiltration under different crops.

| Crop | Surface Rate | Subsurface Rate |
|---|---|---|
| Pasture or native range | 4.40 | 6.68 |
| Potatoes | 6.30 | 12.00 |
| Sweet clover, Red clover | 5.61 | 7.67 |
| Small grains | 5.27 | 3.05 |
| Sugar beets | 3.50 | 1.00 |
| Alfalfa | 2.47 | 2.80 |
| Wheat fallow | 2.31 | 2.28 |

The distribution of water at the end of several infiltration measurements was observed by digging a trench through the center of the ring locations.

Early in an infiltration study the water wets a disc-like mass of soil directly beneath the source of water. When the source is confined, as it was in the study, the water moves vertically under the capillary potential of the soil aided by the gravitational force. Horizontal movement is motivated by the capillary potential alone. Thus downward movement is more rapid than lateral movement. The occurance of hemispherical patterns (figure 5) was coincidental with the termination of each measurement. Where gravity was working with capillarity, the movement was approximately 1.5 times what it was where capillarity alone was active. Each hemisphere has a diameter 2.5 times that of the ring, while the desired pattern would have been a cylinder no larger than the ring in diameter. The hemisphere has a volume 4.16 times greater than the volume of the described cylinder. Therefore the field rates were reduced to .241 of their measured values before comparisons were made to the core data.

Kirkham, D. (18) measured the water permeability rate through the soil beneath a water table by determining the flow from a tube. His calculations included modifications for the pressure exerted by the presence of the water table and the flow to an infinite area of the water table surface. To apply his calculation to this study the positive effect of the soil capillary potential replaces the negative effect of the pressure exerted by the presence of the water table and the calculations for flow involve measurable distances.

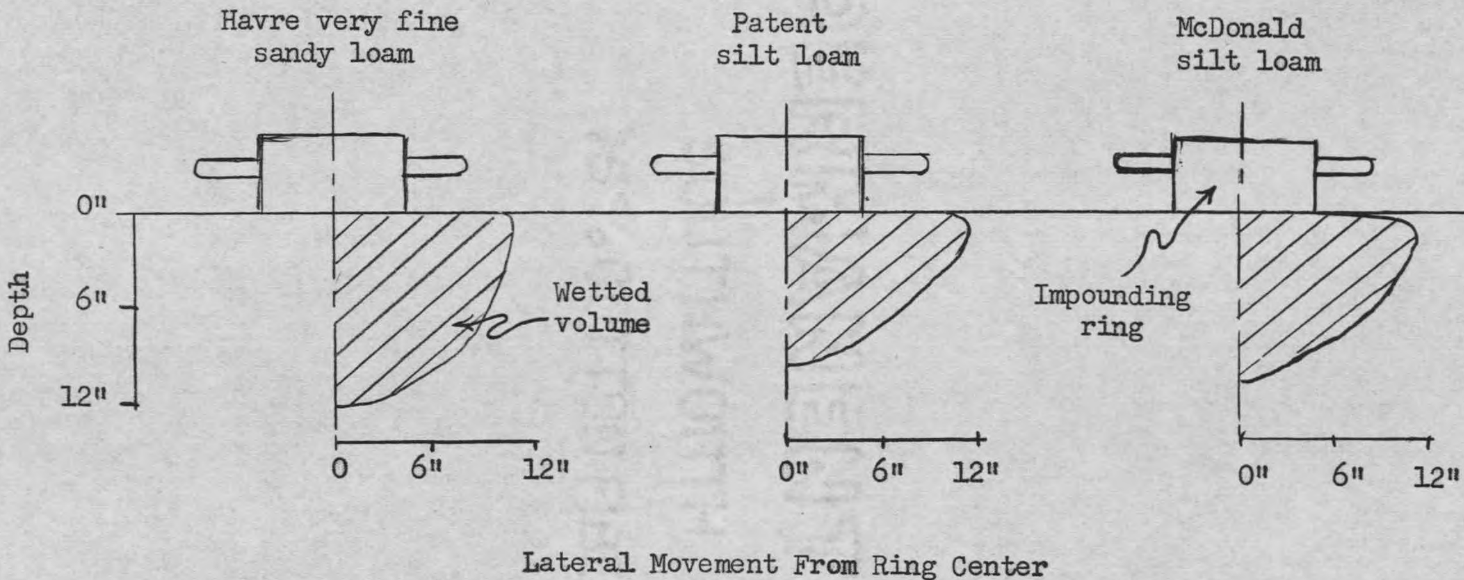


Figure 5. - The distribution of water infiltered from impounding rings after three hours.

# LABORATORY DETERMINATIONS

The volume weight data, collected at the time the infiltration measurement were made, are presented in table XI. The average volume weights and the infiltration rates for the soils in the Bozeman area are presented in table XII and compared graphically in figure 6. The highly significant correlation coefficient of -.704 measures the inverse relationship between the two variables. The line representing the equation = Log I = 5.7 $(\frac{1}{W} - .714)$ is drawn on figure 6 for reference, indicating a logarithmic relationship between these values. The symbol "I" represents the infiltration rate and "W" the volume weight. According to this equation light fluffy soils would have high infiltration rates and very dense soils would have rates approaching zero.

The moisture content of samples taken at the time the infiltration data was collected, indicate that all sites selected were within the moisture range of well drained soils. This information is given in table XIII.

The relative permeability rates of the soils sampled in the Bozeman area in the fall as determined by Fireman's method (14) are listed in table XIV. The most prominent feature of the data is the difference in relative permeability of the surface and subsurface soils of the fine sandy loams as compared to the silt loams. In the silt loam soils the subsurface samples are more permeable than the surface samples, whereas in the fine sandy loams the relative permeability was reversed. Figure 7 presents the relative infiltration rate of surface and subsurface samples for the two textural groups as ratios of surface soil permeabilities.

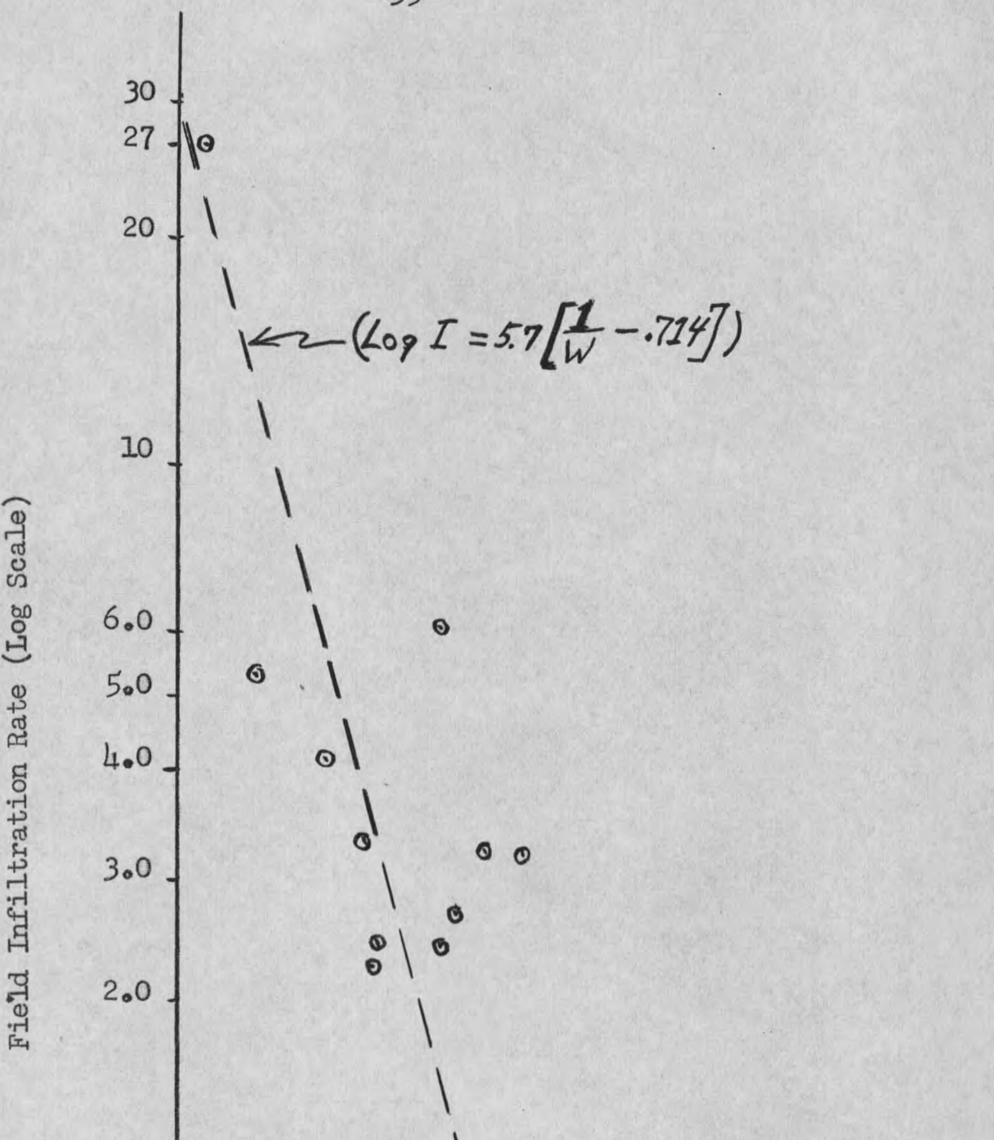


Figure 6. A comparison between field infiltration and field volume weights.

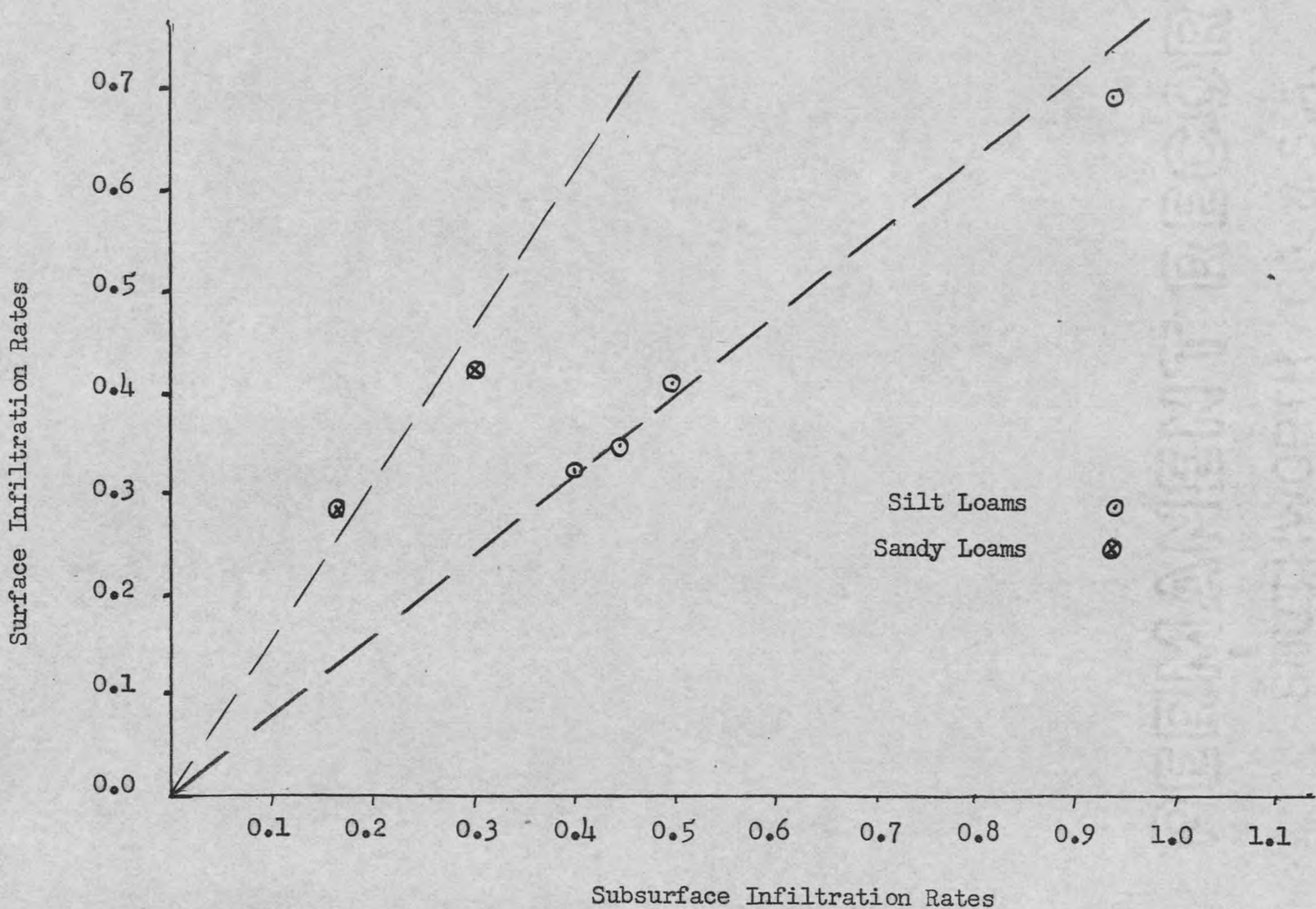


Figure 7. - The relationship between the surface and subsurface permeabilities of sandy loams and of silt loams as determined on disturbed samples.

As previously mentioned the subsurface texture is similar for the two textural groups of soil. This ratio indicates the ability of the soil to retain its permeability when the air-dry sample is broken into fine particles and packed into cylinders. These results reveal that the permeability rates of the surface material were maintained at a higher level in the sandy loams compared to the silt loams, when based on the subsurface rates. A summary of the analysis is given in table VI. The surface and subsurface values as determined by each method are summarized in table XVI and the ratios of these values are listed in table XVII.

The data obtained from the use of the Uhland procedure are tabulated in table XV. There was a highly significant correlation of .724 between the rates at which water percolated through the cores after saturation and the rates of field infiltration.

Table VI Summary of the statistical analysis of the data presented in figure 7.

| Soil Texture | No. of Samples | | Degrees of Freedom | | Mean | | Sum of squares of deviations from mean |
|---|---|---|---|---|---|---|---|
| Sa Loam | 2 | | 1 | | 1.52 | | .0313 |
| Si Loam | 4 | | 3 | | .78 | | .0046 |
| | | Sum | 4 | Diff. | .74 | Sum | .0359 |

Pooled variance = $S^2$ = .008975

$$S\bar{x} = .0775$$

$$t = \frac{.74}{.0775} = 9.55$$

A graph showing the averages of this data is included as figure 8. Figure 9 pictures the comparison between the volume weights determined with the Uhland samples and the volume weights determined with the field samples.

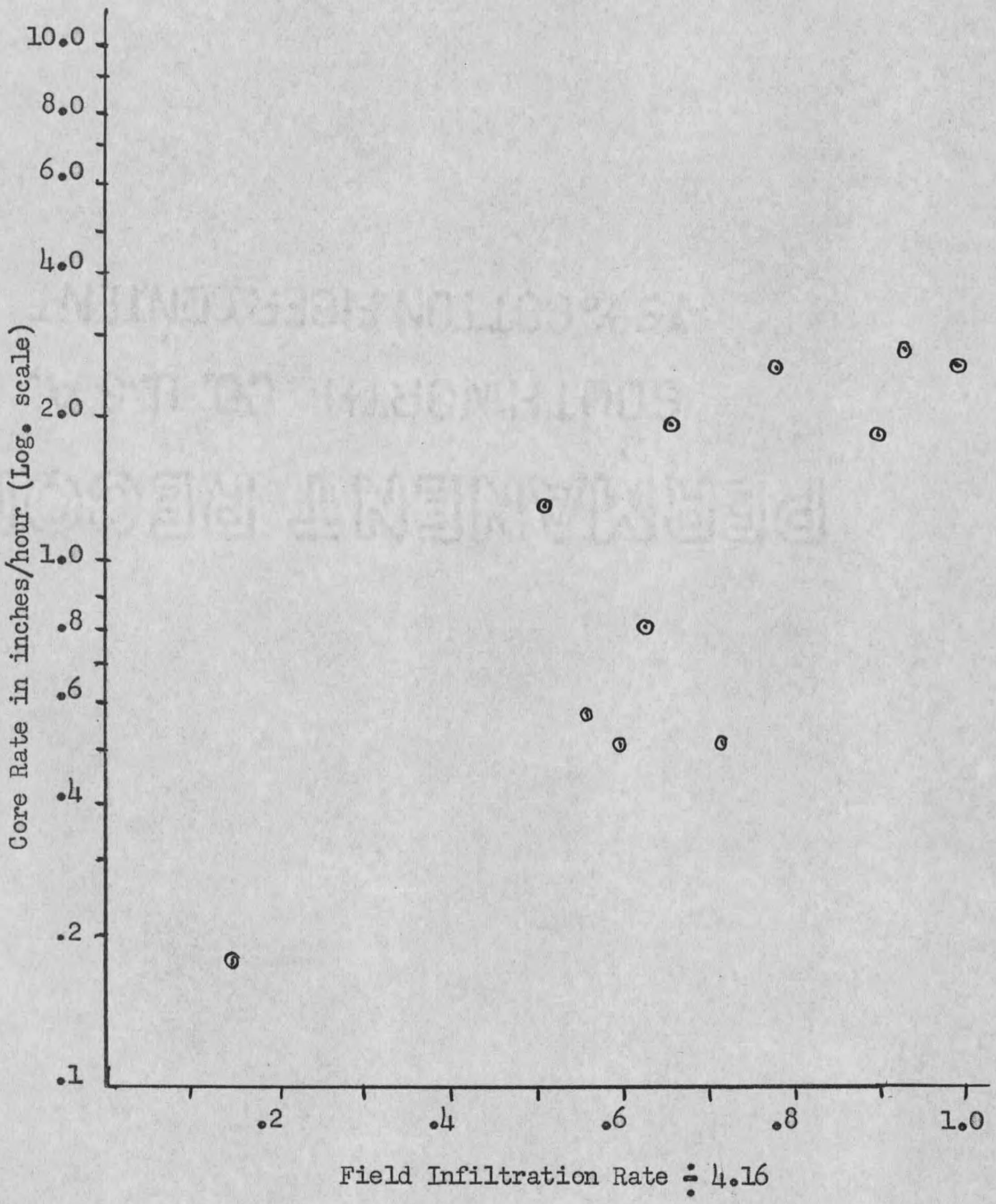


Figure 8. Saturated undisturbed core percolation rates compared to field infiltration rates after adjustment for lateral movement during infiltration.

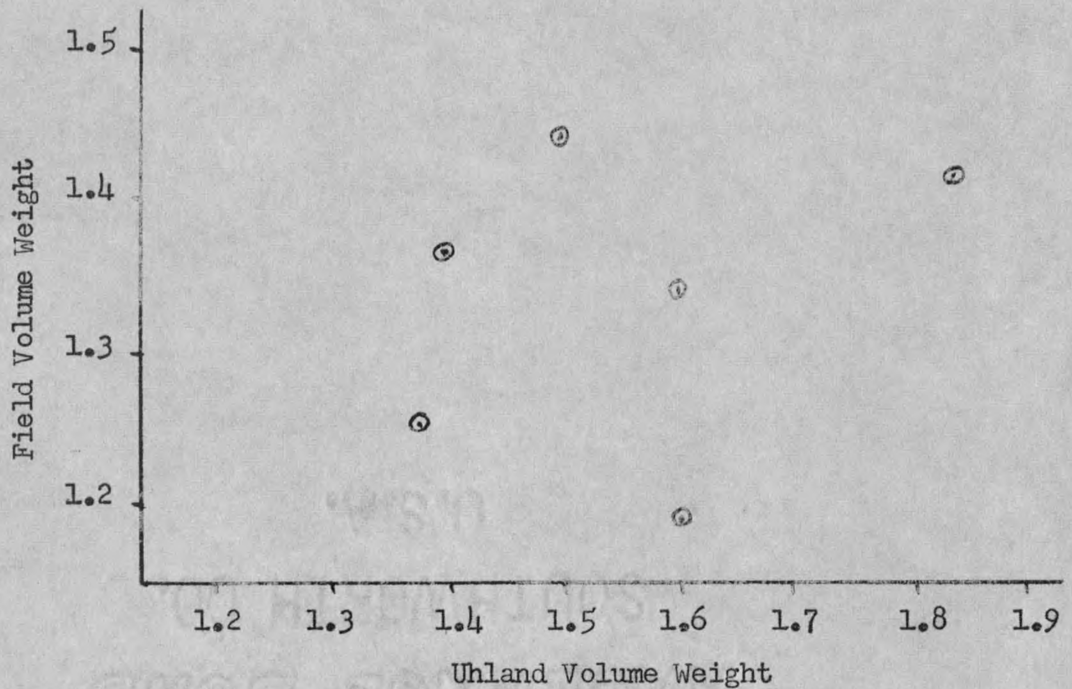


Figure 9. Comparison between field and undisturbed laboratory volume weights.

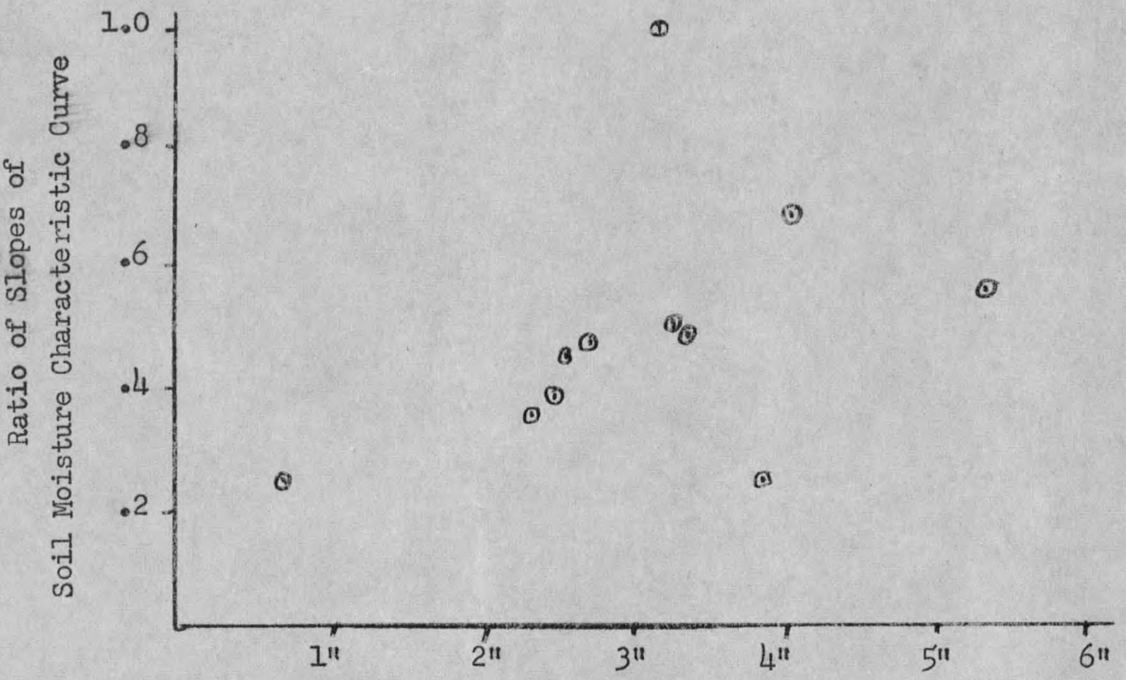


Figure 10. Relationship between field nfiltration and ratios of slopes between 500 and 1000 cm $H_2O$ tension of soil moisture charactersitic curve.

A measure of the reliability of the laboratory and the field samples to represent each other is indicated by the scatter pattern and by the correlation coefficient of .262.

An examination of the pore size distribution of the soil yields information about its permeability. The curves in figure 44-54 were drawn from the data measured by the use of the pressure plate apparatus and presented in table XVIII. Analysis of these curves included comparing the slope or rate of change of pore size at several points to the corresponding infiltration rate. Some slopes were calculated by using the difference in values at two adjacent measurements. These values are tabulated in table XIX along with some slopes calculated from estimated tangents. The relationship between the slopes of these curves near the maximum tensions used and the field infiltration rates is shown by the correlation coefficient of .317. These data are presented in figure 10 and table XX.

DISCUSSION

Infiltration rate was found to vary considerably within each soil type studied even when measurements were made within a few feet of each other. However, between soil types, infiltration rates varied over a much broader range. Thus infiltration rate within a soil type varies considerably, but falls into a distinct range which is characteristic of the soil type as shown in table VIII of the appendix. Similar differences were evident in table XVI which presents permeability measurements made by the Uhland (30) and Fireman (14) techniques. Analysis of several of these soils revealed variability in volume weights and non-capillary pore space. Figure 6 shows the relationship between infiltration rate and volume weight for soils developed on similar parent material in the vicinity of Bozeman for which the correlation coefficient is -0.704. This relationship did not hold for the other soils studied. The permeability rates through the saturated cores in Uhland's (3) procedure were similar to the field infiltration rates. Figure 8 depicts this relationship for which the correlation coefficient is 0.724.

The pressure plate procedure was used to measure size distribution of pore space in different soils. Reference to figures 44-54 reveals that differences occurred between soils in the volume of pore space from which water was removed at specific tensions over the selected range of tensions. The greatest changes occurred at the low tensions. In the spring the values obtained for field infiltration and the amount of large pores were both greater than the comparable values obtained in the fall.

However, the change in pore space appears to have very little relationship to the change in infiltration rate. In the soils studied it appears that some factor in pore space arrangement must dominate over pore volume in controlling infiltration.

Kostiakov (26) was apparently the first to propose the equation: $I = bt^a$ to represent the relationship between elapsed time and accumulated infiltration. Figures 1-4 illustrate how some of the infiltration data from this study correlates with curves of his equation. This indicates the presence of variables that affect the infiltration at a logarithmic rate as well as at an arithmetical rate, and can be represented by the proper coefficients. The infiltration must be modified by at least two factors to be analogous with this equation.

Infiltration values between 1.5 and 9 inches per hour were recorded at 70 per cent of the sites. When corrected for lateral movement, this range is between .36 and 2.16 inches per hour.

Soil compaction from spring to fall is indicated by slower infiltration rates, higher volume weight values, and fewer large pores. Fall plowing loosens a layer of soil that readily takes in water during the winter and early spring. Musgrave and Free (23) have measured distinct increases in infiltration rates by cultivation at depths of 4 inches and 6 inches as compared to no cultivation.

The tracks of animals and vehicles are examples of extreme compaction resulting in very low infiltration rates. Kirby (17) attributes the lower rates on grazed lands partly to the tramping effect of livestock.

The data on Hamilton silt loam (fig. 21) and Scobey loam (fig. 28) were believed to have been affected by packing from haying equipment.

The variability of the data masked any differences between the rates measured on irrigated and dryland sites.

Yarnell (32) has plotted maps showing the intensity of storms that can be expected and the frequency with which storms of a specific intensity are apt to occur. These maps are based on long time rainfall records. The infiltration rate appears to be proportional to the rainfall under which the soil developed, and to the expected storm intensities of the area.

A comparison of these values is made in table IV for the soils near Bozeman. The rainfall on these soils was one of the most variable factors in the development of these similar soils. It will be noted that these soils in the condition measured had infiltration capacities adequate to absorb most of the storms encountered. If several brief, high intensity storms occur within a short period of time, the infiltration will be inadequate and runoff will result.

Figure 10 illustrates the relationship between the field infiltration and the pore space values at the maximum tension measured. Apparently the field infiltration corresponded with the pore size arrangement and distribution at the higher tensions on these samples. In some soils the finer pores limit the sustained infiltration rate.

When the results were arranged in table V the relationship between the ground cover and the infiltration became noticeable. This could be true because the greater amount of cover protected the soil surface from the packing effect of raindrops and the associated reduction in infiltration rate. More above ground foliage indicates more extensive root systems and plant roots are recognized to have a favorable aggregating effect on soils.

# SUMMARY

Infiltration rates were measured on 21 soil types widely distributed over Montana. On six of these soil types measurements were taken in the spring and in the fall. The cropping history of each site was logged to aid investigations of the infiltration rates. The water distribution was determined in several cases. The following nine points were brought out:

1. The infiltration rate varies between soil types. The soil types encountered ranged between a highly permeable Huffine silt loam (6.49" per hour) and a Havre fine sandy loam with an infiltration rate of only 0.12" per hour.

2. There is considerable variability between closely spaced replications within each soil type in its ability to take water. Careful selection of sites and adequate replications are necessary.

3. The equation: Accumulated Infiltration = b(time)$^{a}$ is representative of the data. The infiltration rate decreased as time of infiltration advanced for every soil. The field data fits this equation well.

4. During infiltration measurements the wetted volume below the infiltration ring was 4.16 times the volume of a cylinder having the diameter of the ring and a height equivalent to the depth of wetting. Field infiltration rates were accordingly adjusted by this factor.

5. The infiltration rate at 70 per cent of the locations varied between 0.36 and 2.16 inches per hour. These measurements indicate that the equipment furnished reasonable values for the soil infiltration rates.

6. The infiltration rates for the surface soils decreased from spring to fall. The average percentage of change was 49.4 per cent.

7. A positive relationship was found between infiltration rates and rainfall on soils with similar parent material. The soils ability to absorb water was roughly proportional to the maximum intensity of the rainfall anticipated.

8. The infiltration rates were related to the soil texture. The average of the rates varied directly with the clay content and inversely to the sand content. Apparently other factors had more influence than texture on the infiltration. Structure was probably the dominant factor.

9. A relationship existed between ground cover and the infiltration rates.

Soil samples taken into the laboratory were treated to determine the volume weight, moisture percentage, permeability and pore space distribution. The following conclusions were drawn from these studies:

1. Volume weight measurements were related to the field infiltration where parent material is not a variable. The relationship can be expressed by the formula:

$$\text{Log Infiltration Rate} = 5.7 \left(\frac{1}{\text{volume weight}} - .714\right).$$

2. Soil texture affected the relationship between the surface and subsurface percolation as measured on disturbed samples. In the sandy loam soils, the surface rate was greater than the subsurface while the reverse was true for the silt loam soils.

3. The saturated undisturbed core permeability rates were related to the field infiltration rates. Calculations indicate a correlation value of .724 between these two factors.

4. The major change in pore distribution between spring and fall samples was a decrease in large pores. The decrease in pore distribution was not proportional to the decrease in infiltration rates of the few samples measured.

# LITERATURE CITED

1. AUTEN, J. T. - Porosity and water absorption of forest soils. Jour. Agr. Res. 46: 997-1014. 1933.

2. BAVER, L. D. - Soil Physics. 2nd Ed. New York. John Wiley and Sons, Inc. p. 3. 1948.

3. BEUTNER, E. L., GAEBE R. R., HORTON, R. E. - Sprinkled-plot runoff- and infiltration- experiments on Arizona desert soils. Trans. Amer. Geoph. Union 21: 550-558. 1940.

4. BOURNE, W. C. (and others). - Soil survey of the Bitterroot Valley Area. Unpublished.

5. CHILDS, E. C. - The use of soil moisture characteristics in soil studies. Soil Sci. 50: 239-252. 1940.

6. DEYOUNG, W. - Soil survey of the Sun River irrigation project. Mont. Agri. Exp. Sta. Bul. No. 217. 1928.

7. __________. - Soil survey of the Valier irrigation project. Mont. Agri. Exp. Sta. Bul. No. 217. 1928.

8. __________, YOUNGS, F. O., and GLASSEY, T. W. - Soil survey of the Milk River area, Montana. Bureau of Chemistry and Soils in cooperation with the Mont. Agr. Exp. Sta. Series. 1928, Number 22.

9. __________, and ROBERTS, R. C. - Soil survey of the lower Flat-head valley area, Montana. Bureau of Chemistry and Soils in cooperation with Montana Agr. Exp. Sta. Series. 1929, No. 22.

10. __________, and SMITH, L. H. - Soil survey of the Gallatin Valley area, Montana. Bureau of Chemistry and Soils in cooperation with Mont. Agr. Exp. Sta. Series 1931, No. 16

11. __________, NUNNS, F. K. and SMITH, L. H. - The middle Yellowstone Valley area, Montana. U. S. Department of Agriculture in coopera-tion with the Montana Exp. Sta. Series 1933, No. 33. 1940.

12. DULEY, F. L. and KELLY, L. L. - Effect of soil type, slope, and surface conditions on intake of water. Nebr. Agr. Exp. Sta. Res. Bul. 112. 1939.

13. EVANKO, A. B. - A tin can infiltrometer with improved baffle. Northern Rocky Mountain Forest and Range Exp. Sta. Research Note 76. 1950.

14. FIREMAN, M. - Permeability measurements on disturbed soil samples. Soil Sci. 58: 337-353. 1944.

15. FREE, G. R., BROWING, G. M., and MUSGRAVE, G. W. - Relative infiltration and related physical characteristics of certain soils. U.S.D.A. Tech. Bul. 729. 1940.

16. HORTON, R. E. - An approach toward a physical interpretation of infiltration capacity. Soil Sci. Soc. Amer. Proc. 5:399-417. 1940.

17. KIRBY, F. L. - Infiltration test. Jour. Forestry 46: 375-376. 1948.

18. KIRKHAM, D. - Proposed methods for field measurement of permeability of soil below the water table. Soil Sci. Soc. Amer. Proc. 10:58-68. 1945.

19. LEWIS, M. R. - The rate of infiltration of water in irrigation practice. Trans. Amer. Geoph. Union. 18: 361-368. 1937.

20. LEWIS, M. R. and POWERS, W. L. - A study of factors affecting infiltration. Soil Sci. Soc. Amer. Proc. 3:334-339. 1938.

21. LOWDERMILK, W. C. - Influence of forest litter on runoff, percolation, and erosion. Jour. Forestry 28: 474-491. 1930.

22. MUSGRAVE, G. W. - The infiltration capacity of soils in relation to the control of surface runoff and erosion. Jour. Amer. Soc. Agron. 27:336-345. 1935.

23. MUSGRAVE, G. W. and FREE, G. R. - Some factors which modify the rate and total amount of infiltration of field soils. Jour. Amer. Soc. Agron. 28:727-739. 1936.

24. NELSON, W. R. and BAVER, L. D. - Movement of water through soils in relation to the nature of the pores. Soil Sci. Soc. Amer. Proc. 5:69-76. 1940.

25. NUNNS, F. K. - Soil survey of the Upper Flathead Area, Montana. U. S. D. A. in cooperation with Montana Agr. Exp. Sta. Unpublished.

26. PHILIP, J. R. - An infiltration equation with physical significance. Soil Sci. 77: 153-157. 1954.

27. RICHARDS, L. A. - Report of the subcommittee on permeability and infiltration, committee on terminology. Soil Science Society of America. Soil Sci. Soc. Amer. Proc. 16:85. 1952.

28. RICHARDS, L. A. and FIREMAN, M. - Pressure plate apparatus for measuring moisture sorption and transmission by soils. Soil Sci. 56:395-404. 1943.

29. SNEDECOR, G. W. - Statistical Methods. Iowa State College Press. 1950.

30. UHLAND, R. E. and O'NEAL, A. M. - Soil Permeability determinations for use in soil and water conservation. SCS-TP-101. Washington, D. C. 1951.

31. U. S. Geological Survey. Ground Water Branch, Bozeman, Montana. Open file.

32. YARNELL, D. L. - Rainfall intensity-frequency data. Division of Drainage. U. S. Bureau of Agricultural Engineering. Misc. Publ. 204. 1935.

Table VII. Legal description of location of each site for each soil type.

| Soil Type | Location |
|---|---|
| Amsterdam very fine sandy loam | 130 ft. NW of SE corner of NE$\frac{1}{4}$,SE$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.34,T1S,R3E |
| Amsterdam silt loam | 130 ft. SW of NE corner of SE$\frac{1}{4}$,NW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.31,T1S,R4E |
| Bozeman silt loam | 380 ft. SE of NW corner of NE$\frac{1}{4}$,NW$\frac{1}{4}$,SW$\frac{1}{4}$,Sec.15,T2S,R6E |
| Bozeman silt loam, brown phase | 130 ft. NE of SW corner of SW$\frac{1}{4}$,NW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.32,T1S,R5E |
| Huffine silt loam | 150 ft. SE of NW corner of NW$\frac{1}{4}$,SW$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.14,T2S,R5E |
| Manhattan very fine sandy loam (1) | 260 ft. SW of NE corner of NE$\frac{1}{4}$,NE$\frac{1}{4}$,SE$\frac{1}{4}$,Sec.29,T1N,R3E |
| Manhattan very fine sandy loam (2) | 70 ft. SSE of NW corner of NW$\frac{1}{4}$,NW$\frac{1}{4}$,SW$\frac{1}{4}$,Sec.35,T1N,R1E |
| Burnt fork loam | 130 ft. NE of SW corner of NE$\frac{1}{4}$,SE$\frac{1}{4}$,SW$\frac{1}{4}$,Sec.27,T7N,R20W |
| Hamilton silt loam | 330 ft. NbyE of SW corner of NE$\frac{1}{4}$,NW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.9,T6N,R20W |
| Post very fine sandy loam | 300 ft. NE of SW corner of NW$\frac{1}{4}$,NE$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.10,T20N,R20W |
| McDonald silt loam | 360 ft. SW of NE corner of NE$\frac{1}{4}$,SE$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.11,T20N,R20W |
| Brockton fine sandy loam | 280 ft. NW of SE corner of SE$\frac{1}{4}$,SW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.16,T28N,R20W |
| Creston silt loam | 330 ft. NW of SE corner of SE$\frac{1}{4}$,NW$\frac{1}{4}$,SW$\frac{1}{4}$,Sec.15,T28N,R20W |
| Swimms silty clay loam | 370 ft. SE of NW corner of SE$\frac{1}{4}$,SW$\frac{1}{4}$,SW$\frac{1}{4}$,Sec.15,T28N,R20W |
| Pondera silt loam | 250 ft. NE of SW corner of SW$\frac{1}{4}$,SW$\frac{1}{4}$,SW$\frac{1}{4}$,Sec.15,T28N,R3W |
| Scobey loam | 280 ft. ENE of SW corner of SE$\frac{1}{4}$,SW$\frac{1}{4}$,SE$\frac{1}{4}$,Sec.4,T29N,R2W |
| Havre fine sandy loam | 150 ft. SE of NW corner of NW$\frac{1}{4}$,SW$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.30,T33N,R19E |
| Havre silt loam (1) | 370 ft. SE of NW corner of NW$\frac{1}{4}$,SE$\frac{1}{4}$,SE$\frac{1}{4}$,Sec.23,T33N,R18E |
| Fairfield loam | 75 ft. ESE of NW corner of SE$\frac{1}{4}$,SW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.18,T22N,R2W |
| Ashulot silt loam | 130 ft. ESE of NW corner of SE$\frac{1}{4}$,NE$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.1,T21N,R2W |
| Havre very fine sandy loam | 130 ft. ENE of SW corner of NE$\frac{1}{4}$,NW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.13,T7N,R46E |
| Havre silt loam (2) | 20 ft. NE of SW corner of SW$\frac{1}{4}$,SE$\frac{1}{4}$,SE$\frac{1}{4}$,Sec.13,T7N,R46E |
| Patent silt loam | 40 ft. SW of NE corner of NE$\frac{1}{4}$,NE$\frac{1}{4}$,NE$\frac{1}{4}$,Sec.24,T7N,R46E |
| Patent silt loam, sandy | 330 ft. EbyS of NW corner of NW$\frac{1}{4}$,NW$\frac{1}{4}$,NW$\frac{1}{4}$,Sec.19,T7N,R47E |

Table VIII. - The infiltration rates in inches per hour after two hours as measured in the field.

| Crop | Season | Surface Rates | | | | Ave. | Subsurface Rates | | | | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Amsterdam very fine sandy loam | | | | | | |
| Alfalfa | Spring | 6.00 | 2.00 | 1.75 | 3.50 | 3.31 | 3.50 | 5.25 | | | 4.38 |
| Alfalfa | Fall | 2.25 | 1.25 | 2.75 | 3.75 | 2.50 | 2.25 | 3.00 | | | 2.62 |
| | | | | | Amsterdam silt loam | | | | | | |
| Wheat fallow | Spring | 1.00 | 4.50 | 2.00 | 2.75 | 2.56 | 1.50 | 1.00 | | | 1.25 |
| Wheat fallow | Fall | 0.25 | 0.50 | 0.75 | 1.00 | .62 | 5.00 | 2.50 | | | 3.75 |
| | | | | | Bozeman silt loam | | | | | | |
| Grain | Spring | 3.75 | 1.00 | 4.75 | 12.00 | 5.38 | 4.75 | 5.25 | | | 5.00 |
| Grain | Fall | 1.50 | 48.00* | 4.50 | 6.50 | 4.12 | 2.75 | 5.00 | | | 3.88 |
| Pasture | Spring | 6.00 | 3.00 | 4.00 | 5.50 | 4.62 | 2.25 | 1.25 | | | 1.75 |
| | | | | | Bozeman silt loam, brown phase | | | | | | |
| Grain | Spring | 10.00 | 5.25 | 3.75 | 5.00 | 6.00 | 1.75 | 1.00 | | | 1.38 |
| Grain | Fall | 0.50 | 4.25 | 4.75 | 1.50 | 2.75 | 1.50 | 2.75 | | | 2.12 |
| Pasture | Spring | 48.00 | 40.00 | | | 40.00 | 6.00 | 4.00 | 2.50 | | 4.27 |
| | | | | | Huffine silt loam | | | | | | |
| Potatoes | Spring | 22.00 | 2.00* | 24.00 | 36.00 | 27.00 | 10.50 | 22.00 | 22.00 | 30.00 | 21.12 |
| Potatoes | Fall | 0.25 | 4.50 | 5.00 | | 3.25 | 7.50* | 60.00 | 36.00 | | 48.00 |
| Pasture | Spring | 9.00 | 9.00 | 7.50 | 4.00 | 7.38 | 12.50 | 10.00 | | | 11.25 |
| | | | | | Manhattan very fine sandy loam | | | | | | |
| Wheat fallow(1) | Spring | 3.50 | 4.00 | 1.75 | 4.25 | 3.38 | 2.50 | 3.25 | | | 2.88 |
| Wheat fallow(1) | Fall | 2.50 | 1.50 | 2.50 | 2.75 | 2.34 | 3.50 | 2.50 | | | 3.00 |
| Wheat fallow(2) | Spring | 3.25 | 4.00 | 4.00 | 4.25 | 3.88 | | | | | |

Table VIII. - (Continued)

| Crop | Season | Surface Rates | | | | Ave. | Subsurface Rates | | | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Burnt Fork Loam | | | | | | | | |
| Potatoes | | 12.00 | 4.00 | 10.50 | 11.00 | 9.38 | 2.25 | 3.50 | | 2.88 |
| | | Hamilton silt loam | | | | | | | | |
| Alfalfa | | 0.25 | 0.50 | 1.25 | 0.75 | 0.69 | 2.75 | 4.25 | | 3.50 |
| | | Post very fine sandy loam | | | | | | | | |
| Sugar beets | | 5.50 | 7.75 | 6.00 | 3.25 | 5.62 | 0.50 | 0.50 | | 0.50 |
| | | Mc Donald silt loam | | | | | | | | |
| Alfalfa | | 4.50 | 4.50 | 4.00 | 6.50 | 4.88 | 2.00 | 2.25 | | 2.12 |
| | | Brockton fine sandy loam | | | | | | | | |
| Grain | | 8.50 | 7.50 | 6.00 | 10.50 | 8.20 | 2.50 | 3.25 | | 2.88 |
| | | Creston silt loam | | | | | | | | |
| Clover | | 8.50 | 11.00 | 40.00* | 5.00 | 8.17 | 6.25 | 9.50 | | 7.88 |
| | | Swimms silty clay loam | | | | | | | | |
| Clover | | 5.50 | 7.50 | 7.50 | 7.50 | 7.00 | 13.00 | 6.50 | | 9.75 |
| | | Pondera silt loam | | | | | | | | |
| Alfalfa | | 0.75 | 0.75 | 1.00 | 1.00 | 0.88 | 1.50 | 2.50 | 3.25 | 2.42 |
| | | Scobey loam | | | | | | | | |
| Alfalfa | | 1.75 | 1.25 | 1.00 | 1.25 | 1.31 | 1.75 | 1.50 | | 1.62 |

Table VIII. - Continued

| Crop | Season | Surface Rates | | | | Ave. | Subsurface Rates | | Ave. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Havre fine sandy loam | | | | | |
| Alfalfa | | 0.25 | 0.25 | 0.50 | 1.00 | 0.50 | 2.00 | 1.75 | 1.88 |
| | | | | Havre silt loam (1) | | | | | |
| Sugar beets | | 1.50 | 1.00 | 1.00 | 2.00 | 1.38 | 1.50 | 1.50 | 1.50 |
| | | | | Ashulot silt loam | | | | | |
| Alfalfa | | 3.50 | 6.00 | 6.50 | 7.50 | 5.88 | 5.50 | 5.50 | 5.50 |
| | | | | Fairfield loam | | | | | |
| Alfalfa | | 3.25 | 1.75 | 2.50 | 1.75 | 2.31 | 1.00 | 1.25 | 1.12 |
| | | | | Havre very fine sandy loam | | | | | |
| Sweet clover | | 1.25 | 1.50 | 1.50 | 2.25 | 1.62 | 6.00 | 4.75 | 5.38 |
| | | | | Havre silt loam (2) | | | | | |
| Wheat | | 1.25 | 1.00 | 0.75 | | 1.00 | 0.50 | 0.50 | 0.50 |
| | | | | Patent silt loam | | | | | |
| Pasture | | 4.00 | 1.50 | 3.00 | 4.50 | 3.25 | 7.00 | 11.00 | 9.00 |
| | | | | Patent silt loam (sandy) | | | | | |
| Pasture | | 3.00 | 2.00 | 2.00 | 2.50 | 2.38 | 5.75 | 8.50 | 7.12 |

Table IX. - The average infiltration rate in inches per hour for both surface and subsurface layers of each soil; subdivided by textural groups.

| Textural Group | | | | | | | |
|---|---|---|---|---|---|---|---|
| Very fine sandy loam | | Loam | | Silt Loam | | Silty Clay Loam | |
| Surface | Subsurface | Surface | Subsurface | Surface | Subsurface | Surface | Subsurface |
| 3.31 | 4.38 | 9.38 | 2.88 | 2.56 | 1.25 | 7.00 | 9.75 |
| 2.50 | 2.62 | 1.31 | 1.62 | 0.69 | 3.75 | | |
| 3.38 | 2.88 | 2.31 | 1.12 | 5.38 | 5.00 | | |
| 2.34 | 3.00 | | | 4.12 | 3.88 | | |
| 3.88 | 0.50 | | | 4.62 | 1.75 | | |
| 5.62 | 2.88 | | | 44.00* | 4.27 | | |
| 8.12 | 5.38 | | | 6.00 | 1.38 | | |
| 1.62 | 1.88 | | | 2.75 | 2.12 | | |
| 0.50 | | | | 27.00* | 21.12* | | |
| | | | | 3.25 | 48.00* | | |
| | | | | 7.38 | 11.25 | | |
| | | | | 0.69 | 3.50 | | |
| | | | | 4.88 | 2.12 | | |
| | | | | 8.17 | 7.88 | | |
| | | | | 0.88 | 2.42 | | |
| | | | | 1.38 | 1.50 | | |
| | | | | 5.88 | 5.50 | | |
| | | | | 1.00 | 0.50 | | |
| | | | | 3.25 | 9.00 | | |
| | | | | 2.38 | 7.12 | | |
| Av. 3.47 | 2.94 | 4.33 | 1.87 | 6.81 | 7.16 | 7.00 | 9.75 |

* Value not included in average

Table X. The average infiltration values in inches per hour under each crop.

| | Crop | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Alfalfa | | Wheat Fallow | | Small Grains | | Pasture | |
| | Surface | Subsurface | Surface | Subsurface | Surface | Subsurface | Surface | Subsurface |
| | 3.31 | 4.38 | 2.56 | 1.25 | 5.38 | 5.00 | 4.62 | 1.75 |
| | 2.50 | 2.62 | 0.69 | 3.75 | 4.12 | 3.88 | 44.00* | 4.27 |
| | 0.69 | 3.50 | 3.38 | 2.88 | 6.00 | 1.38 | 7.38 | 11.25 |
| | 4.88 | 2.12 | 2.34 | 3.00 | 2.75 | 2.12 | 3.25 | 9.00 |
| | 0.88 | 2.42 | 3.88 | 0.50 | 8.12 | 2.88 | 2.38 | 7.12 |
| | 1.31 | 1.62 | 1.00 | | | | | |
| | 0.50 | 1.88 | | | | | | |
| | 5.88 | 5.50 | | | | | | |
| | 2.31 | 1.12 | | | | | | |
| Ave. | 2.47 | 2.80 | 2.31 | 2.28 | 5.27 | 3.05 | 4.40 | 6.68 |

*Not included in average

Table X. - Continued

| | Crop | | | | | |
|---|---|---|---|---|---|---|
| | Sweet Clover,Red Clover | | Potatoes | | Sugar Beets | |
| | Surface | Subsurface | Surface | Subsurface | Surface | Subsurface |
| | 8.20 | 7.88 | 27.00* | 21.12 | 5.62 | 0.50 |
| | 7.00 | 9.75 | 3.25 | 48.00 | 1.38 | 1.50 |
| | 1.62 | 5.38 | 9.38 | 2.88* | | |
| Ave. | 5.61 | 7.67 | 6.30 | 34.56 | 3.50 | 1.00 |

*Not included in average

Table XI. Volume weight of soil samples taken at the infiltration sites

| Soil Type | Depth | Volume Weight | | | | Ave. |
|---|---|---|---|---|---|---|
| Amsterdam very fine sandy loam | 0-3 | 1.39 | 1.33 | 1.42 | 1.53 | 1.42 |
| Spring | 3-6 | 1.42 | 1.25 | 1.32 | 1.57 | 1.39 |
| | 6-9 | | 1.42 | 1.28 | | 1.35 |
| | 9-12 | | 1.40 | 1.57 | | 1.48 |
| Amsterdam very fine sandy loam | 0-3 | 1.32 | 1.21 | 1.32 | 1.43 | 1.32 |
| Fall | 3-6 | 1.43 | 1.33 | 1.30 | 1.76 | 1.35 |
| | 6-9 | | 1.46 | 1.28 | | 1.37 |
| | 9-12 | | 1.45 | 1.39 | | 1.42 |
| Amsterdam silt loam | 0-3 | 1.43 | 1.20 | 1.32 | 1.24 | 1.30 |
| Spring | 3-6 | 1.35 | 1.26 | 1.06 | 1.17 | 1.21 |
| | 6-9 | | 1.14 | 1.17 | | 1.16 |
| | 9-12 | | 1.09 | 1.20 | | 1.14 |
| Amsterdam silt loam | 0-3 | 1.47 | 1.41 | 1.44 | 1.42 | 1.44 |
| Fall | 3-6 | 1.27 | 1.32 | 1.58 | 1.41 | 1.40 |
| | 6-9 | | 1.21 | 1.30 | | 1.26 |
| | 9-12 | | 1.28 | 1.06 | | 1.17 |
| Bozeman silt loam | 0-3 | 1.25 | 1.28 | 1.08 | .92 | 1.13 |
| Spring | 3-6 | 1.07 | 1.00 | 1.27 | .89 | 1.06 |
| | 6-9 | 1.25 | | 1.18 | | 1.22 |
| | 9-12 | 1.05 | | 1.03 | | 1.04 |
| Bozeman silt loam | 0-3 | 1.16 | 1.20 | 1.16 | 1.08 | 1.12 |
| Fall | 3-6 | 1.34 | 1.24 | 1.27 | 1.19 | 1.26 |
| | 6-9 | 1.26 | | | 1.24 | 1.25 |
| | 9-12 | 1.12 | | | 1.28 | 1.20 |
| Bozeman silt loam | 0-3 | .92 | .83 | .59 | .76 | .78 |
| Spring pasture | 3-6 | 1.03 | 1.06 | .95 | 1.02 | 1.02 |
| | 6-9 | | 1.04 | | .99 | 1.02 |
| | 9-12 | | | | | |
| Bozeman silt loam (brown phase) | 0-3 | 1.22 | 1.19 | 1.33 | 1.12 | 1.22 |
| Spring | 3-6 | 1.34 | 1.69 | 1.22 | 1.56 | 1.45 |
| | 6-9 | 1.38 | 1.46 | | | 1.42 |
| | 9-12 | | | | | |
| Bozeman silt loam (brown phase) | 0-3 | .36 | | .60 | | .48 |
| Fall | 3-6 | .90 | 1.31 | 1.26 | | 1.16 |
| | 6-9 | 1.20 | 1.38 | 1.45 | | 1.34 |
| | 9-12 | | | | | |

Table XI. - Continued

| Soil Type | Depth | Volume Weight | | | | Ave. |
|---|---|---|---|---|---|---|
| Bozeman silt loam (brown phase) | 0-3 | .36 | | .60 | | .48 |
| Spring - pasture | 3-6 | .90 | 1.31 | 1.26 | | 1.16 |
| | 6-9 | 1.20 | 1.38 | 1.45 | | 1.34 |
| | 9-12 | | | | | |
| Huffine silt loam | 0-3 | .86 | | 1.39 | .88 | 1.04 |
| Spring | 3-6 | .86 | | 1.03 | 1.17 | 1.02 |
| | 6-9 | .85 | | 1.18 | .94 | .99 |
| | 9-12 | .85 | | 1.23 | .97 | 1.02 |
| Huffine silt loam | 0-3 | 1.86 | | 1.30 | 1.10 | 1.42 |
| Fall | 3-6 | 1.50 | | 1.47 | 1.42 | 1.46 |
| | 6-9 | 1.27 | | 1.43 | 1.22 | 1.31 |
| | 9-12 | 1.21 | | 1.21 | 1.26 | 1.23 |
| Huffine silt loam | 0-3 | 1.24 | 1.12 | 1.33 | 1.20 | 1.22 |
| Spring - pasture | 3-6 | 1.36 | 1.44 | 1.35 | 1.31 | 1.36 |
| | 6-9 | | 1.52 | 1.08 | | 1.30 |
| | 9-12 | | 1.18 | 1.14 | | 1.16 |
| Manhattan very fine sandy loam(1) | 0-3 | 1.22 | | | 1.11 | 1.16 |
| Spring | 3-6 | 1.45 | | | 1.18 | 1.32 |
| | 6-9 | | 1.41 | 1.37 | | 1.39 |
| | 9-12 | | 1.50 | 1.30 | | 1.40 |
| Manhattan very fine sandy loam(1) | 0-3 | 1.22 | 1.30 | 1.11 | 1.06 | 1.17 |
| Fall | 3-6 | 1.09 | 1.29 | 1.46 | 1.48 | 1.33 |
| | 6-9 | | 1.33 | 1.29 | | 1.31 |
| | 9-12 | | 1.29 | 1.30 | | 1.30 |
| Manhattan very fine sandy loam(2) | 0-3 | 1.24 | 1.55 | 1.42 | 1.13 | 1.34 |
| Spring | 3-6 | 1.35 | 1.09 | 1.35 | 1.03 | 1.10 |
| | 6-9 | | | | | |
| | 9-12 | | | | | |
| Burnt fork loam | 0-3 | 1.20 | 1.35 | 1.26 | 1.46 | 1.32 |
| | 3-6 | 1.53 | 1.30 | 1.47 | 1.29 | 1.40 |
| | 6-9 | | 1.35 | 1.65 | | 1.50 |
| | 9-12 | | 1.02 | 1.44 | | 1.23 |

Table XI. - Continued

| Soil Type | Depth | Volume Weight | | | | Ave. |
|---|---|---|---|---|---|---|
| Loveland silt loam | 0-3 | 1.62 | 1.57 | 1.58 | 1.53 | 1.58 |
| | 3-6 | 1.39 | 1.50 | 1.50 | 1.51 | 1.48 |
| | 6-9 | | 1.35 | 1.51 | | 1.43 |
| | 9-12 | | 1.30 | 1.25 | | 1.28 |
| Post very fine sandy loam | 0-3 | .99 | .91 | .98 | 1.03 | .98 |
| | 3-6 | 1.10 | 1.07 | 1.03 | 1.19 | 1.10 |
| | 6-9 | | 1.35 | 1.48 | | 1.42 |
| | 9-12 | | 1.81 | 1.35 | | 1.58 |
| McDonald silt loam | 0-3 | .99 | 1.03 | .95 | .99 | .99 |
| | 3-6 | .90 | .92 | 1.01 | 1.05 | .97 |
| | 6-9 | | 1.11 | 1.15 | | 1.13 |
| | 9-12 | | 1.37 | 1.50 | | 1.44 |
| Brockton fine sandy loam | 0-3 | 1.46 | 1.35 | 1.28 | 1.29 | 1.34 |
| | 3-6 | 1.32 | 1.39 | 1.76 | 1.44 | 1.48 |
| | 6-9 | 1.46 | | | 1.62 | 1.54 |
| | 9-12 | 1.31 | | | 1.37 | 1.34 |
| Creston silt loam | 0-3 | 1.11 | .89 | .91 | 1.03 | .98 |
| | 3-6 | .98 | 1.10 | 1.33 | 1.07 | 1.12 |
| | 6-9 | .95 | | | 1.16 | 1.06 |
| | 9-12 | 1.06 | | | 1.18 | 1.12 |
| Swimms silty clay loam | 0-3 | .82 | .82 | .78 | .95 | .84 |
| | 3-6 | .99 | .88 | 1.05 | .90 | .96 |
| | 6-9 | | .91 | | .91 | .91 |
| | 9-12 | | .95 | | 1.11 | 1.03 |
| Pondera silt loam | 0-3 | 1.23 | 1.28 | 1.35 | 1.30 | 1.34 |
| | 3-6 | 1.40 | 1.27 | 1.30 | 1.28 | 1.31 |
| | 6-9 | 1.33 | | 1.15 | | 1.24 |
| | 9-12 | 1.17 | | 1.27 | | 1.22 |
| Scobey loam | 0-3 | 1.40 | 1.50 | 1.49 | 1.51 | 1.48 |
| | 3-6 | 1.50 | 1.44 | 1.47 | 1.38 | 1.47 |
| | 6-9 | 1.36 | | | 1.34 | 1.35 |
| | 9-12 | 1.16 | | | 1.16 | 1.16 |

Table XI. - Continued

| Soil Type | Depth | Volume Weight | | | | Ave. |
|---|---|---|---|---|---|---|
| Havre silty clay loam | 0-3 | 1.38 | 1.22 | 1.46 | 1.42 | 1.37 |
| | 3-6 | 1.29 | 1.32 | 1.28 | 1.26 | 1.35 |
| | 6-9 | 1.39 | | | 1.30 | 1.34 |
| | 9-12 | 1.21 | | | 1.19 | 1.20 |
| Havre silt loam (1) | 0-3 | 1.30 | 1.16 | 1.12 | 1.38 | 1.24 |
| | 3-6 | 1.38 | 1.38 | 1.40 | 1.41 | 1.39 |
| | 6-9 | | 1.32 | 1.52 | | 1.42 |
| | 9-12 | | 1.53 | 1.56 | | 1.54 |
| Ashulot silt loam | 0-3 | 1.30 | 1.30 | 1.23 | 1.34 | 1.29 |
| | 3-6 | 1.20 | 1.19 | 1.16 | 1.18 | 1.18 |
| | 6-9 | 1.19 | | 1.25 | | 1.22 |
| | 9-12 | 1.17 | | 1.06 | | 1.24 |
| Fairfield loam | 0-3 | 1.31 | 1.39 | 1.40 | 1.36 | 1.36 |
| | 3-6 | 1.43 | 1.42 | 1.29 | 1.33 | 1.37 |
| | 6-9 | 1.32 | | | 1.20 | 1.26 |
| | 9-12 | 1.31 | | | 1.50 | 1.40 |
| Havre very fine sandy loam | 0-3 | 1.32 | 1.40 | 1.31 | 1.30 | 1.34 |
| | 3-6 | 1.39 | 1.46 | 1.45 | 1.24 | 1.38 |
| | 6-9 | | 1.36 | 1.44 | | 1.40 |
| | 9-12 | | 1.18 | 1.36 | | 1.27 |
| Havre silt loam (2) | 0-3 | 1.41 | 1.14 | 1.14 | 1.28 | 1.24 |
| | 3-6 | 1.51 | 1.40 | 1.25 | 1.41 | 1.39 |
| | 6-9 | | | 1.44 | 1.45 | 1.44 |
| | 9-12 | | | | | |
| Patent silt loam | 0-3 | 1.41 | 1.43 | 1.34 | 1.60 | 1.44 |
| | 3-6 | 1.48 | 1.71 | 1.78 | 1.28 | 1.56 |
| | 6-9 | 1.51 | | | 1.08 | 1.30 |
| | 9-12 | 1.43 | | | 1.23 | 1.33 |
| Patent silt loam - Sandy | 0-3 | 1.24 | 1.18 | 1.55 | 1.31 | 1.32 |
| | 3-6 | 1.40 | 1.42 | 1.31 | 1.40 | 1.38 |
| | 6-9 | 1.49 | | | 1.22 | 1.36 |
| | 9-12 | 1.38 | | | 1.39 | 1.38 |

Table XII - The average infiltration rate in inches per hour compared to the volume weight.

| Soil type | Season | Infiltration Rate (Unadjusted) | Volume Weight |
|---|---|---|---|
| Huffine silt loam | Spring | 27.00 | 1.03 |
| Bozeman silt loam (brown phase) | Spring | 6.00 | 1.34 |
| Bozeman silt loam | Spring | 5.38 | 1.10 |
| Bozeman silt loam | Fall | 4.12 | 1.19 |
| Manhattan very fine sandy loam (1) | Spring | 3.38 | 1.24 |
| Amsterdam very fine sandy loam | Spring | 3.31 | 1.40 |
| Huffine silt loam | Fall | 3.25 | 1.44 |
| Bozeman silt loam (brown phase) | Fall | 2.75 | 1.37 |
| Amsterdam silt loam | Spring | 2.56 | 1.26 |
| Amsterdam very fine sandy loam | Fall | 2.50 | 1.34 |
| Manhattan very fine sandy loam (1) | Fall | 2.34 | 1.25 |
| Amsterdam silt loam | Fall | .62 | 1.42 |

Table XIII. Moisture content of soil when the infiltration was measured.

| Soil Type | Depth | Moisture Content | | | | Ave. |
|---|---|---|---|---|---|---|
| Amsterdam very fine sandy loam | Surface | 19.9 | 19.8 | 18.0 | 23.2 | 20.2 |
| Spring | Subsurface | | 21.9 | 18.0 | | 20.0 |
| | Surface | 19.6 | 19.3 | 18.4 | 18.8 | 19.0 |
| Fall | Subsurface | | 19.4 | 24.0 | | 21.7 |
| Amsterdam silt loam | Surface | 20.3 | 22.2 | 18.7 | 19.6 | 20.2 |
| Spring | Subsurface | | 20.7 | 20.1 | | 20.4 |
| Fall | Surface | 17.1 | 16.3 | 17.2 | 17.6 | 17.0 |
| | Subsurface | | 16.7 | 13.6 | | 15.0 |
| Bozeman silt loam | Surface | 27.9 | 28.0 | 29.6 | 26.7 | 28.0 |
| Spring | Subsurface | 26.4 | | | 23.7 | 25.0 |
| Fall | Surface | 22.9 | 22.0 | 23.6 | 19.6 | 22.0 |
| | Subsurface | 15.0 | | | 22.5 | 18.8 |
| Spring - pasture | Surface | 15.2 | 18.8 | 33.1 | 15.8 | 20.7 |
| | Subsurface | | 13.1 | 22.4 | | 17.8 |

Table XIII. Continued

| Soil Type | Depth | Moisture Content | | | | Ave. |
|---|---|---|---|---|---|---|
| Bozeman silt loam - brown phase | Surface | 7.8 | 12.6 | 17.2 | 18.0 | 13.9 |
| Spring | Subsurface | 17.3 | | | 15.9 | 16.6 |
| Fall | Surface | 20.1 | 19.0 | 18.1 | 19.5 | 19.2 |
| | Subsurface | 12.8 | | | 12.3 | 12.6 |
| Spring - pasture | Surface | 16.0 | | 13.5 | | 14.8 |
| | Subsurface | 13.2 | 12.6 | 11.8 | | 12.5 |
| Huffine silt loam | Surface | 34.4 | 26.6 | 27.6 | 31.6 | 30.1 |
| Spring | Subsurface | 19.3 | 19.0 | 23.8 | 26.9 | 22.2 |
| Fall | Surface | 31.2 | | 27.2 | 28.1 | 28.8 |
| | Subsurface | 24.5 | | 23.9 | 23.2 | 23.9 |
| Spring - pasture | Surface | 15.2 | 14.3 | 13.4 | 15.7 | 14.6 |
| | Subsurface | | 20.6 | 24.6 | | 22.6 |
| Manhattan very fine sandy loam (1) | Surface | 20.6 | | 16.3 | 19.26 | 18.7 |
| Spring | Subsurface | | 16.5 | 16.3 | | 16.2 |
| Fall | Surface | 17.3 | 17.6 | 18.4 | 17.6 | 17.7 |
| | Subsurface | | 22.0 | 20.9 | | 21.4 |

Table XIII. Continued

| Soil Type | Depth | Moisture Content | | | | Ave. |
|---|---|---|---|---|---|---|
| Manhattan very fine sandy loam (2) | Surface | 11.6 | 10.7 | 9.8 | 9.6 | 10.2 |
| Spring | Subsurface | | | | | |
| Burnt fork loam | Surface | 16.8 | 15.5 | 14.7 | 15.2 | 15.0 |
| | Subsurface | | 12.6 | 12.7 | | 12.6 |
| Loveland silt loam | Surface | 17.8 | 18.1 | 16.6 | 17.0 | 17.4 |
| | Subsurface | | 21.8 | 21.4 | | 21.6 |
| Post very fine sandy loam | Surface | 21.8 | 23.2 | 27.8 | 24.8 | 24.4 |
| | Subsurface | | 12.6 | 20.1 | | 16.4 |
| McDonald silt loam | Surface | 9.8 | 9.6 | 8.7 | 11.0 | 9.8 |
| | Subsurface | | 7.8 | 7.4 | | 7.6 |
| Brockton fine sandy loam | Surface | 9.1 | 9.4 | 8.1 | 14.0 | 10.2 |
| | Subsurface | 12.2 | | | 13.9 | 13.0 |
| Creston silt loam | Surface | 28.7 | 29.4 | 25.3 | 26.8 | 27.6 |
| | Subsurface | 29.9 | | | 23.0 | 26.4 |
| Swimms silty clay loam | Surface | 38.0 | 34.9 | 32.8 | 38.4 | 33.5 |
| | Subsurface | | 38.5 | | 35.5 | 37.0 |
| Pondera silt loam | Surface | 19.8 | 21.1 | 20.6 | 21.1 | 20.6 |
| | Subsurface | 25.0 | | 24.4 | | 24.7 |

Table XIII. Continued

| Soil Type | Depth | Moisture Content | | | | Ave. |
|---|---|---|---|---|---|---|
| Scobey loam | Surface | 7.6 | 8.3 | 8.4 | 9.3 | 8.4 |
| | Subsurface | 11.3 | | | 12.2 | 11.8 |
| Havre silty clay loam | Surface | 12.4 | 13.2 | 12.1 | 12.7 | 12.6 |
| | Subsurface | 13.8 | | | 13.5 | 13.6 |
| Havre silt loam (1) | Surface | 21.2 | 23.2 | 20.2 | 17.5 | 20.5 |
| | Subsurface | | 23.5 | 21.4 | | 22.4 |
| Ashulot silt loam | Surface | 11.3 | 11.4 | 14.6 | 15.0 | 13.1 |
| | Subsurface | 18.2 | | 19.1 | | 18.6 |
| Fairfield loam | Surface | 11.4 | 12.7 | 12.0 | 10.6 | 11.7 |
| | Subsurface | 13.7 | | | 16.5 | 15.1 |
| Havre very fine sandy loam | Surface | 7.6 | 8.2 | 8.3 | 5.0 | 7.3 |
| | Subsurface | | 6.7 | 9.1 | | 7.9 |
| Havre silt loam (2) | Surface | 8.9 | 8.7 | 7.1 | 8.5 | 8.3 |
| | Subsurface | | | 5.4 | 9.9 | 7.6 |
| Patent silt loam | Surface | 3.8 | 2.1 | 4.1 | 3.6 | 3.4 |
| | Subsurface | 2.8 | | | 4.2 | 3.5 |
| Patent silt loam (sandy) | Surface | 4.4 | 5.4 | 4.4 | 6.4 | 5.2 |
| | Subsurface | 2.9 | | | 2.7 | 2.8 |

Table XIV. The permeability in inches per hour of disturbed soil cores.

| Soil type | Infiltration rate in inches per hour | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Surface | | | | | Subsurface | | |
| | | | | | Ave. | | | Ave. |
| Amsterdam very fine sandy loam | .49 | .46 | .17 | .59 | .42 | .28 | .31 | .30 |
| Amsterdam silt loam | .41 | .47 | .31 | .45 | .41 | .47 | .54 | .50 |
| Bozeman silt loam | .81 | .82 | .62 | .51 | .69 | .84 | 1.05 | .94 |
| Bozeman silt loam (brown phase) | .26 | .40 | .35 | .33 | .34 | .42 | .45 | .44 |
| Huffine silt loam | .31 | .31 | .35 | .33 | .32 | .42 | .39 | .40 |
| Manhattan very fine sandy loam | .23 | .20 | .34 | .35 | .28 | .18 | .16 | .17 |

Table XV. - Percolation rates, volume weights and non-capillary pore volume of undisturbed cores.

| Depth | Field Condition: Percolation Inches/hour | Field Condition: % Moisture | Field Condition: % Non-Capillary Pore Volume | Saturated: Percolation Inches/Hour | Saturated: Volume Weight | Saturated: % Non-Capillary Pore Volume |
|---|---|---|---|---|---|---|
| | | Amsterdam very fine sandy loam | | | | |
| Surface | 2.28 | 15.7 | 5.76 | .96 | 1.59 | 3.74 |
| Surface | 2.10 | 13.2 | 5.48 | .28 | 1.57 | 3.74 |
| Surface | .22 | 11.8 | 3.75 | .09 | 1.68 | 1.44 |
| Surface | .88 | 12.6 | 5.18 | .76 | 1.57 | 7.50 |
| Subsurface | 3.90 | 18.8 | 5.76 | 1.38 | 1.54 | 1.73 |
| Subsurface | .40 | 17.7 | 1.44 | .20 | 1.56 | 2.59 |
| | | Amsterdam silt loam | | | | |
| Surface | .29 | 11.7 | 2.03 | .28 | 1.82 | 4.03 |
| Surface | .29 | 13.2 | 2.30 | .22 | 1.77 | 9.21 |
| Surface | .34 | 12.2 | 2.30 | .20 | 1.84 | 3.46 |
| Surface | .01 | 12.6 | .58 | .03 | 1.95 | 2.30 |
| Subsurface | 2.18 | 8.0 | 5.76 | 3.28 | 1.57 | 4.03 |
| Subsurface | 1.35 | 12.7 | 5.76 | .48 | 1.80 | 6.91 |
| | | Bozeman silt loam | | | | |
| Surface | .35 | 18.6 | 4.90 | .20 | 1.76 | 4.03 |
| Surface | 33.00 | 13.7 | 13.00 | 5.46 | 1.53 | 10.10 |
| Surface | 7.80 | 19.4 | 9.80 | 4.03 | 1.59 | 9.50 |
| Surface | 2.97 | 19.8 | 9.80 | .39 | 1.51 | 8.06 |
| Subsurface | 7.27 | 13.8 | 8.64 | 2.38 | 1.63 | 10.10 |
| Subsurface | 4.32 | 9.0 | 8.64 | 3.18 | 1.75 | 16.13 |

Table XV. Continued

| Depth | Field Condition: Percolation Inches/hour | Field Condition: % Moisture | Field Condition: % Non-Capillary Pore Volume | Saturated: Percolation Inches/Hour | Saturated: Volume Weight | Saturated: % Non-Capillary Pore Volume |
|---|---|---|---|---|---|---|
| | | Bozeman silt loam (brown phase) | | | | |
| Surface | 1.60 | 17.6 | 5.19 | 1.35 | 1.46 | 4.32 |
| Surface | 7.61 | 12.6 | 8.93 | 3.94 | 1.37 | 10.94 |
| Surface | 2.33 | 16.5 | 10.40 | 1.28 | 1.44 | 4.62 |
| Surface | 1.59 | 16.7 | 4.90 | 1.25 | 1.34 | 8.64 |
| Subsurface | 3.76 | 8.1 | 8.64 | 1.17 | 1.53 | 6.91 |
| Subsurface | .26 | 9.9 | 5.19 | 1.42 | 1.56 | 8.07 |
| | | Huffine silt loam | | | | |
| Surface | 45.80 | 23.7 | 2.03 | 19.20 | 1.49 | 1.15 |
| Surface | 19.30 | 19.7 | 6.34 | 2.84 | 1.50 | 5.76 |
| Surface | 5.03 | 21.1 | 3.46 | .36 | 1.51 | 2.59 |
| Subsurface | 52.40 | 18.9 | 2.30 | 16.40 | 1.50 | 1.44 |
| Subsurface | 20.60 | 16.8 | 3.75 | 3.12 | 1.51 | 2.59 |
| Subsurface | 15.20 | 20.7 | 6.63 | 2.19 | 1.44 | 4.03 |
| | | Manhattan very fine sandy loam (1) | | | | |
| Surface | 1.96 | 8.9 | 7.48 | .83 | 1.33 | 5.47 |
| Surface | 1.35 | | 4.03 | .47 | 1.47 | 1.44 |
| Surface | .16 | | 5.18 | .18 | 1.36 | 1.44 |
| Surface | 1.00 | 7.8 | 7.20 | .79 | 1.34 | 5.18 |
| Subsurface | .64 | 11.5 | 4.32 | .53 | 1.50 | 3.17 |
| Subsurface | .72 | 12.8 | 4.61 | .49 | 1.52 | 3.17 |

Table XVI. Summary of field infiltration rates and permeability rates by Fireman and Uhland methods.

| Soil Type | Depth | Fireman | Uhland Initial | Uhland Final | Field ÷ 4.16 |
|---|---|---|---|---|---|
| Amsterdam very fine sandy loam | Surface | .42 | 1.37 | .52 | .60 |
| | Subsurface | .30 | 2.16 | .80 | .63 |
| Amsterdam silt loam | Surface | .41 | .23 | .18 | .15 |
| | Subsurface | .50 | 1.76 | 1.86 | .90 |
| Bozeman silt loam | Surface | .69 | 10.97 | 2.53 | .99 |
| | Subsurface | .94 | 5.80 | 2.76 | .93 |
| Bozeman silt loam, brown phase | Surface | .34 | 3.28 | 1.96 | .66 |
| | Subsurface | .44 | 2.01 | 1.30 | .51 |
| Huffine silt loam | Surface | .32 | 17.54 | 2.60 | .78 |
| | Subsurface | .40 | 44.10 | 10.86 | 11.50 |
| Manhattan very fine sandy loam (1) | Surface | .28 | 1.12 | .57 | .56 |
| | Subsurface | .17 | .68 | .51 | .72 |

Table XVII. Summary of the ratio of the surface and subsurface infiltration rates as determined by the different procedures.

| Soil Type | Fireman | Uhland Initial | Uhland Final | Field |
|---|---|---|---|---|
| Amsterdam very fine sandy loam | 1.40 | .63 | .65 | .96 |
| Amsterdam silt loam | .82 | 1.30 | 9.70 | .16 |
| Bozeman silt loam | .73 | 1.89 | .92 | 3.88 |
| Bozeman silt loam, brown phase | .77 | 1.87 | 1.51 | 1.31 |
| Huffine silt loam | .80 | .80 | 1.03 | .09 |
| Manhattan very fine sandy loam (1) | 1.65 | 1.06 | 1.12 | .78 |

Table XVIII. Moisture content of soils at different moisture tensions.

| Soil Type | Rep. | Tension 10 | 20 | 60 | 100 | 346 | 1000 |
|---|---|---|---|---|---|---|---|
| Amsterdam very fine sandy loam - Spring | 1 | 51.6 | 50.2 | 45.6 | 41.6 | 28.7 | 19.7 |
| | 2 | 48.4 | 47.8 | 42.1 | 38.4 | 25.5 | 20.5 |
| | 3 | 52.5 | 48.8 | 41.9 | 37.3 | 26.8 | 22.2 |
| | 4 | 58.5 | 54.8 | 47.4 | 42.6 | 31.1 | 26.1 |
| | Ave. | 52.8 | 50.4 | 44.2 | 40.0 | 28.0 | 22.1 |
| Amsterdam very fine sandy loam - Fall | 1 | 47.1 | 45.1 | 40.4 | 37.6 | 27.7 | 22.3 |
| | 2 | 46.3 | 44.4 | 39.8 | 37.5 | 27.6 | 22.3 |
| | 3 | 49.9 | 47.7 | 42.0 | 38.8 | 28.7 | 22.5 |
| | 4 | 50.7 | 48.2 | 42.4 | 38.9 | 28.1 | 22.2 |
| | Ave. | 48.5 | 46.4 | 41.2 | 38.2 | 28.0 | 22.3 |
| Amsterdam silt loam Spring | 1 | 63.2 | 58.4 | 52.0 | 45.7 | 30.2 | 23.7 |
| | 2 | 56.2 | 52.8 | 45.4 | 41.2 | 26.2 | 19.2 |
| | 3 | 59.8 | 53.9 | 46.7 | 43.7 | 30.6 | 22.4 |
| | 4 | 58.0 | 55.9 | 48.4 | 45.1 | 29.8 | 23.2 |
| | Ave. | 59.3 | 55.2 | 48.1 | 43.9 | 29.2 | 22.1 |
| Amsterdam silt loam Fall | 1 | 53.9 | 51.2 | 45.9 | 42.2 | 30.0 | 23.2 |
| | 2 | 51.6 | 49.2 | 43.2 | 41.7 | 29.1 | 23.2 |
| | 3 | 56.3 | 54.2 | 48.1 | 44.3 | 32.4 | 23.8 |
| | 4 | 56.5 | 54.3 | 48.2 | 44.7 | 31.4 | 23.7 |
| | Ave. | 54.6 | 52.2 | 46.4 | 43.2 | 30.7 | 23.5 |
| Bozeman silt loam Spring | 1 | 65.4 | 59.5 | 48.8 | 45.2 | 33.7 | 27.2 |
| | 2 | 67.7 | 64.0 | 55.2 | 51.2 | 38.4 | 31.6 |
| | 3 | 62.0 | 57.2 | 46.6 | 42.2 | 28.4 | 23.6 |
| | 4 | 66.5 | 60.9 | 50.2 | 45.8 | 30.3 | 24.8 |
| | Ave. | 65.4 | 60.4 | 50.2 | 46.1 | 32.7 | 27.0 |
| Bozeman silt loam Fall | 1 | 60.8 | 57.5 | 49.8 | 46.3 | 33.8 | 26.5 |
| | 2 | 62.6 | 58.9 | 50.0 | 46.9 | 33.9 | 26.4 |
| | 3 | 63.1 | 58.4 | 49.8 | 45.2 | 33.8 | 26.2 |
| | 4 | 63.8 | 58.8 | 49.8 | 45.2 | 33.2 | 26.2 |
| | Ave. | 62.6 | 58.4 | 49.8 | 45.9 | 33.7 | 26.3 |

Table XVIII. Continued

| Soil Type | | Tension 10 | 20 | 60 | 100 | 345 | 1000 |
|---|---|---|---|---|---|---|---|
| Bozeman silt loam | 1 | 56.4 | 53.8 | 47.4 | 44.4 | 33.4 | 25.2 |
| brown phase - Fall | 2 | 57.4 | 54.1 | 47.2 | 44.0 | 32.5 | 24.0 |
| | 3 | 58.6 | 54.8 | 47.6 | 42.9 | 32.0 | 23.9 |
| | 4 | 59.1 | 54.8 | 47.6 | 43.6 | 32.2 | 23.8 |
| | Ave. | 57.9 | 54.4 | 47.4 | 43.7 | 32.5 | 24.2 |
| Huffine silt loam | 1 | 54.1 | 51.4 | 46.3 | 43.3 | 35.8 | 27.1 |
| Fall | 2 | 46.8 | 44.1 | 38.5 | 34.3 | 27.1 | 22.7 |
| | 3 | 56.7 | 53.7 | 47.7 | 44.3 | 36.0 | 28.3 |
| | 4 | 57.6 | 53.8 | 48.0 | 44.5 | 35.6 | 27.5 |
| | Ave. | 54.3 | 5.08 | 45.1 | 41.6 | 33.6 | 26.4 |
| Manhattan very fine | 1 | 52.0 | 50.0 | 45.1 | 42.2 | 26.8 | 20.4 |
| sandy loam (1) | 2 | 51.9 | 50.3 | 45.6 | 42.3 | 26.0 | 20.2 |
| Spring | 3 | 47.8 | 46.6 | 42.9 | 40.5 | 25.8 | 20.4 |
| | 4 | 50.1 | 48.0 | 43.6 | 41.1 | 26.4 | 20.5 |
| | Ave. | 50.4 | 48.7 | 44.3 | 41.5 | 26.2 | 20.4 |
| Manhattan very fine | 1 | 51.3 | 48.8 | 43.7 | 41.6 | 24.0 | 18.9 |
| sandy loam (1) | 2 | 51.2 | 49.0 | 43.4 | 41.1 | 23.7 | 18.7 |
| Fall | 3 | 51.7 | 47.2 | 41.3 | 39.1 | 23.3 | 18.7 |
| | 4 | 48.4 | 44.8 | 39.5 | 36.6 | 19.8 | 16.1 |
| | Ave. | 50.6 | 47.4 | 42.0 | 39.6 | 22.7 | 18.1 |
| Manhattan very fine | 1 | 40.1 | 38.0 | 33.1 | 29.4 | 13.7 | 11.5 |
| sandy loam (2) | 2 | 40.9 | 38.9 | 34.4 | 30.3 | 14.8 | 12.1 |
| Spring | 3 | 43.9 | 41.9 | 36.7 | 32.2 | 17.3 | 12.3 |
| | 4 | 44.3 | 41.6 | 35.5 | 31.3 | 16.2 | 12.5 |
| | Ave. | 42.3 | 40.1 | 34.9 | 30.8 | 15.5 | 12.1 |

Table XIX. Rate of pore space change as expressed by slope at selected points on the soil moisture characteristic curve.

| Soil Type | Season | Calculated Slopes 10-20 | 60-100 | 100-346 | 346-945 | Observed Slopes 500 | 1000 |
|---|---|---|---|---|---|---|---|
| Bozeman silt loam | Fall | 2.4 | 4.2 | 12.0 | 5.9 | 1.92 | 2.80 |
| Bozeman silt loam | Spring | 2.1 | 3.0 | 10.2 | 5.7 | 2.50 | 4.50 |
| Manhattan very fine sandy loam (2) | Spring | 4.1 | 4.2 | 14.7 | 7.1 | 3.60 | 15.00 |
| Manhattan very fine sandy loam (1) | Spring | 2.4 | 3.2 | 12.5 | 7.2 | 1.90 | 4.00 |
| Amsterdam very fine sandy loam | Spring | 5.0 | 4.1 | 13.4 | 5.7 | 2.40 | 4.75 |
| Huffine silt loam | Fall | 4.2 | 3.9 | 12.2 | 7.4 | 2.00 | 2.00 |
| Bozeman silt loam, brown phase | Fall | 3.5 | 3.7 | 11.7 | 8.3 | 1.50 | 3.20 |
| Amsterdam silt loam | Spring | 3.5 | 3.5 | 8.0 | 7.2 | 1.86 | 4.10 |
| Amsterdam very fine sandy loam | Fall | 1.7 | 2.8 | 15.3 | 5.8 | 2.15 | 5.80 |
| Manhattan very fine sandy loam (1) | Fall | 3.2 | 2.4 | 16.9 | 4.6 | 2.90 | 8.00 |
| Amsterdam silt loam | Fall | 2.2 | 4.1 | 15.3 | 3.4 | 1.66 | 4.70 |

Table XX. The ratios existing between slopes at different points on the soil moisture characteristic curve and corresponding infiltration values.

| Soil Type | Season | Infiltration | Slope 10-20 / 60-100 | Slope 100-346 / 346-1000 | Slope 500 / 1000 |
|---|---|---|---|---|---|
| Bozeman silt loam | Fall | 4.12 | .80 | .75 | .68 |
| Bozeman silt loam | Spring | 5.38 | .90 | .52 | .56 |
| Manhattan very fine sandy loam (2) | Spring | 3.88 | .39 | .27 | .24 |
| Manhattan very fine sandy loam (1) | Spring | 3.38 | .44 | .47 | .48 |
| Amsterdam very fine sandy loam | Spring | 3.31 | .42 | .61 | .50 |
| Huffine silt loam | Fall | 3.25 | .74 | 1.11 | 1.00 |
| Bozeman silt loam brown phase | Fall | 2.75 | .70 | .91 | .47 |
| Amsterdam silt loam | Spring | 2.56 | .72 | .60 | .45 |
| Amsterdam very fine sandy loam | Fall | 2.50 | .52 | .69 | .37 |
| Manhattan very fine sandy loam (1) | Fall | 2.34 | .98 | .33 | .36 |
| Amsterdam silt loam | Fall | .69 | .56 | .71 | .35 |

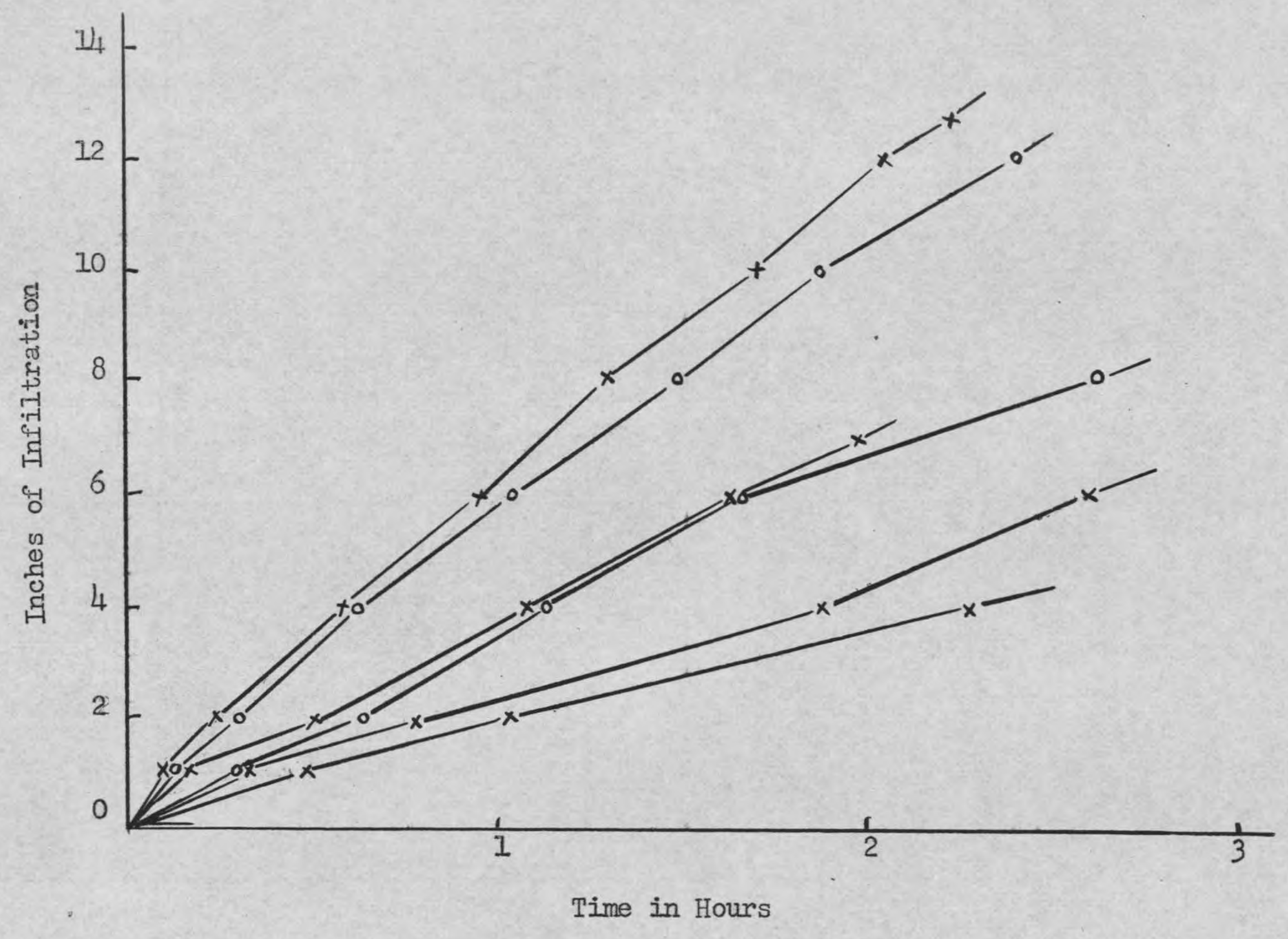


Figure 11. Cumulative infiltration plotted against time for Amsterdam very fine Sandy Loam under alfalfa ten miles south of Manhattan, June 30, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

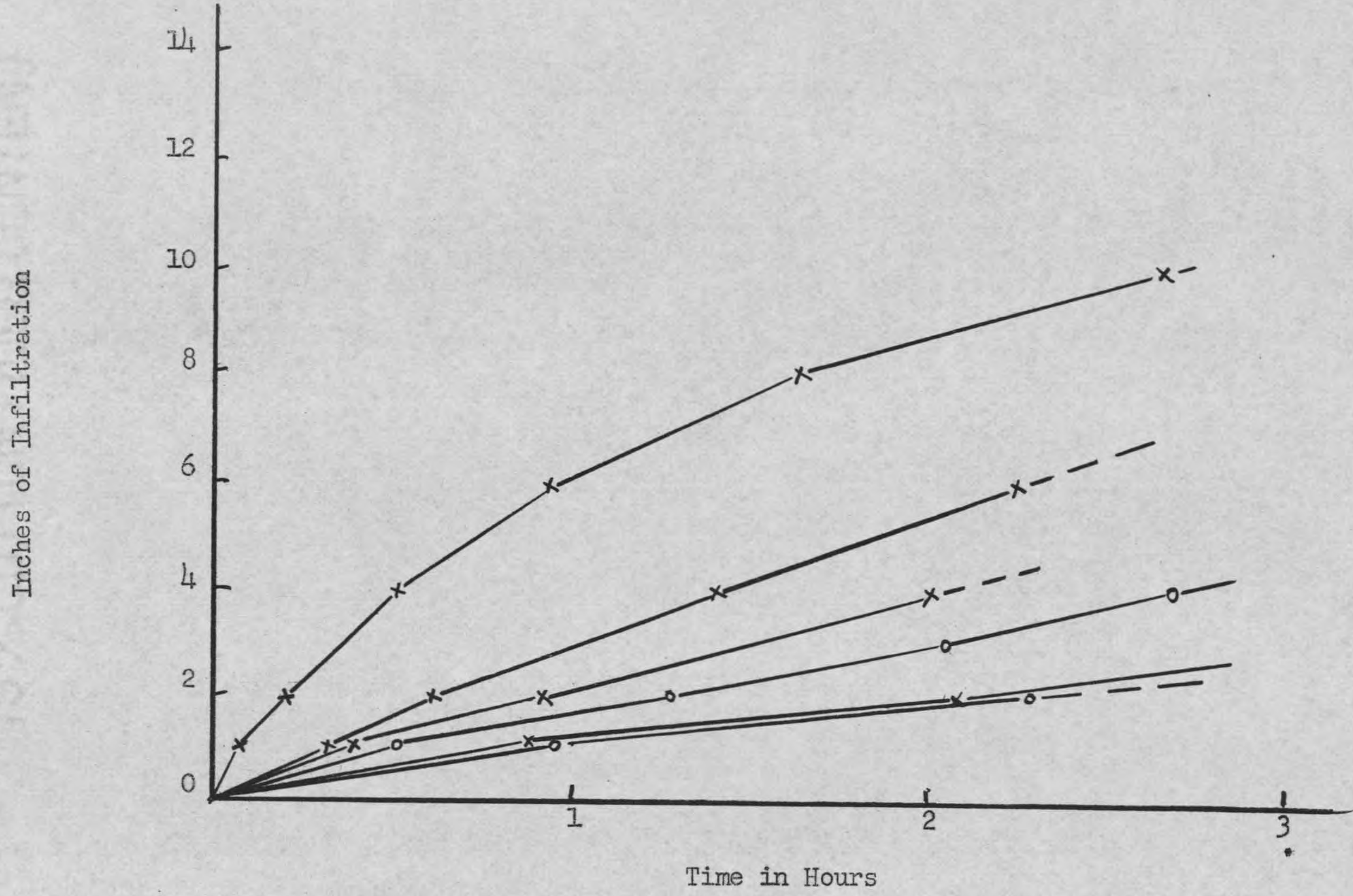


Figure 12. Cumulative infiltration plotted against time for Amsterdam Silt Loam under wheat fallow fourteen miles south of Manhattan, June 28, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

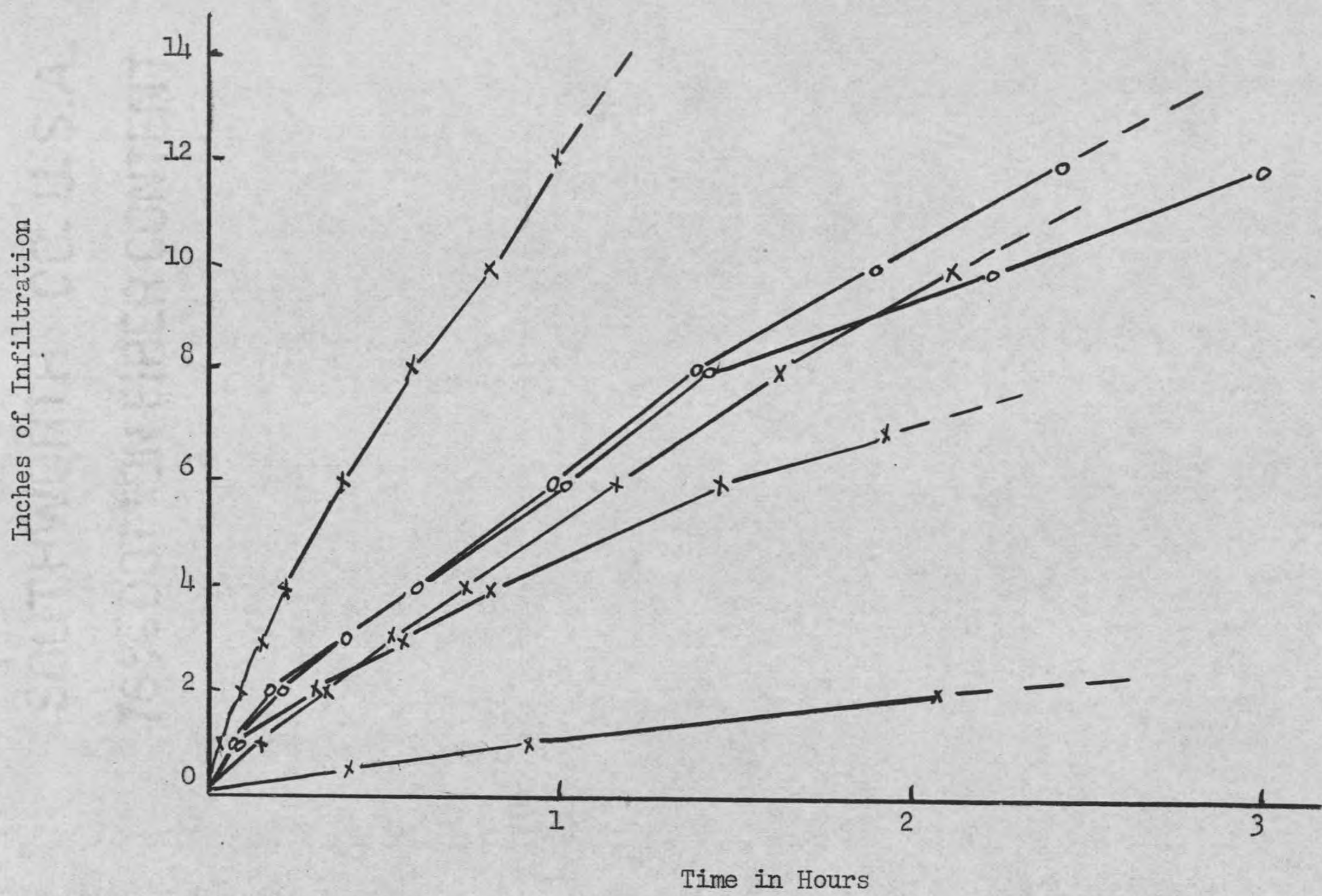


Figure 13. Cumulative infiltration plotted against time for Bozeman Silt Loam under wheat three miles east of Bozeman, June 21, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

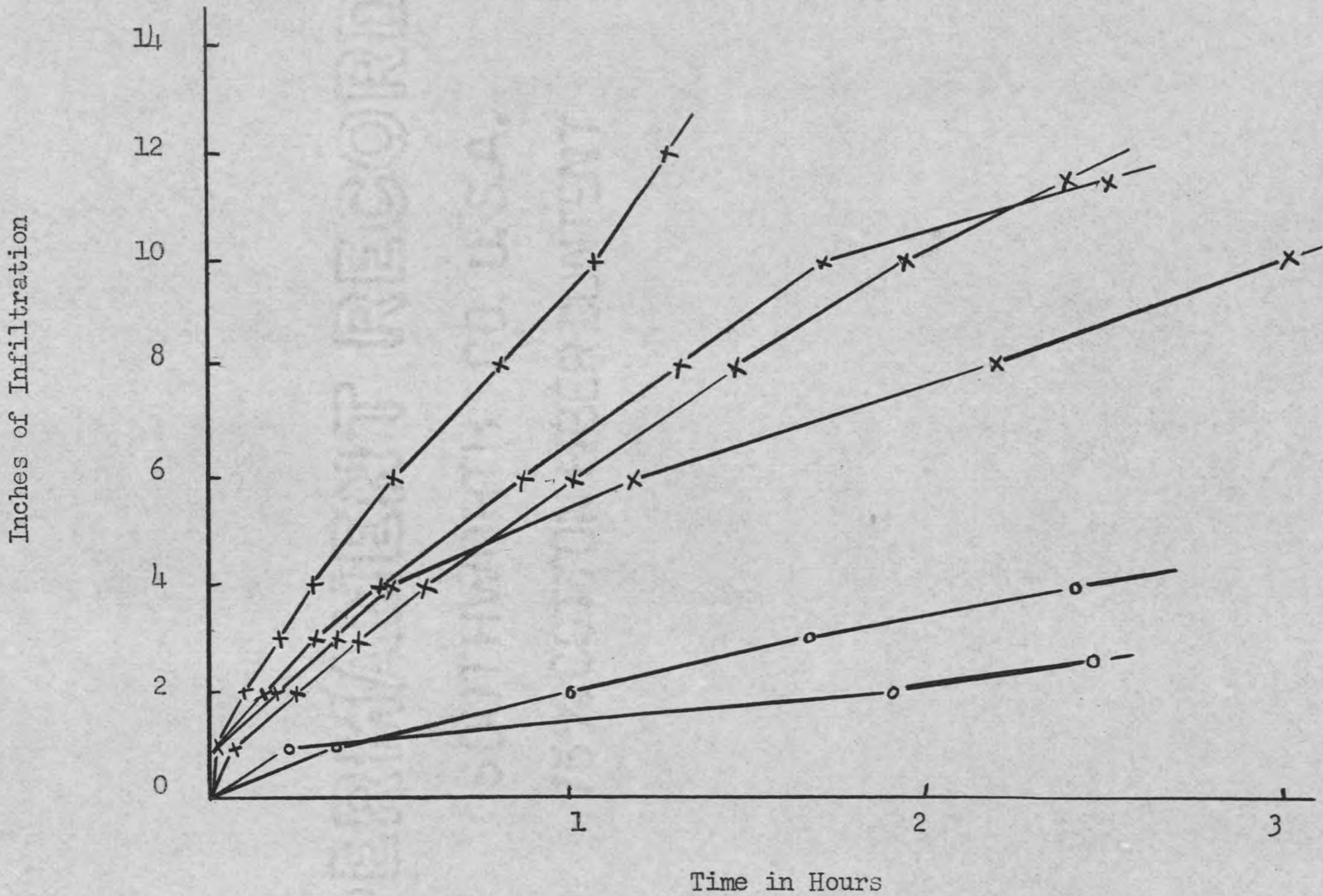


Figure 14. Cumulative infiltration plotted against time for Bozeman Silt Loam, Brown phase, under oats seven miles south of Belgrade, June 23, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

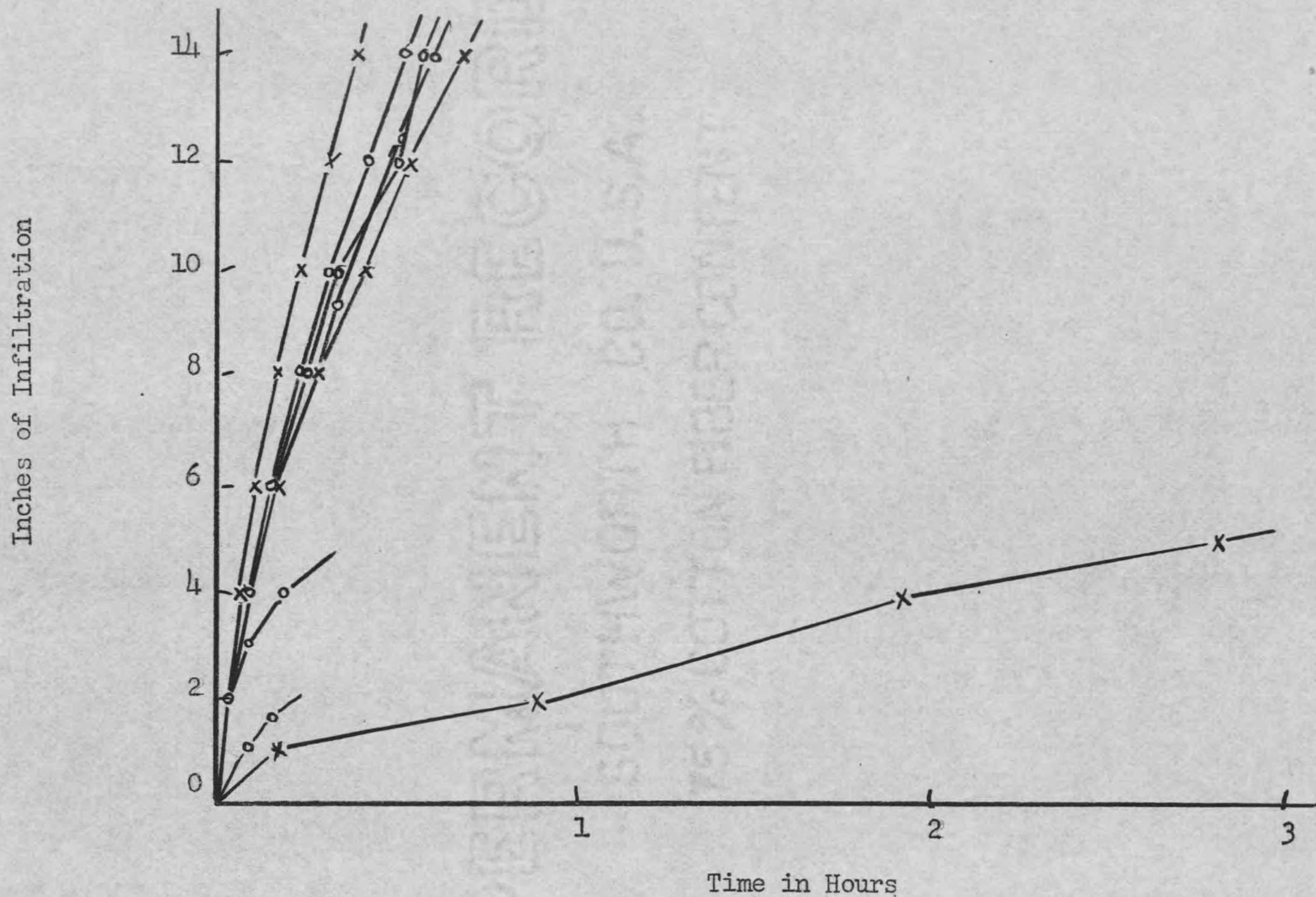


Figure 15. Cumulative infiltration plotted against time for Huffine Silt Loam under potatoes one mile west of Bozeman, June 14, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

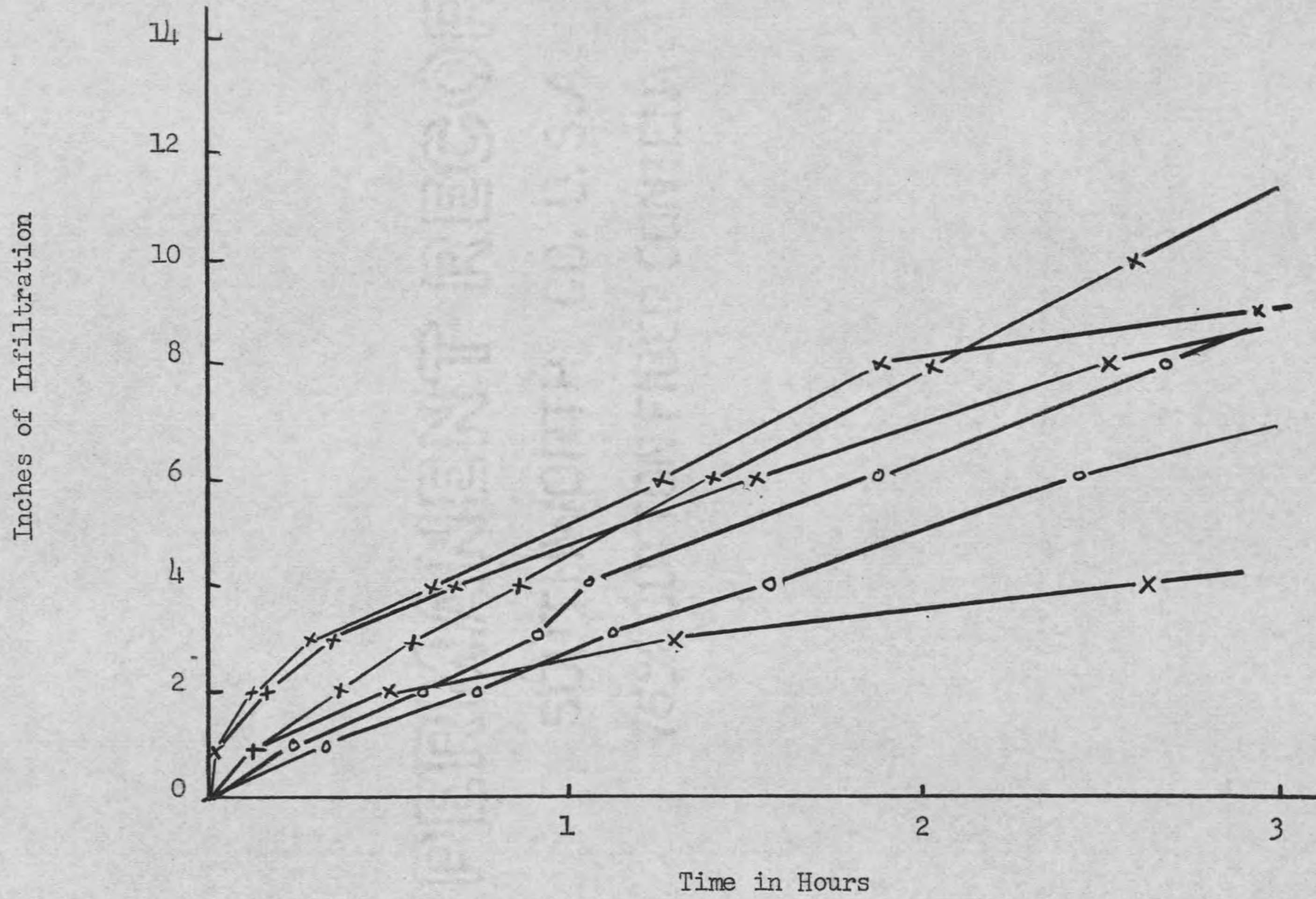


Figure 16. Cumulative infiltration plotted against time for Manhattan Very Fine Sandy Loam under wheat fallow four miles south of Manhattan, July 5, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

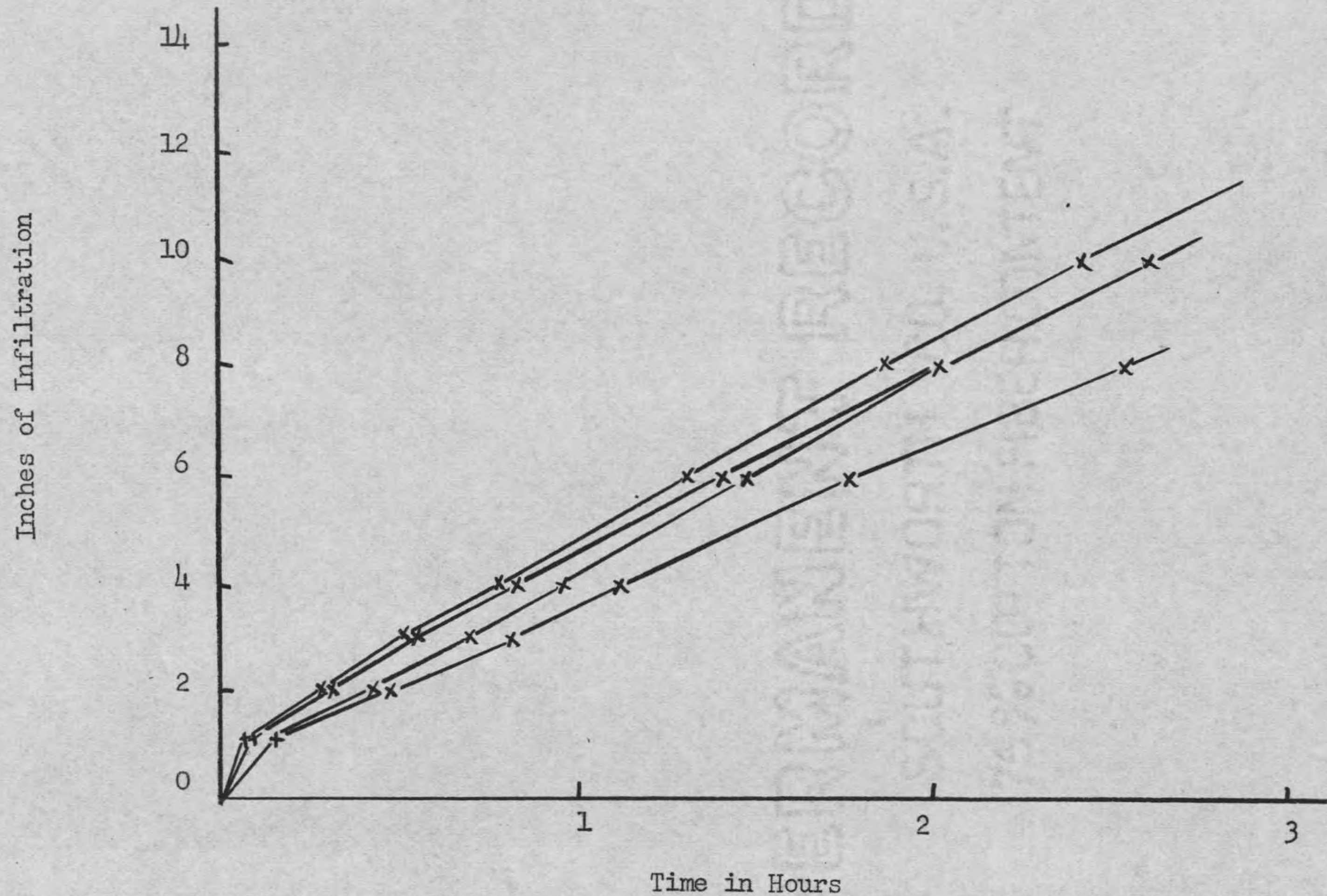


Figure 17. Cumulative infiltration plotted against time for Manhattan Very Fine Sandy Loam under wheat fallow four miles south of Willowcreek, June 8, 1950. "x" indicates surface samples.

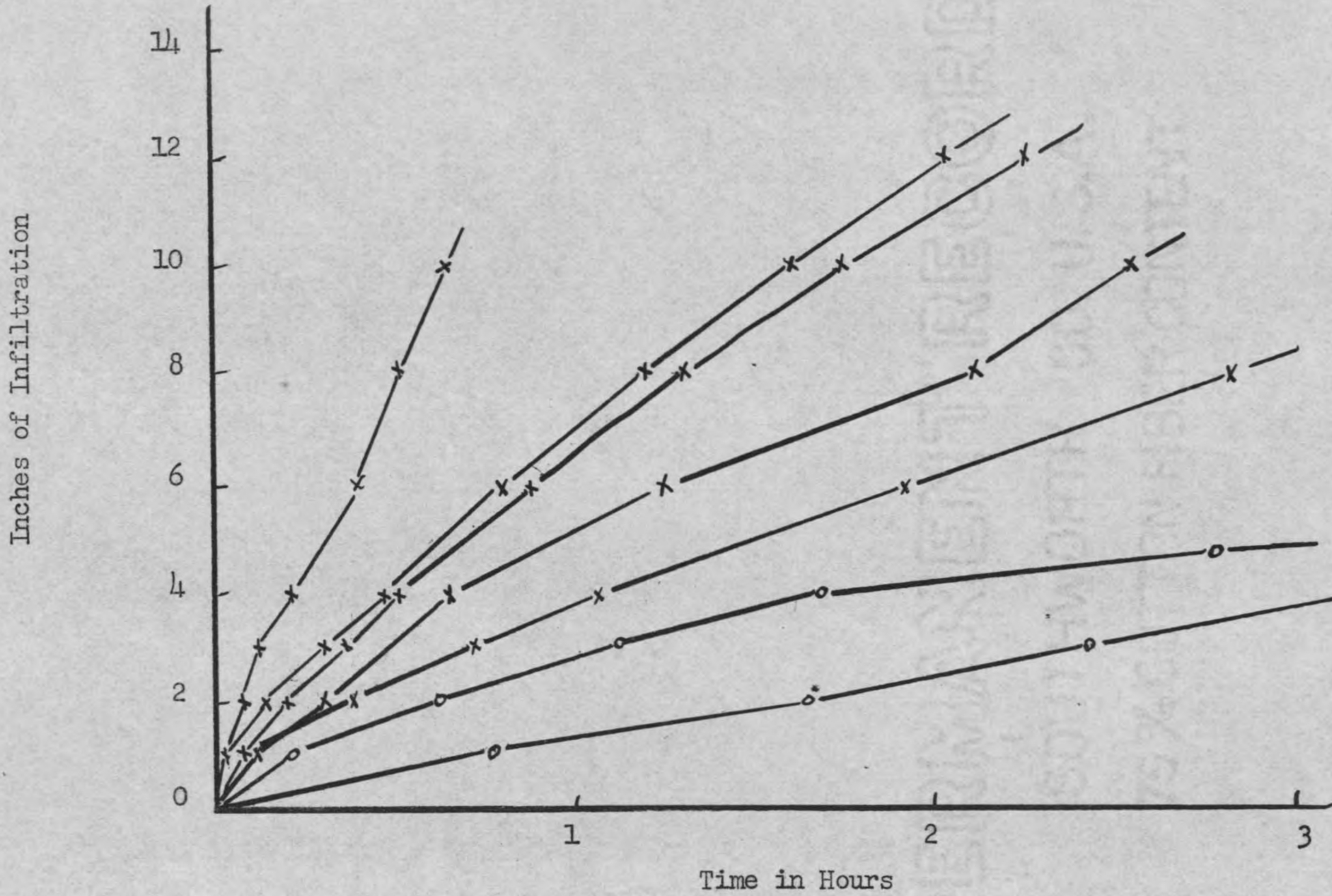


Figure 18. Cumulative infiltration plotted against time for Bozeman Silt Loam under pasture three miles east of Bozeman, June 22, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

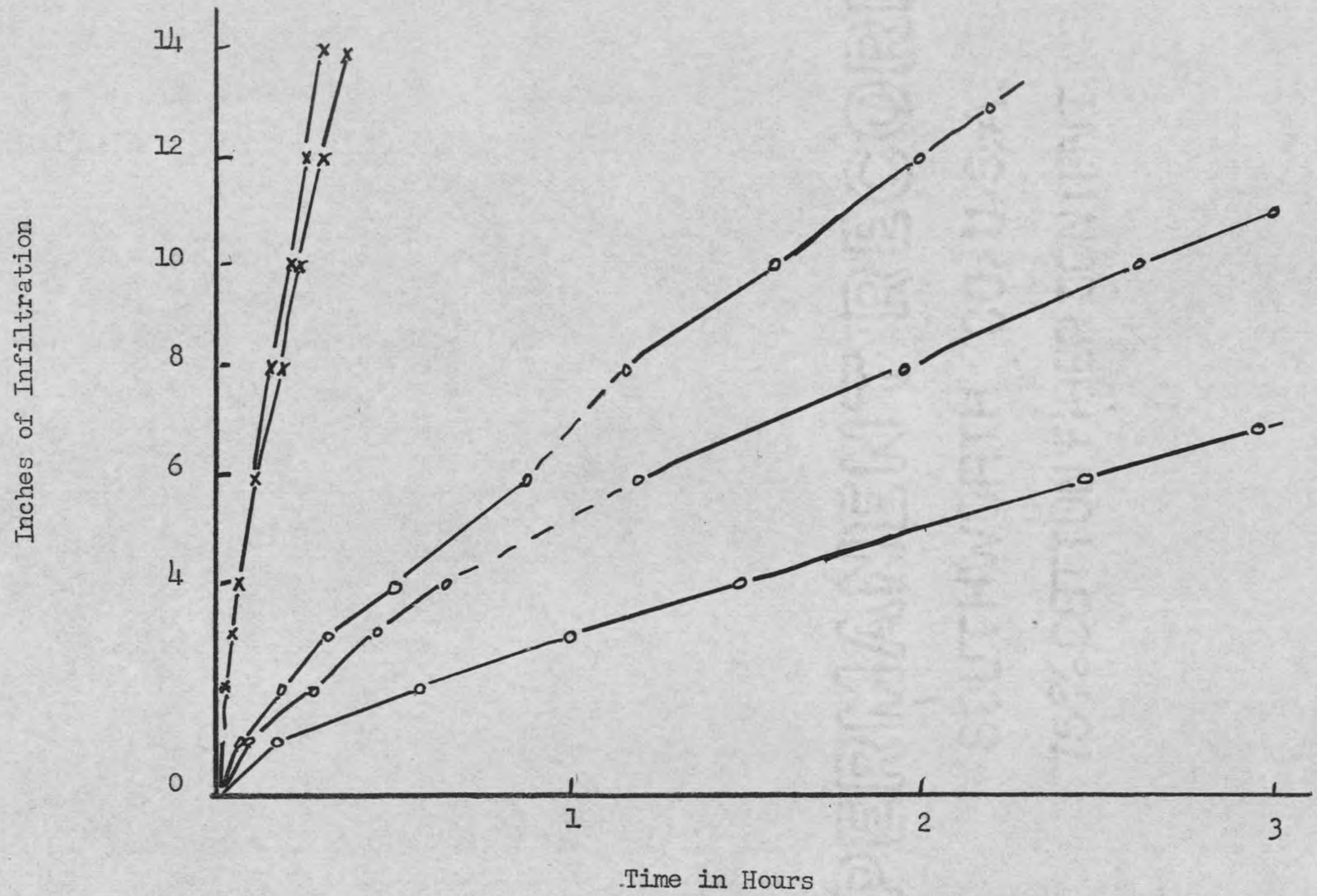


Figure 19. Cumulative infiltration plotted against time for Bozeman Silt Loam, Brown phase under native grass seven miles south of Belgrade, June 27, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

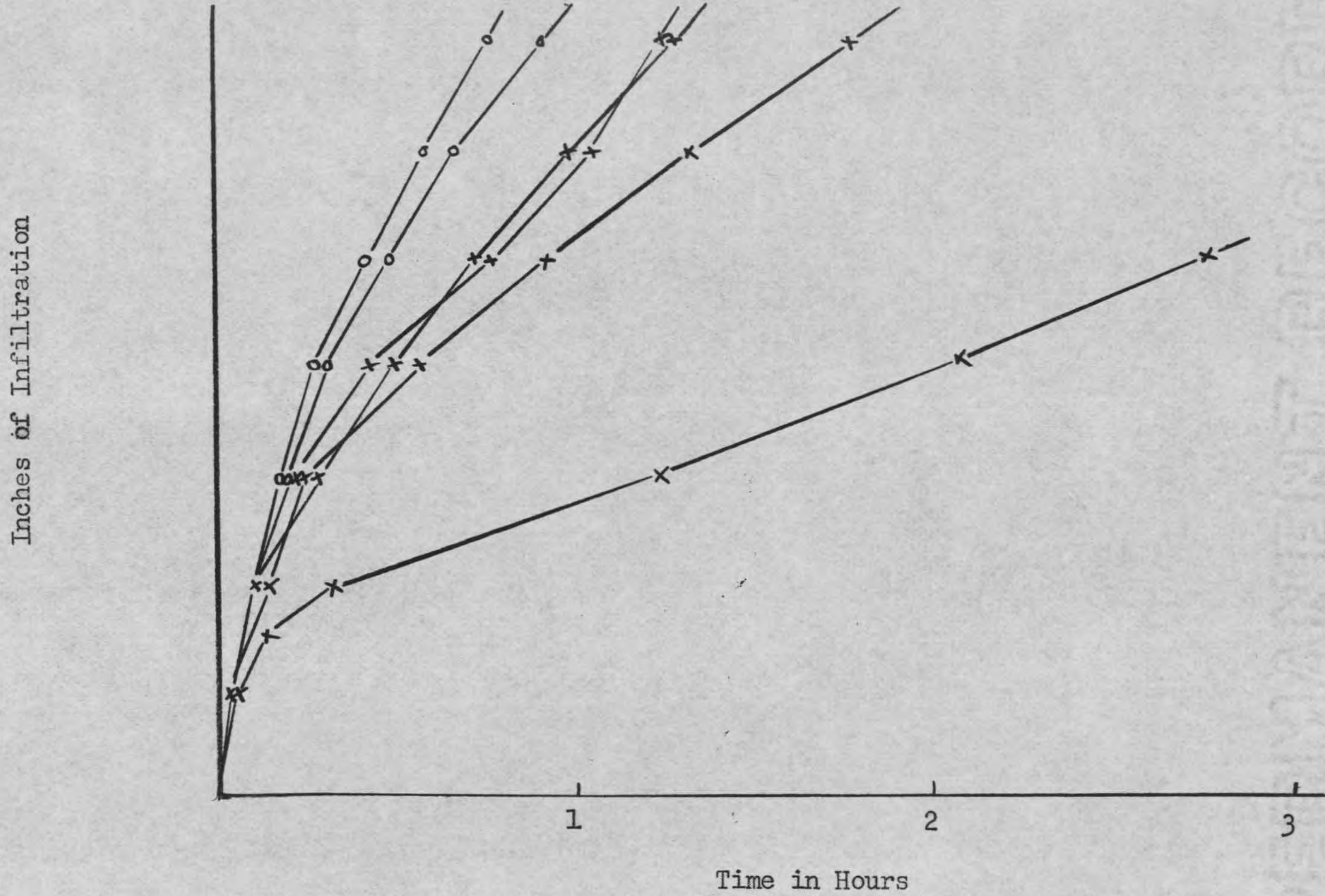


Figure 20. Cumulative infiltration plotted against time for Huffine Silt Loam under pasture grass one mile west of Bozeman, June 16, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

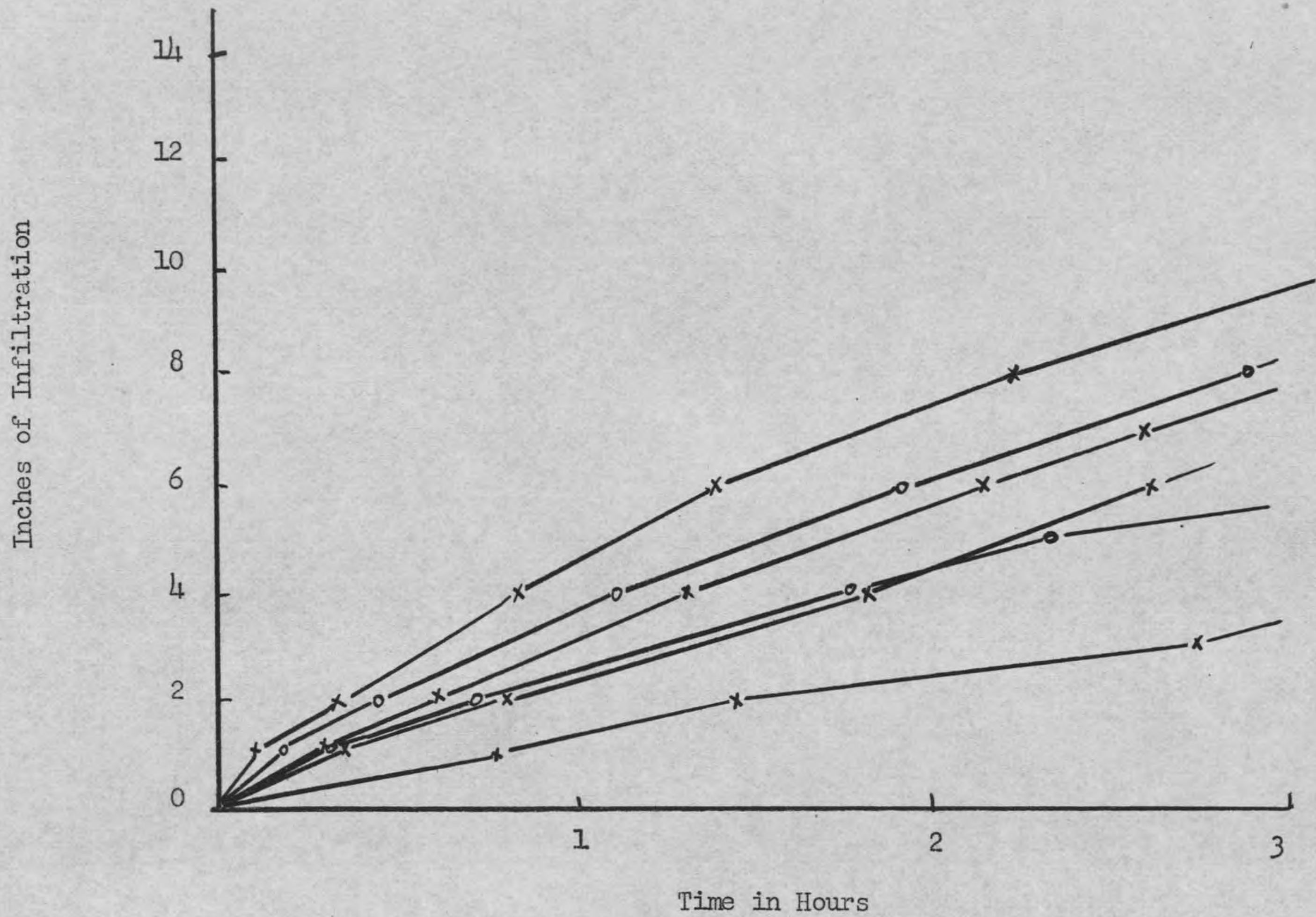


Figure 21. Cumulative infiltration plotted against time for Amsterdam Very Fine Sandy Loam under alfalfa ten miles south of Manhattan, October 10, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

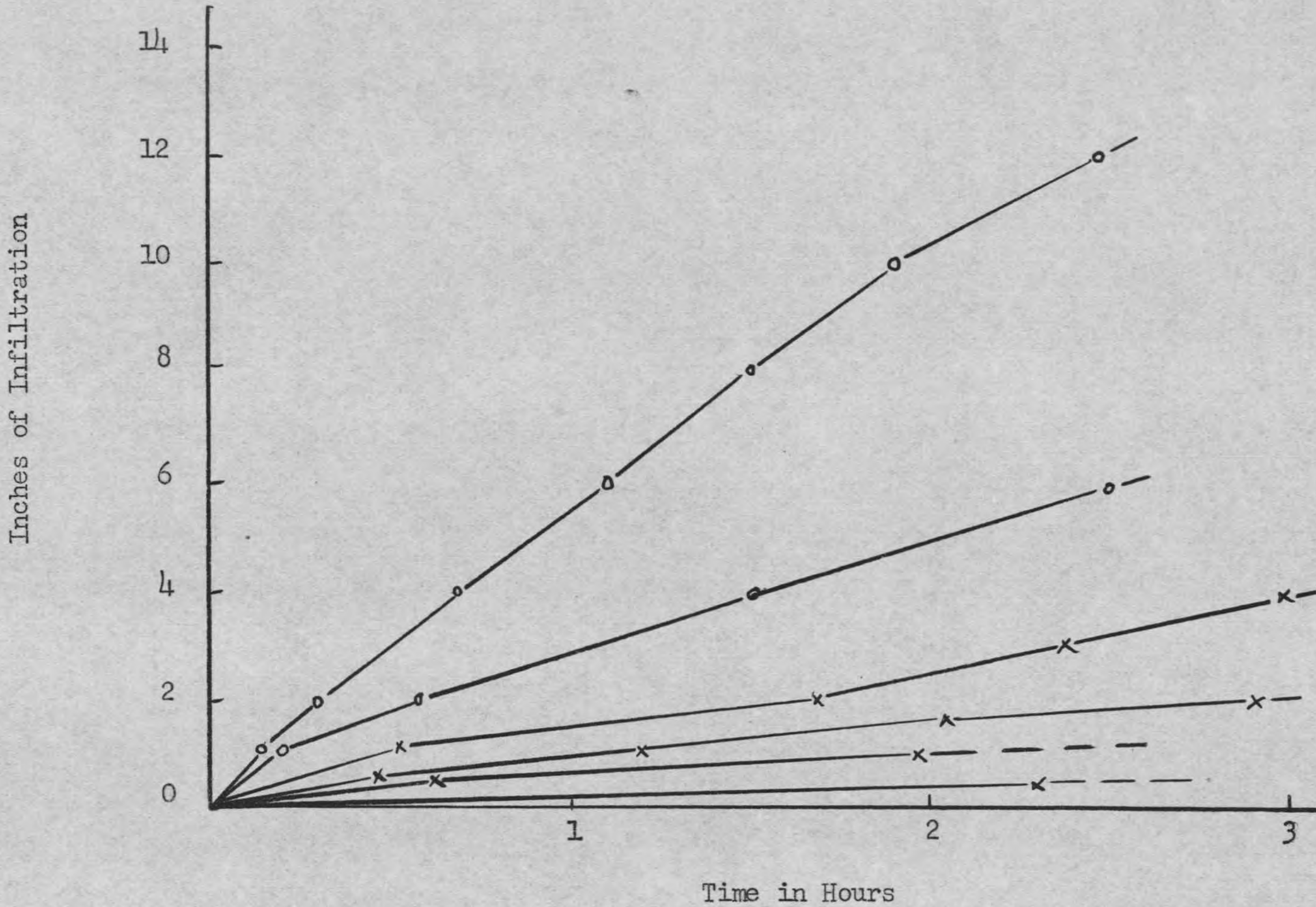


Figure 22. Cumulative infiltration plotted against time for Amsterdam Silt Loam under wheat fallow fourteen miles south of Manhattan, October 9, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

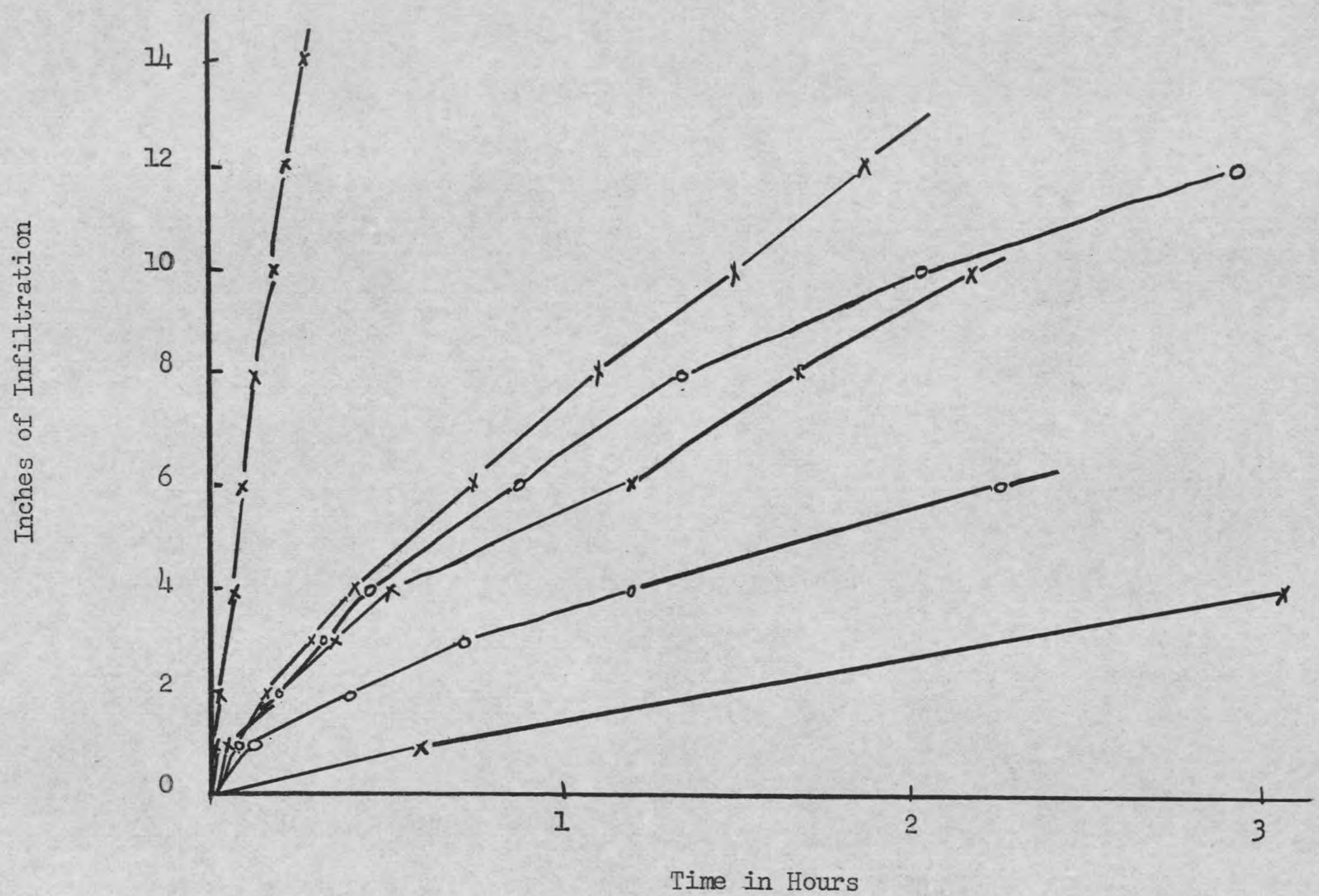


Figure 23. Cumulative infiltration plotted against time for Bozeman Silt Loam under wheat three miles east of Bozeman, October 13, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

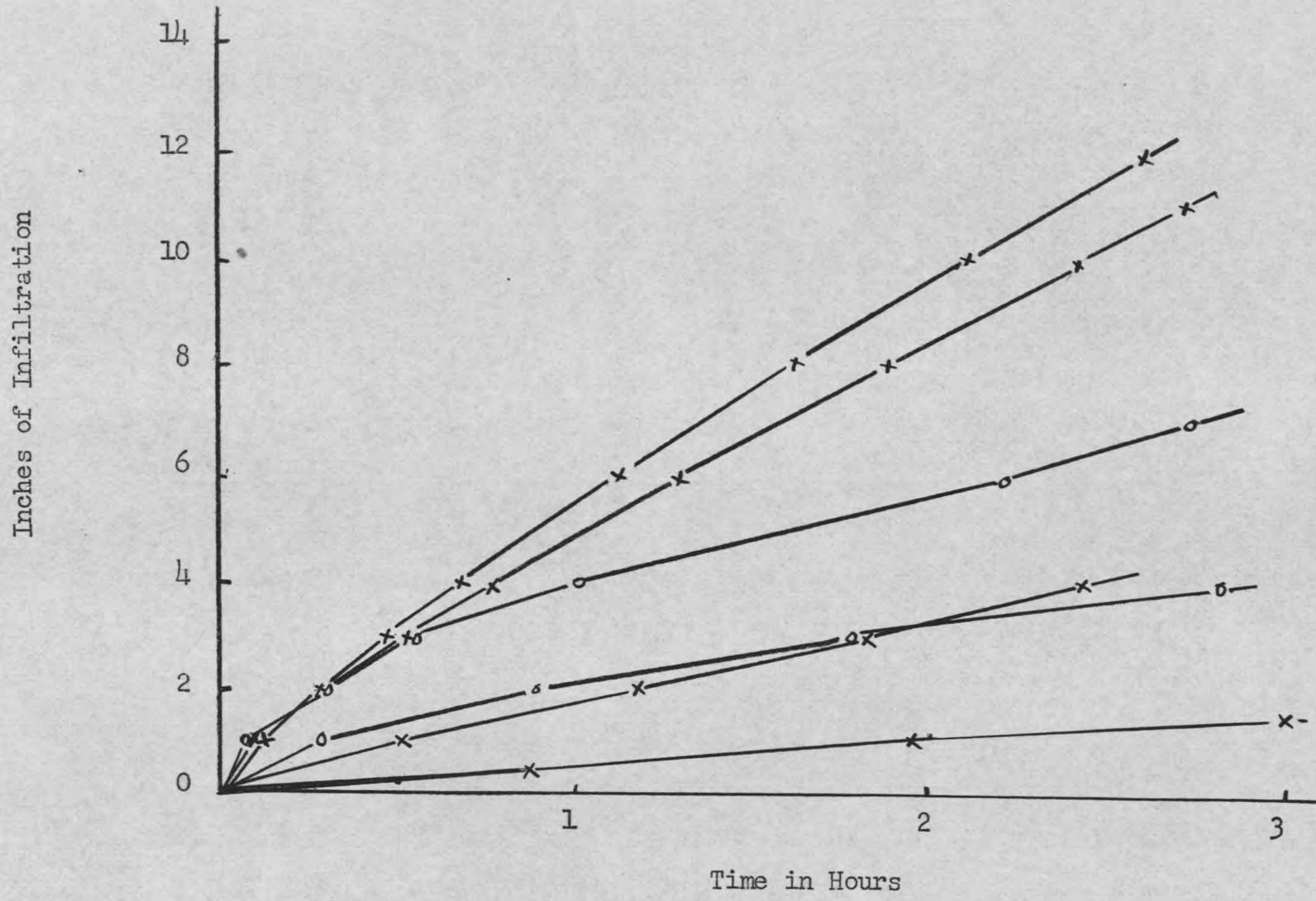


Figure 24. Cumulative infiltration plotted against time for Bozeman Silt Loam, Brown phase under oats seven miles south of Belgrade, October 11, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

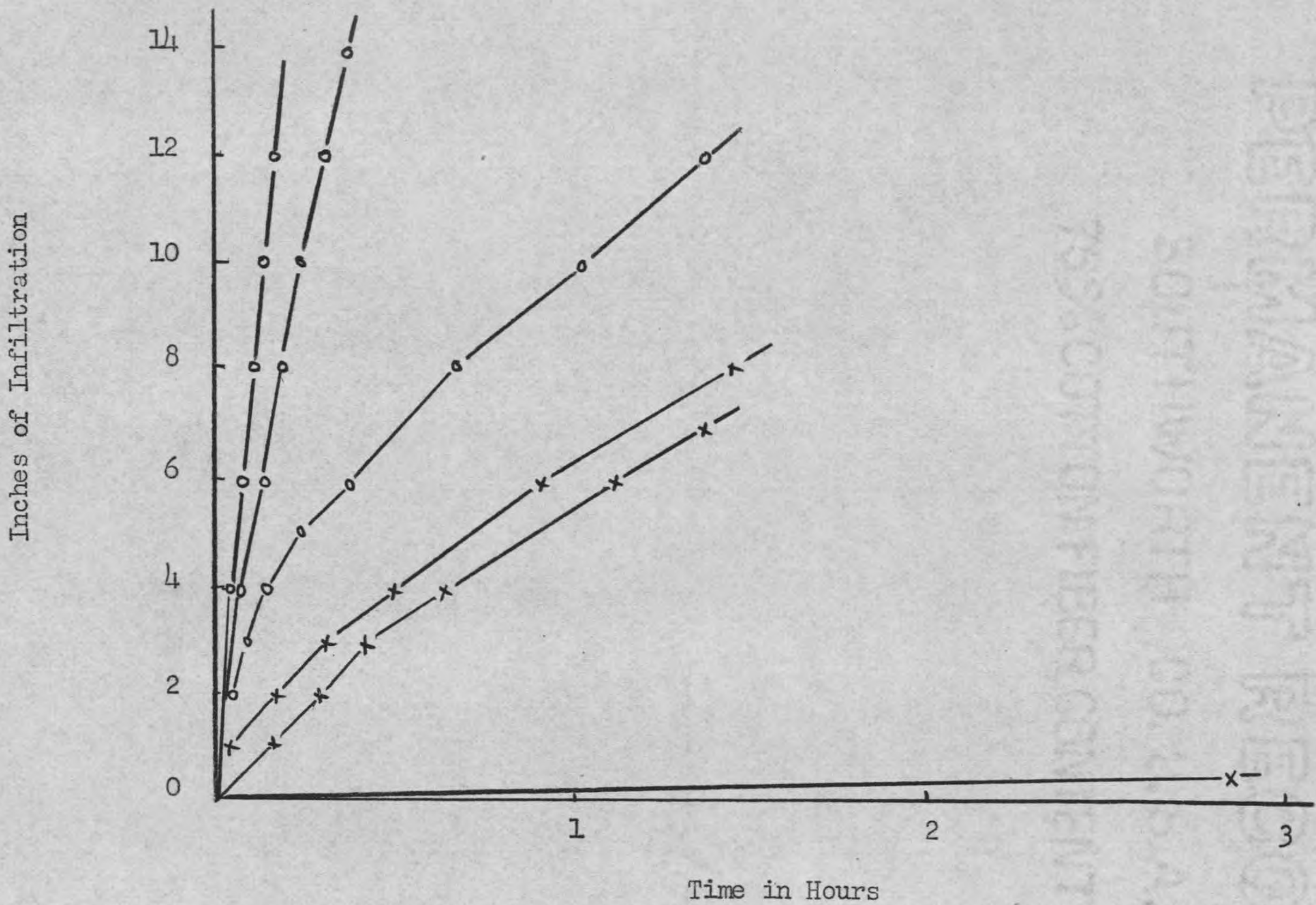


Figure 25. Cumulative infiltration plotted against time for Huffine Silt Loam under potatoes one mile west of Bozeman, October 10, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

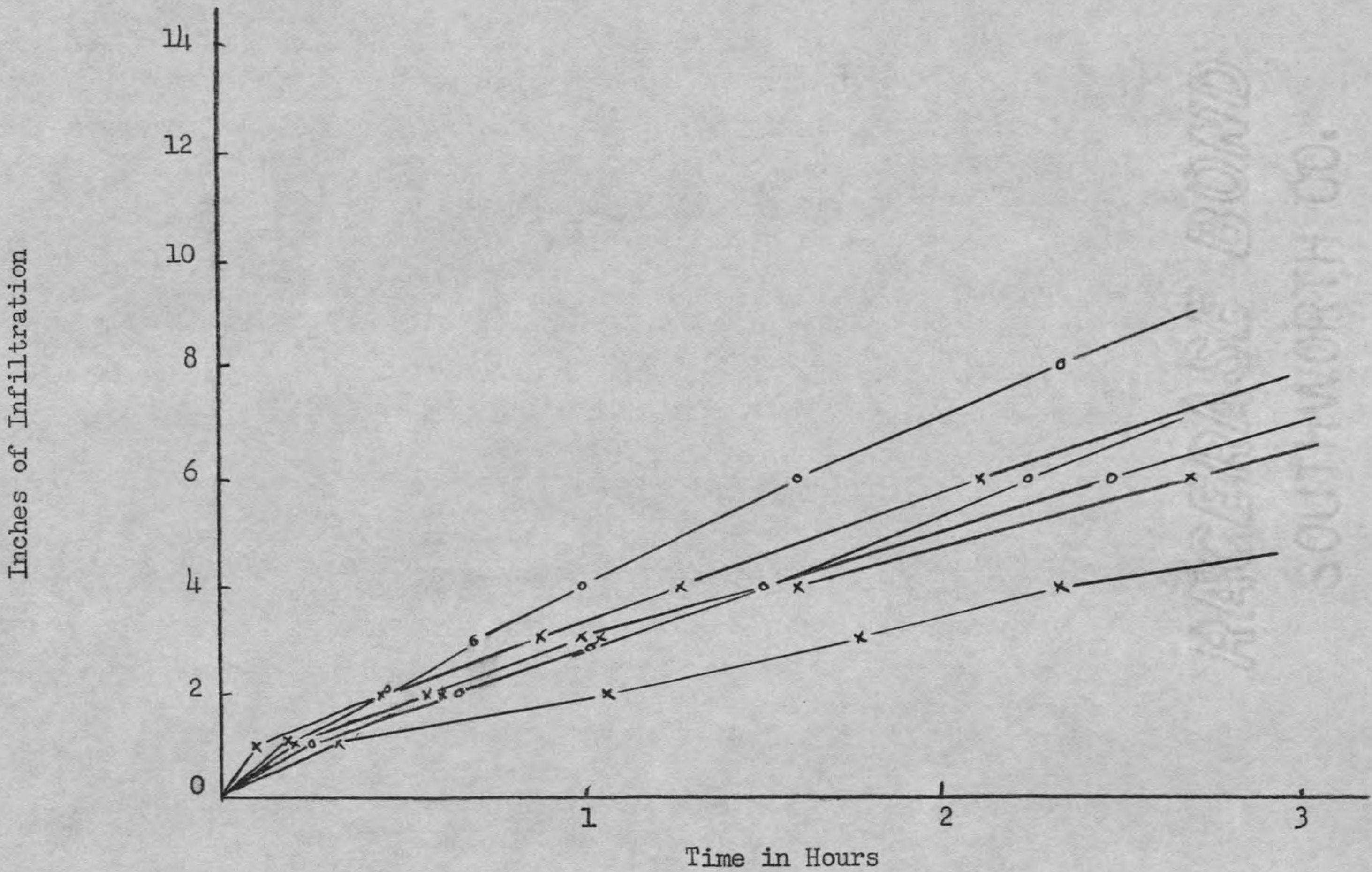


Figure 26. Cumulative infiltration plotted against time for Manhattan Very Fine Sandy Loam under wheat fallow four miles south of Manhattan, September 28, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

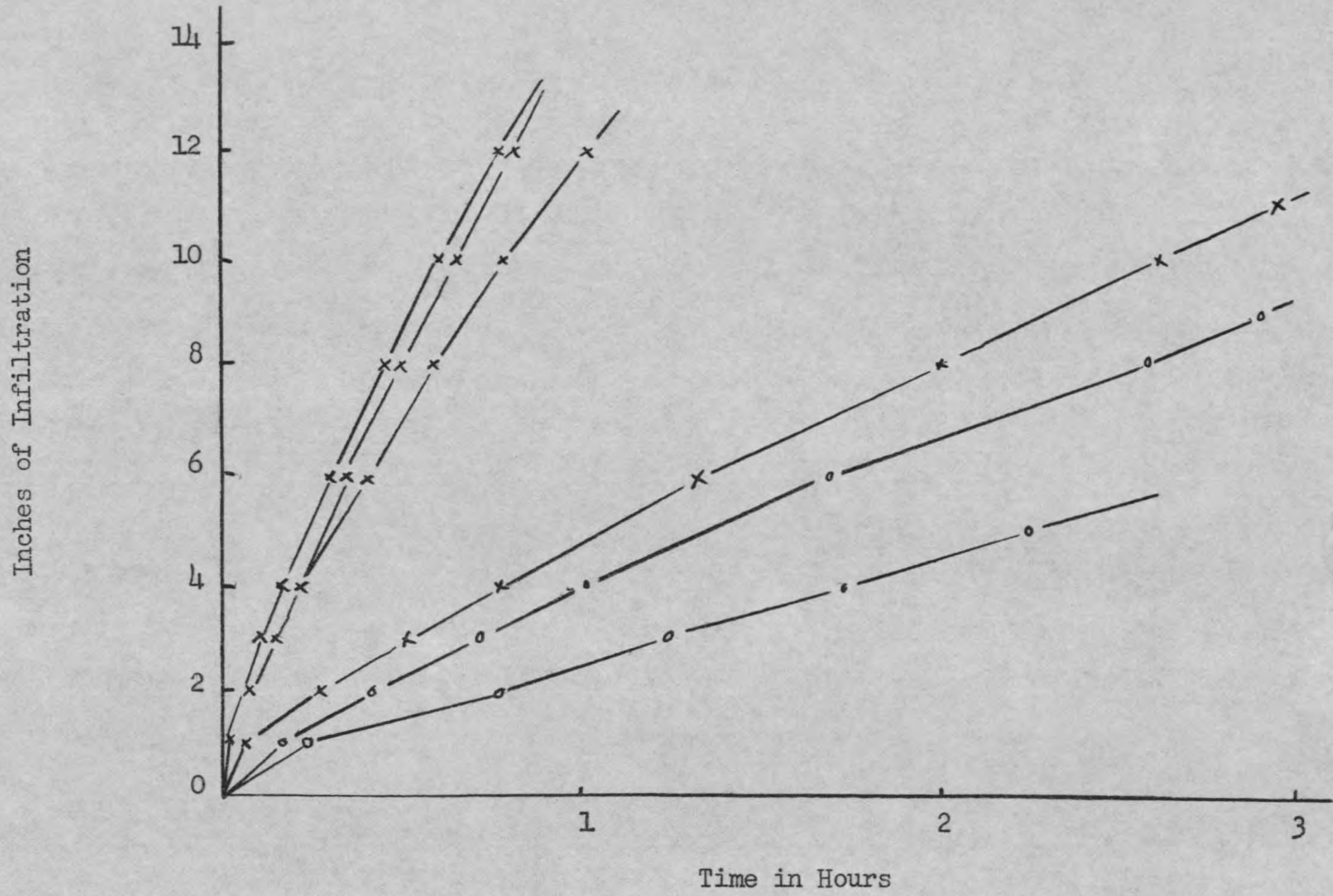


Figure 27. Cumulative infiltration plotted against time for Burnt Fork Loam under potatoes two miles northeast of Corvallis, August 15, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

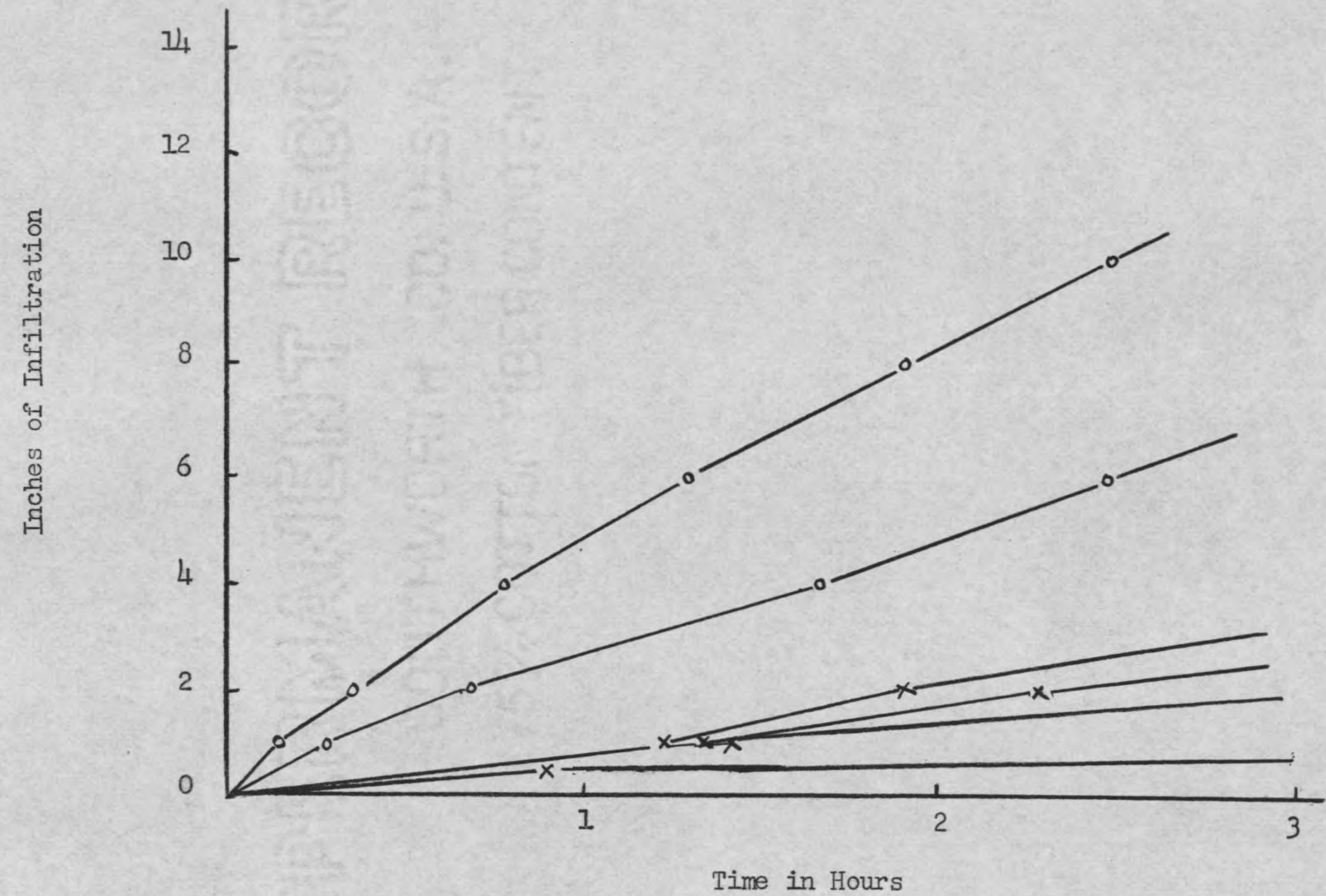


Figure 28. Cumulative infiltration plotted against time for Hamilton Silt Loam under alfalfa one mile south of Corvallis, August 14, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

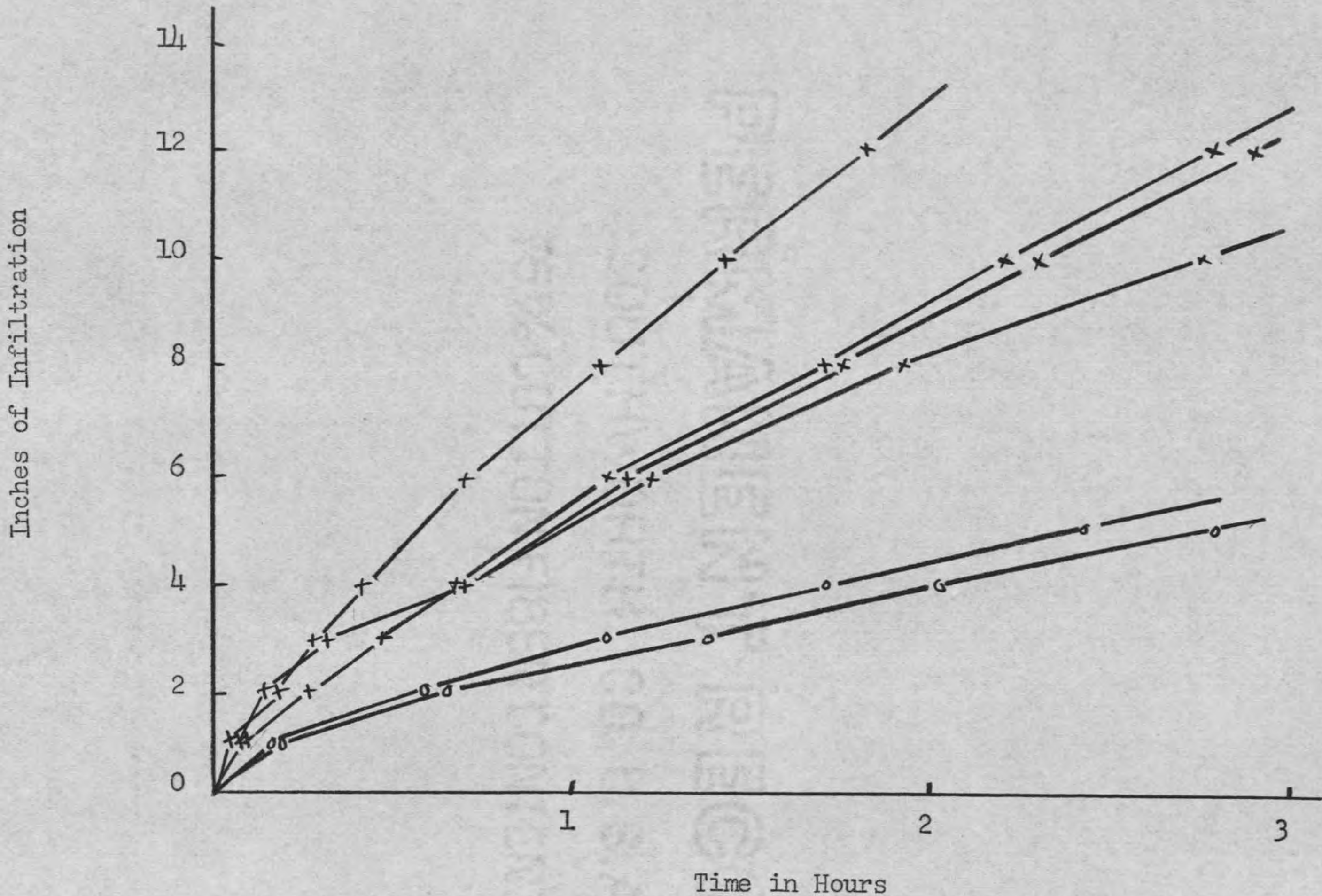


Figure 29. Cumulative infiltration plotted against time for Mc Donald Silt Loam under alfalfa one mile south of Ronan, August 10, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

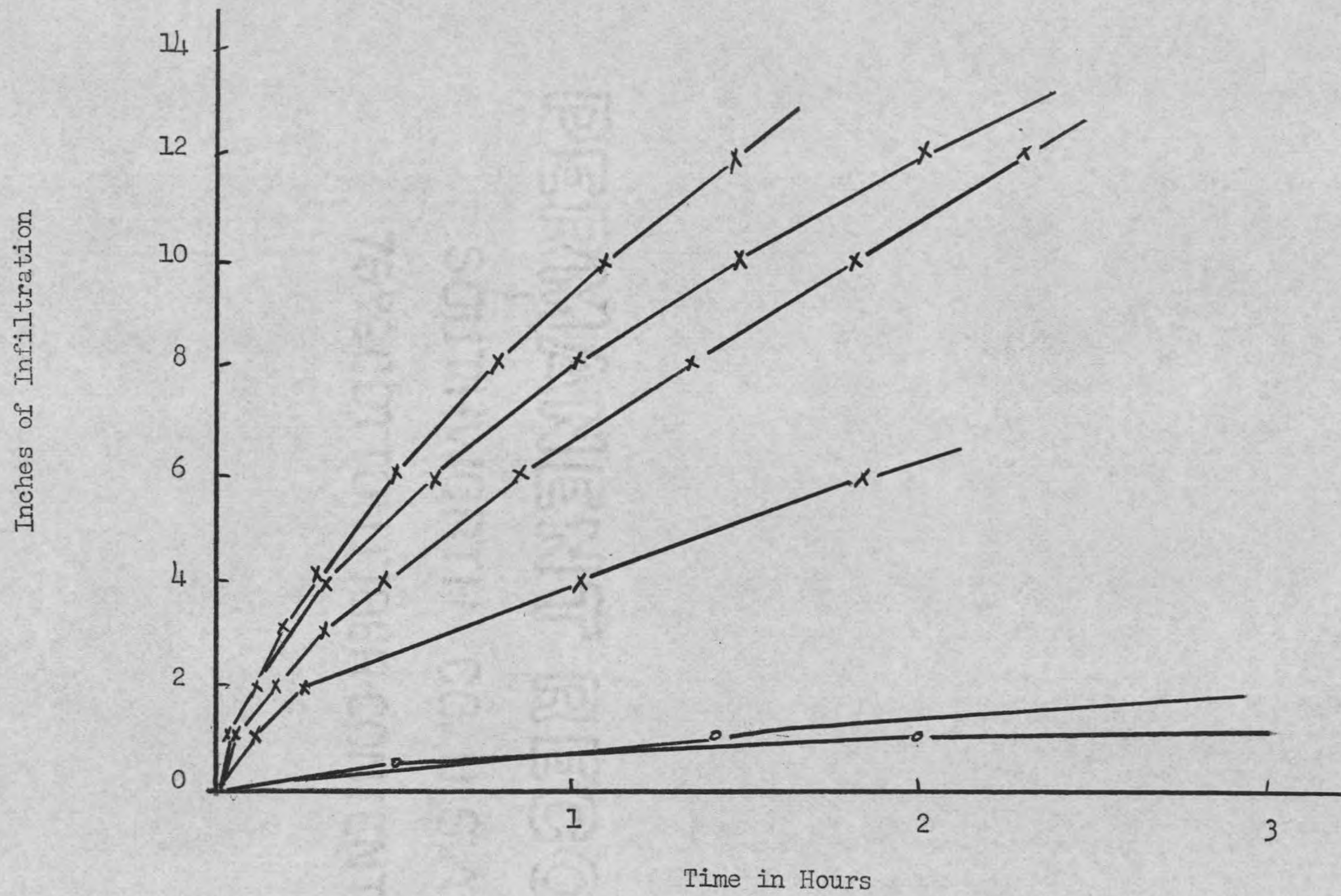


Figure 30. Cumulative infiltration plotted against time for Post Very Fine Sandy Loam under sugar beets two miles southwest of Ronan, August 8, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

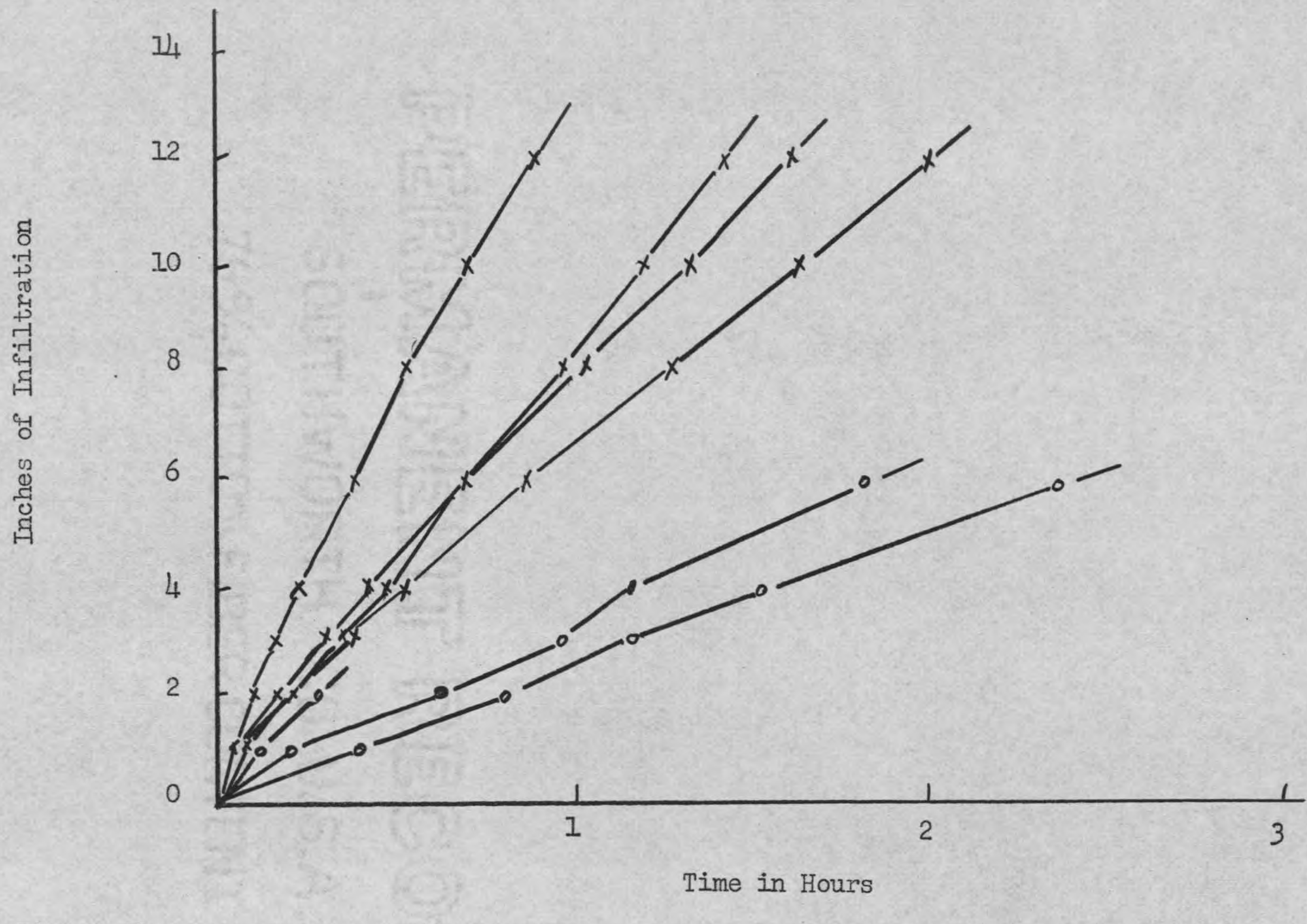


Figure 31. Cumulative infiltration plotted against time for Brockton Fine Sandy Loam under barley eight miles east of Kalispell, August 3, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

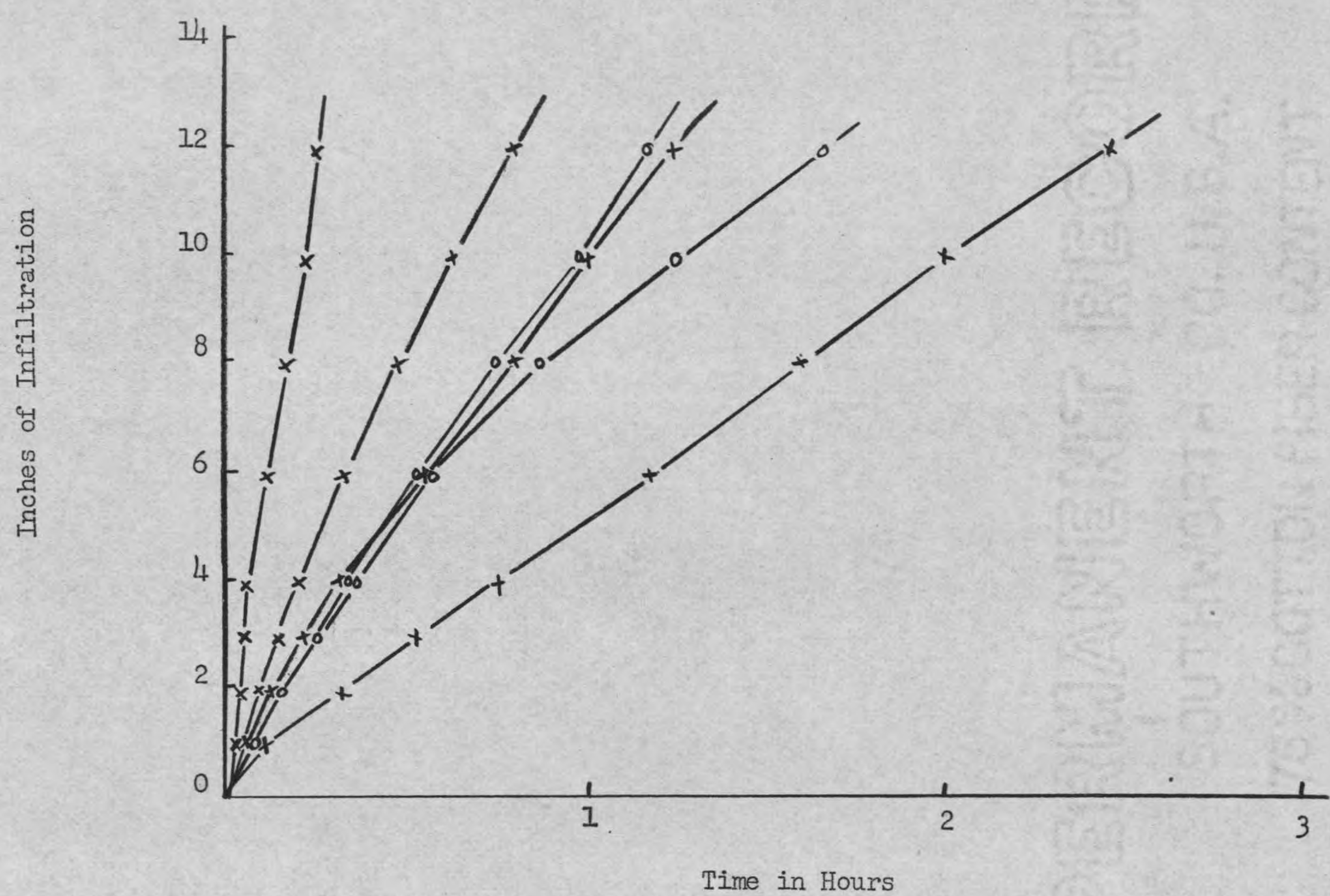


Figure 32. Cumulative infiltration plotted against time for Creston Silt Loam under red clover eleven miles east of Kalispell, August 2, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

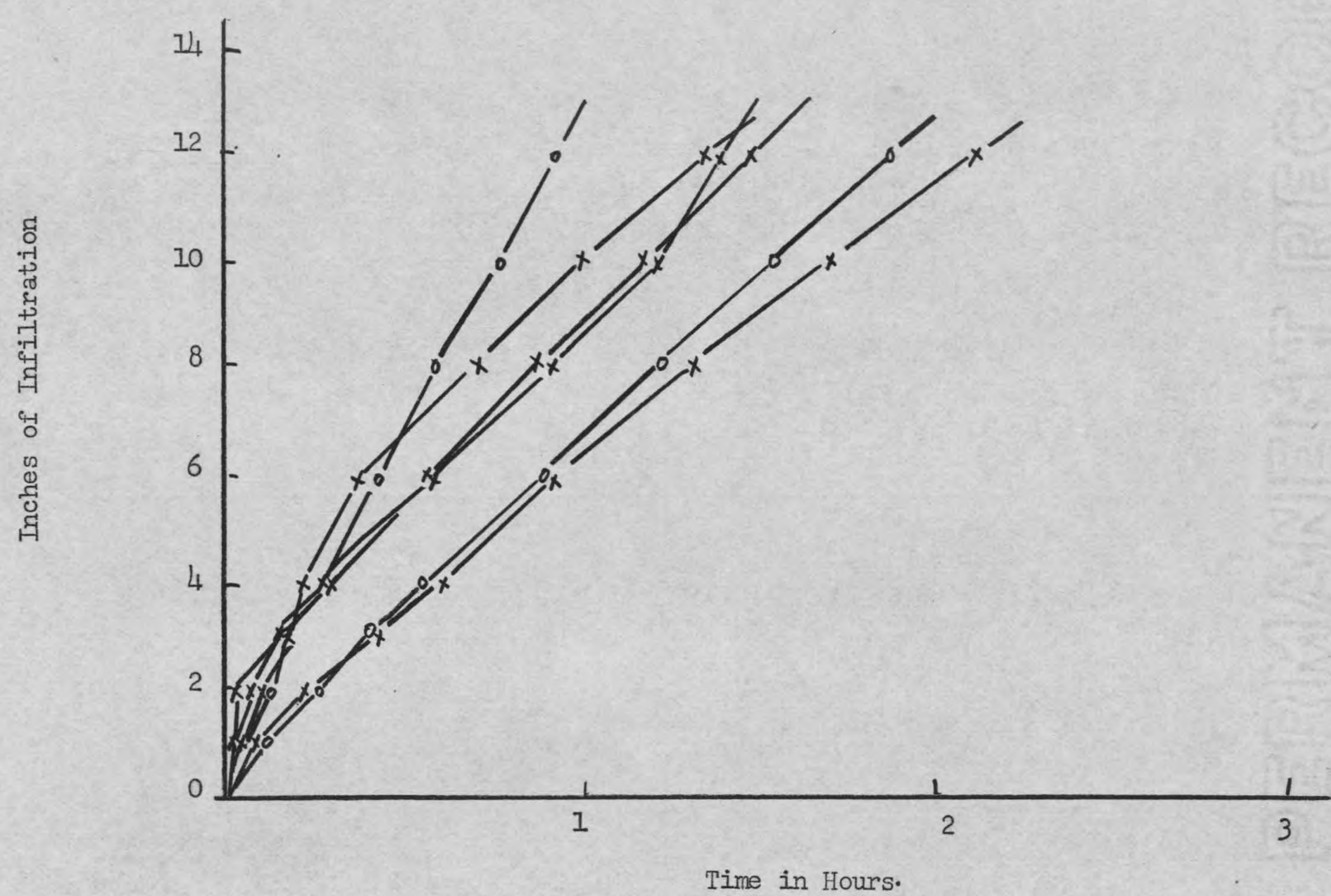


Figure 33. Cumulative infiltration plotted against time for Swimms Silty Clay Loam under red clover eleven miles east of Kalispell, July 31, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

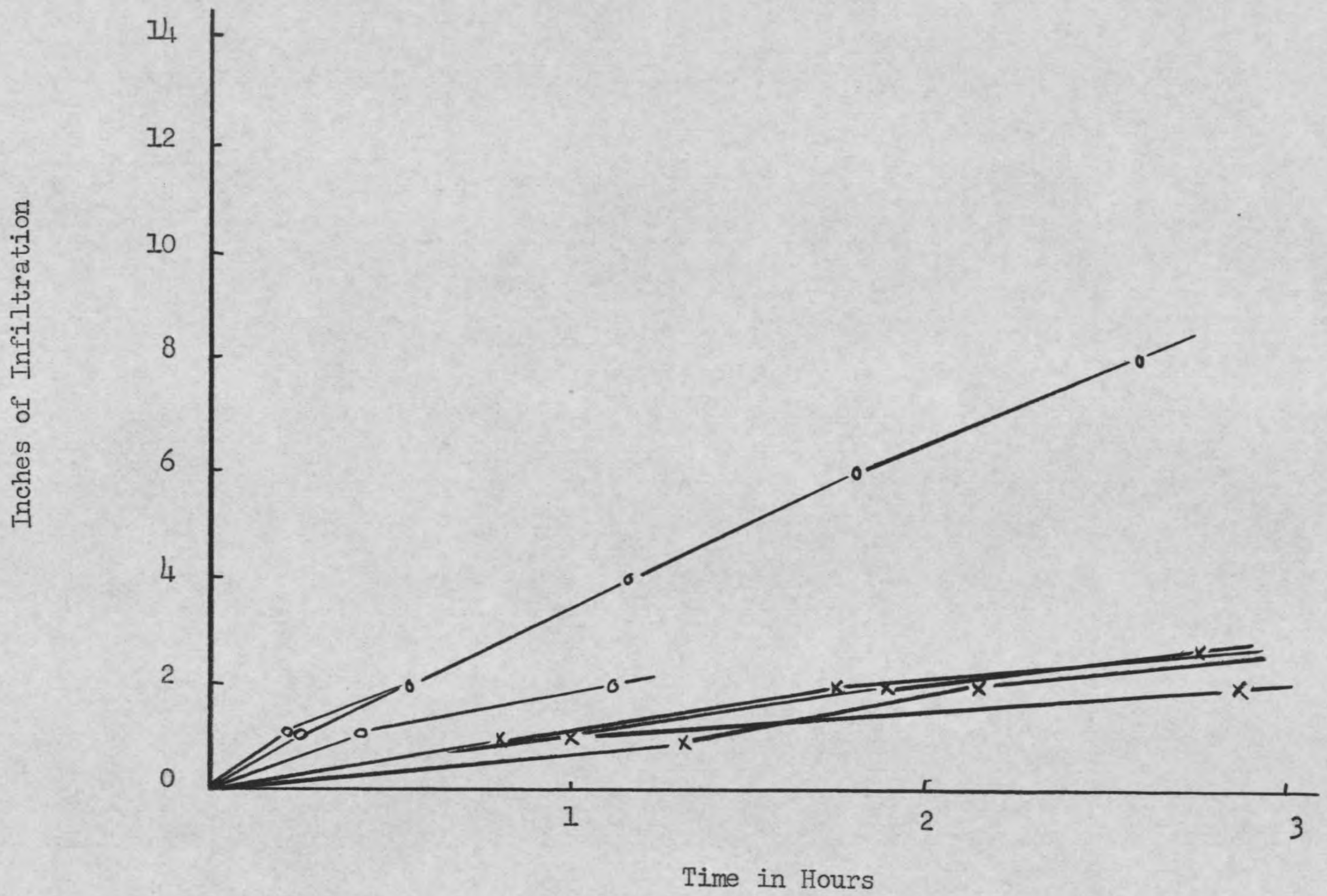


Figure 34. Cumulative infiltration plotted against time for Pondera Silt Loam under alfalfa two miles west of Conrad, August 28, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

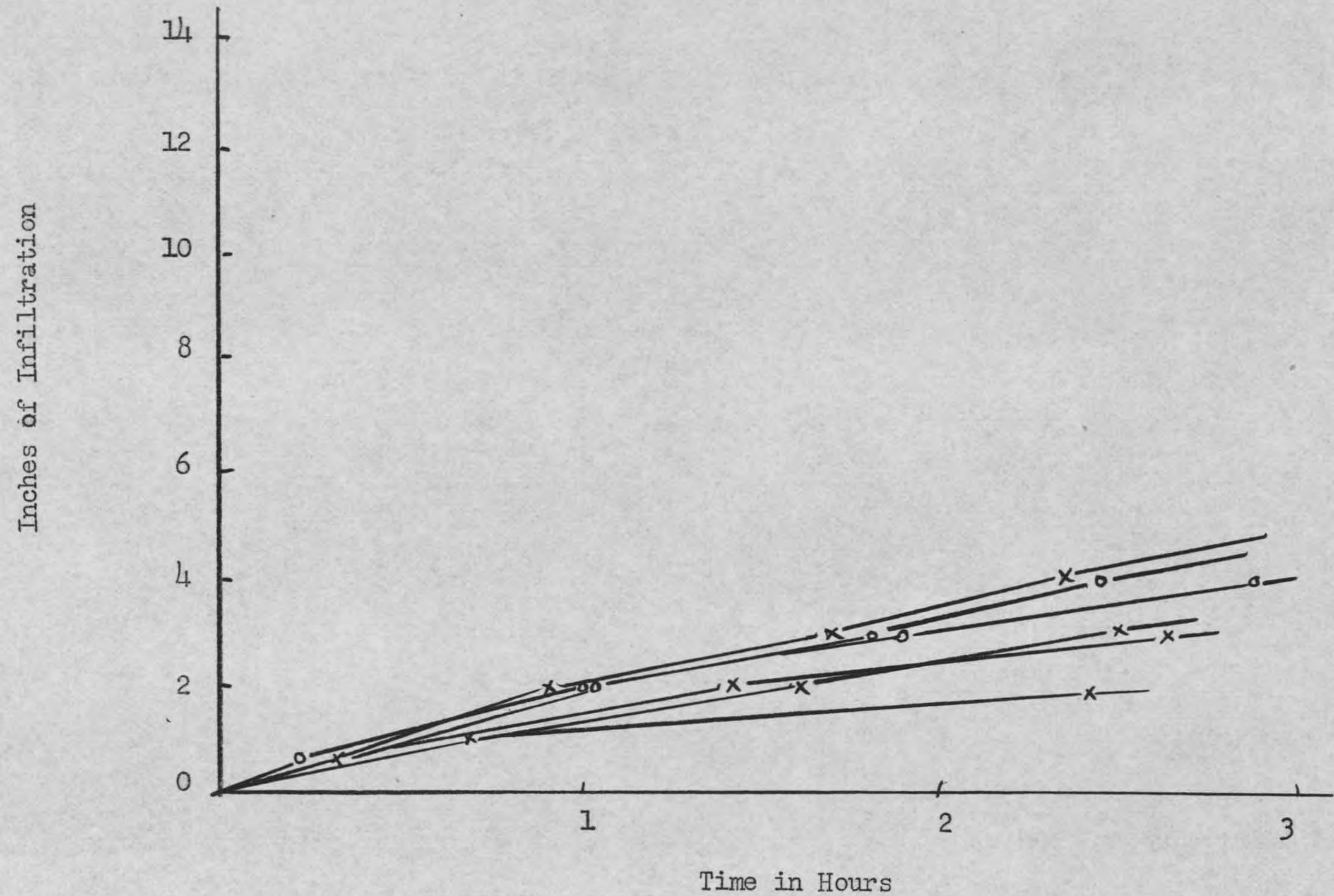


Figure 35. Cumulative infiltration plotted against time for Scobey Loam under alfalfa ten miles northeast of Conrad, August 30, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

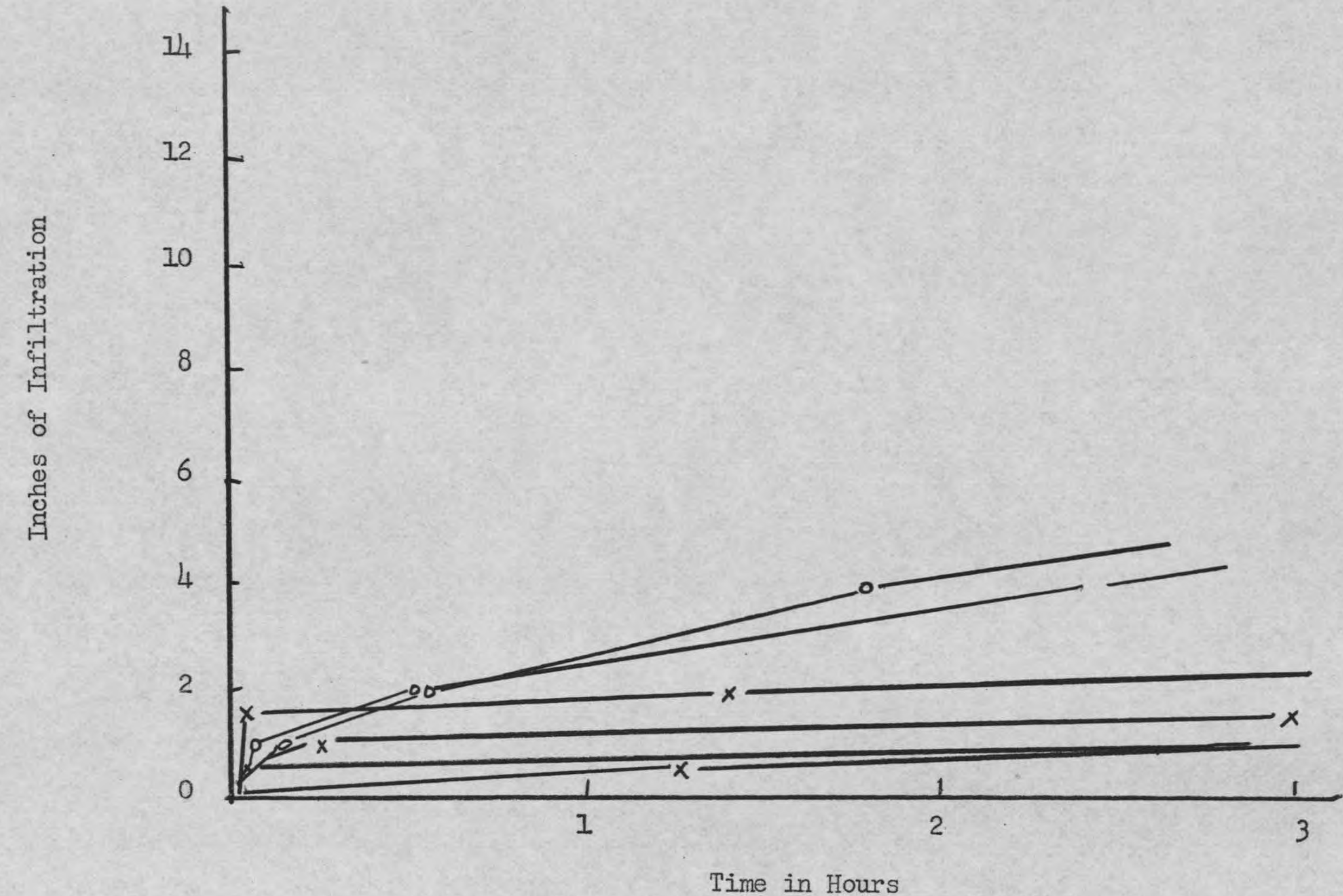


Figure 36. Cumulative infiltration plotted against time for Havre Fine Sandy Loam under alfalfa five miles west of Chinook, August 26, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

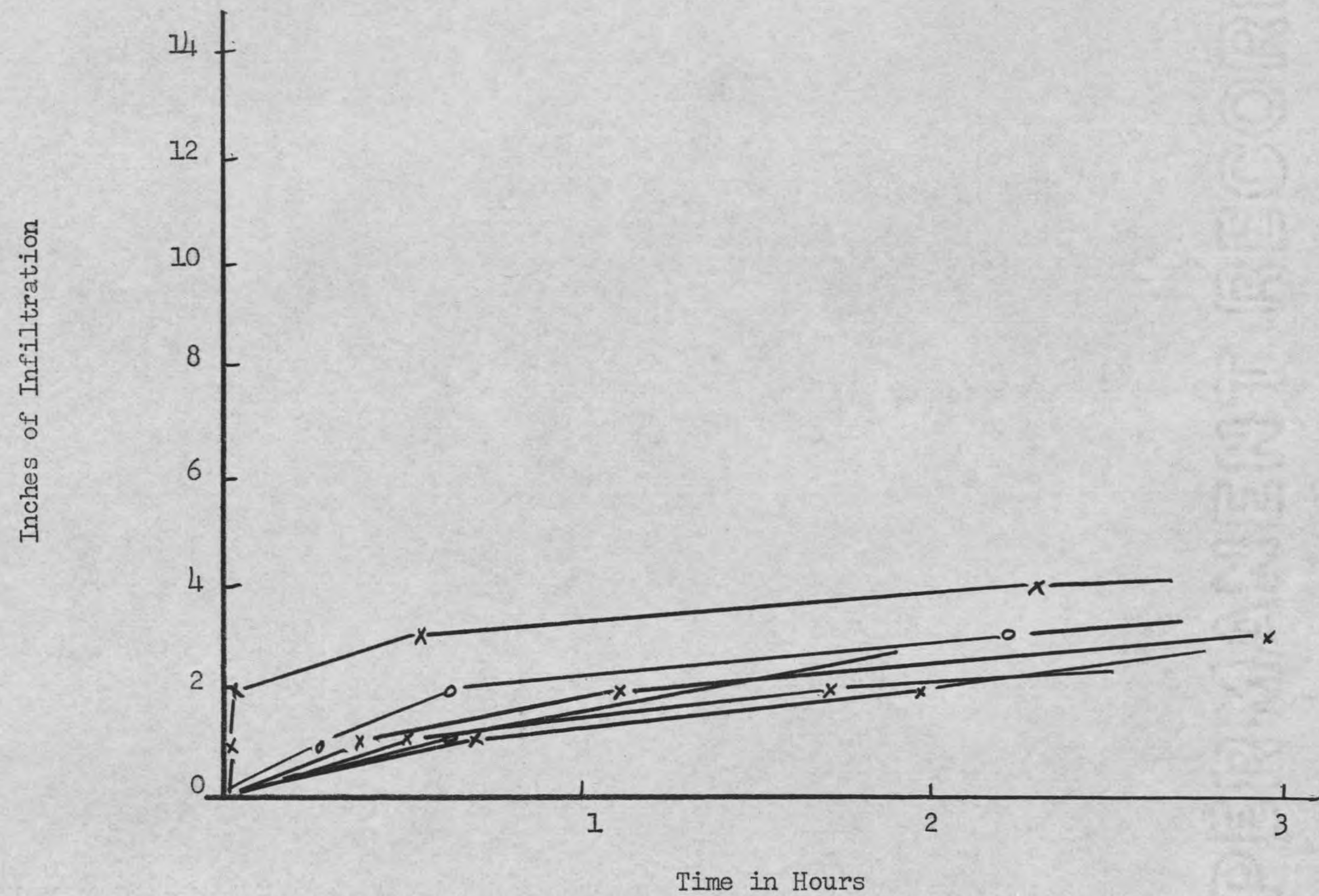


Figure 37. Cumulative infiltration plotted against time for Havre Silt Loam under sugar beets three miles west of Chinook, August 24, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

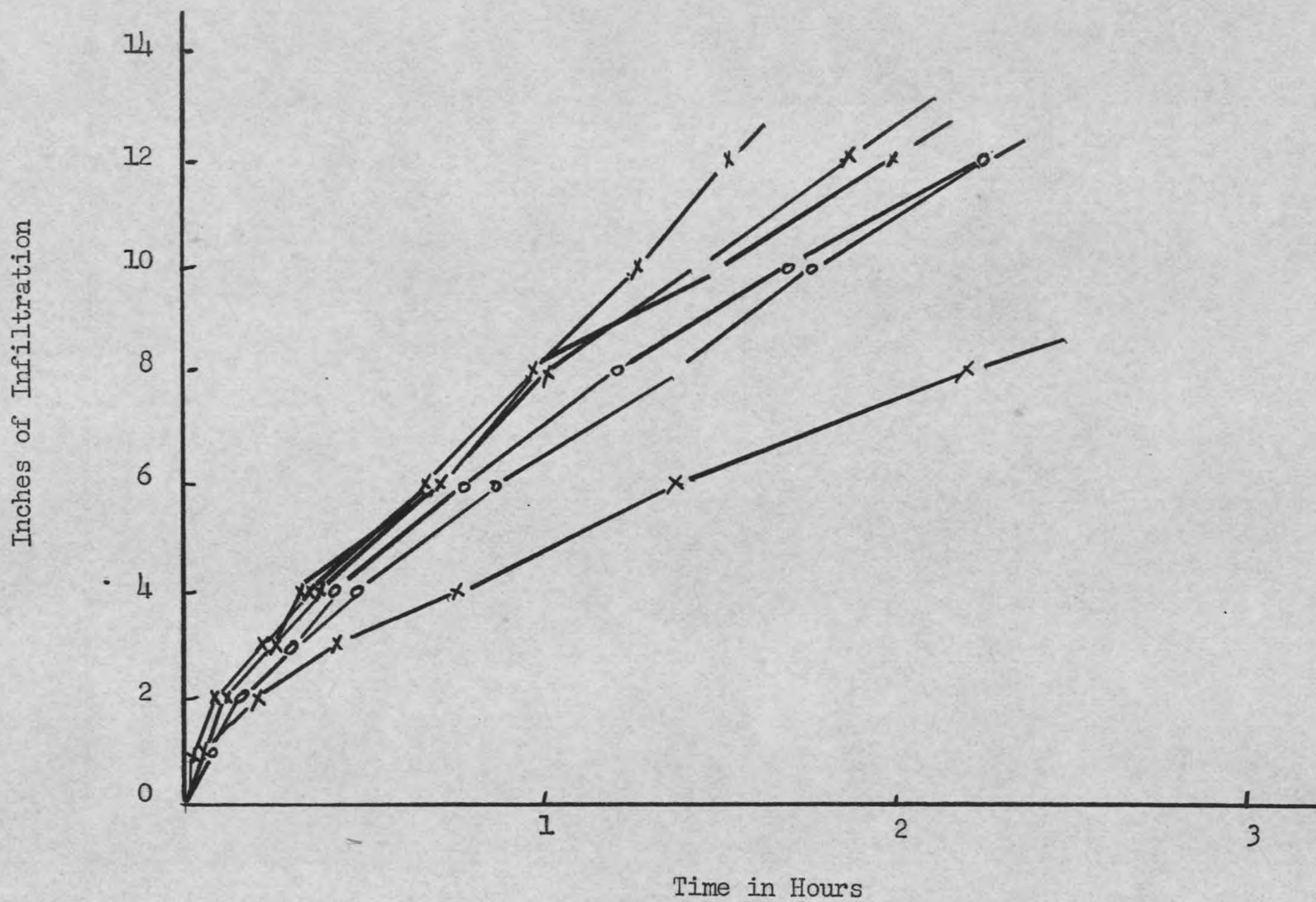


Figure 38. Cumulative infiltration plotted against time for Ashulot Silt Loam under alfalfa eight miles east of Fairfield, September 8, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

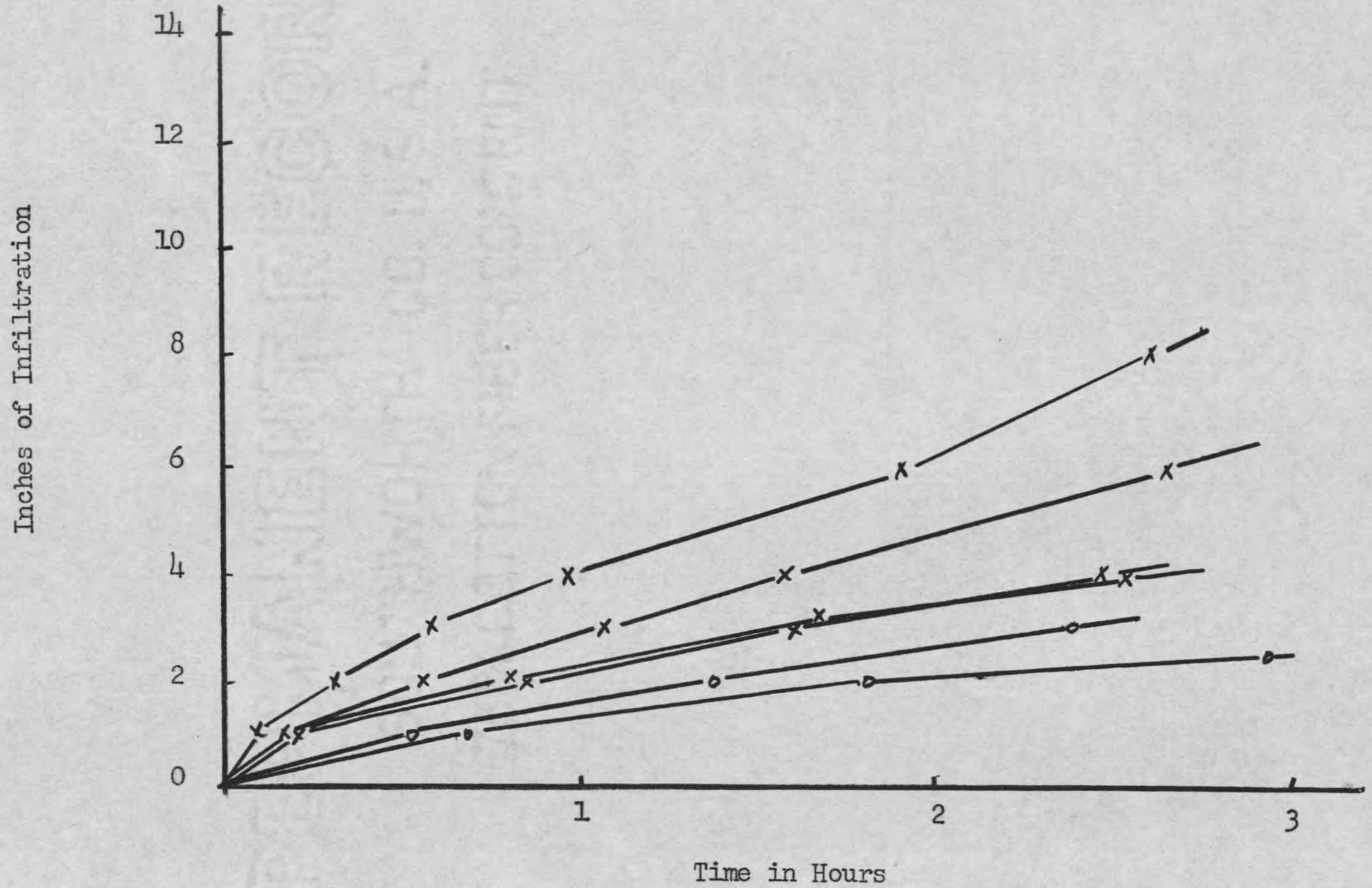


Figure 39. Cumulative infiltration plotted against time for Fairfield Loam under alfalfa four miles east of Fairfield, August 31, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

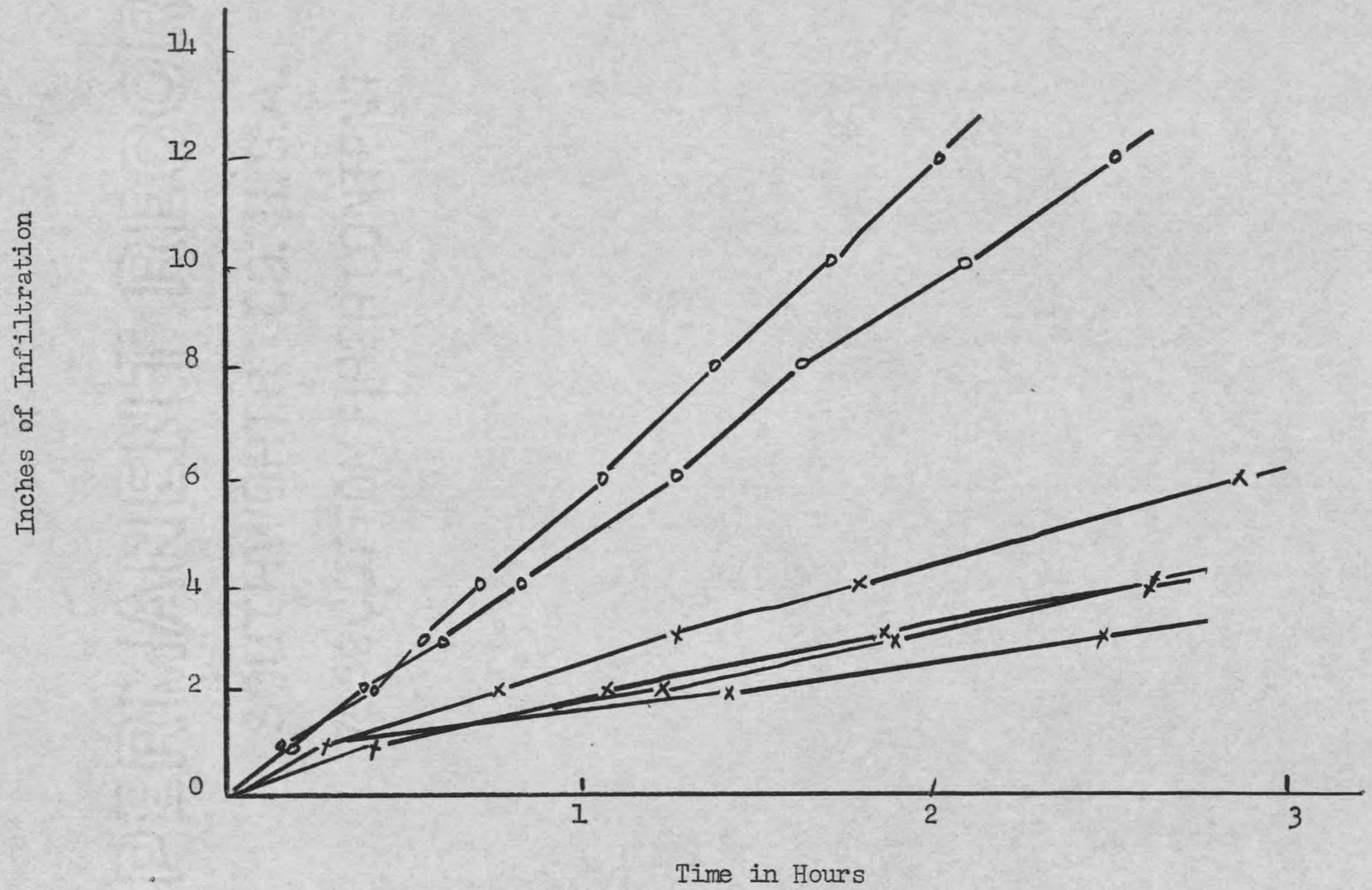


Figure 40. Cumulative infiltration plotted against time for Havre Very Fine Sandy Loam under sweet clover three miles west of Miles City, July 12, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

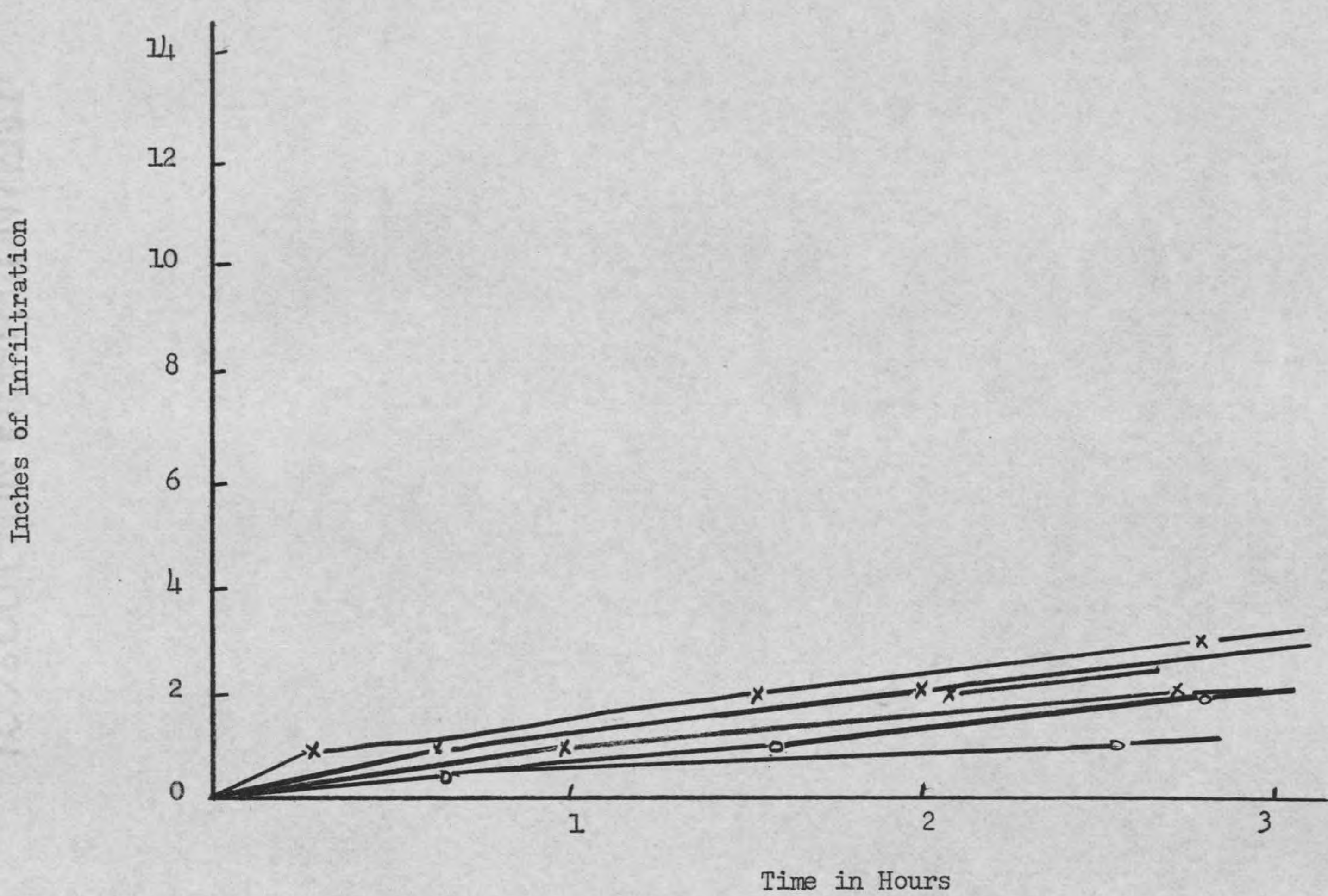


Figure 41. Cumulative infiltration plotted against time fore Havre Silt Loam under wheat fallow three miles west of Miles City, July 17, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

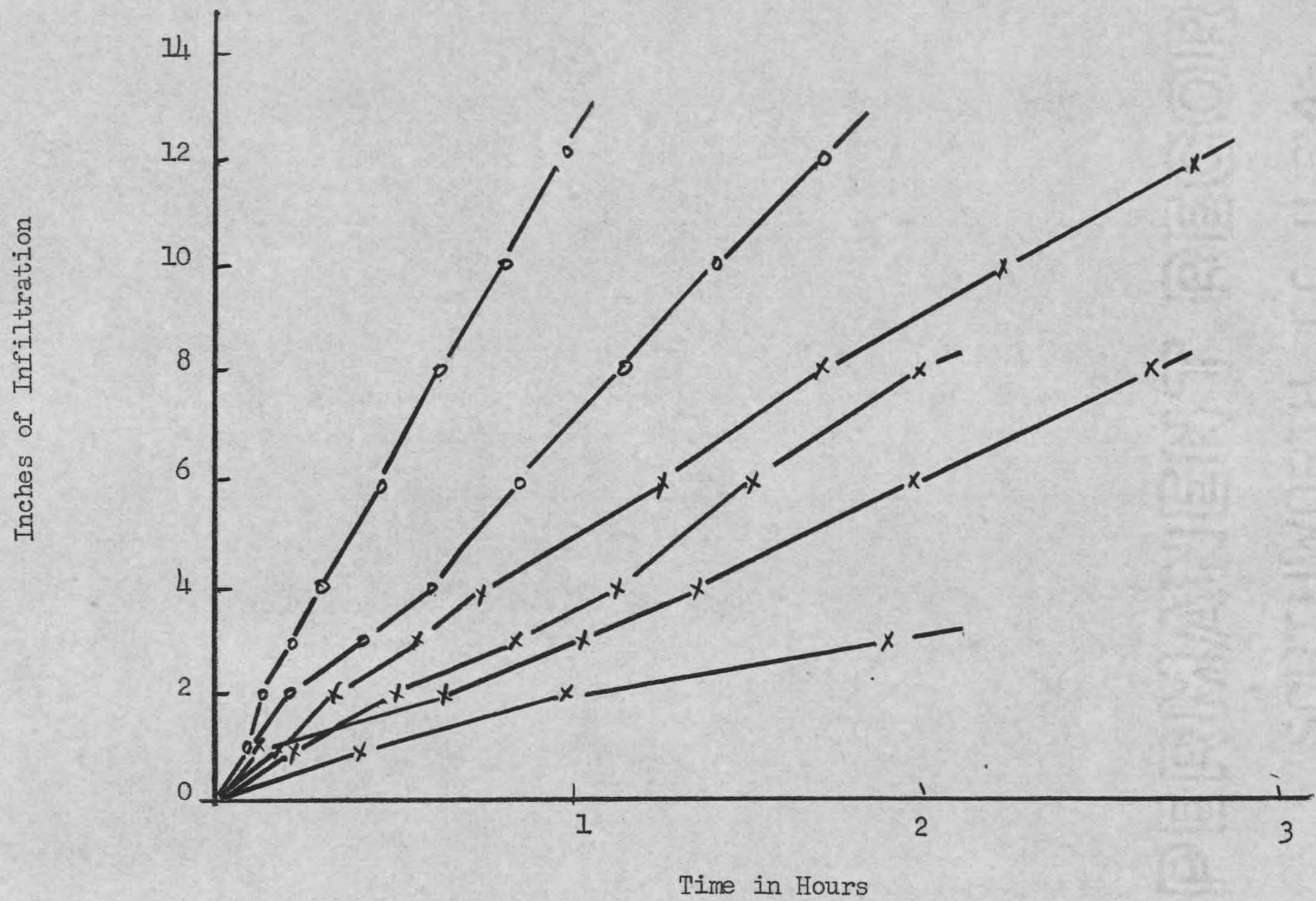


Figure 42. Cumulative infiltration plotted against time for Patent Silt Loam under pasture three miles west of Miles City, July 14, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

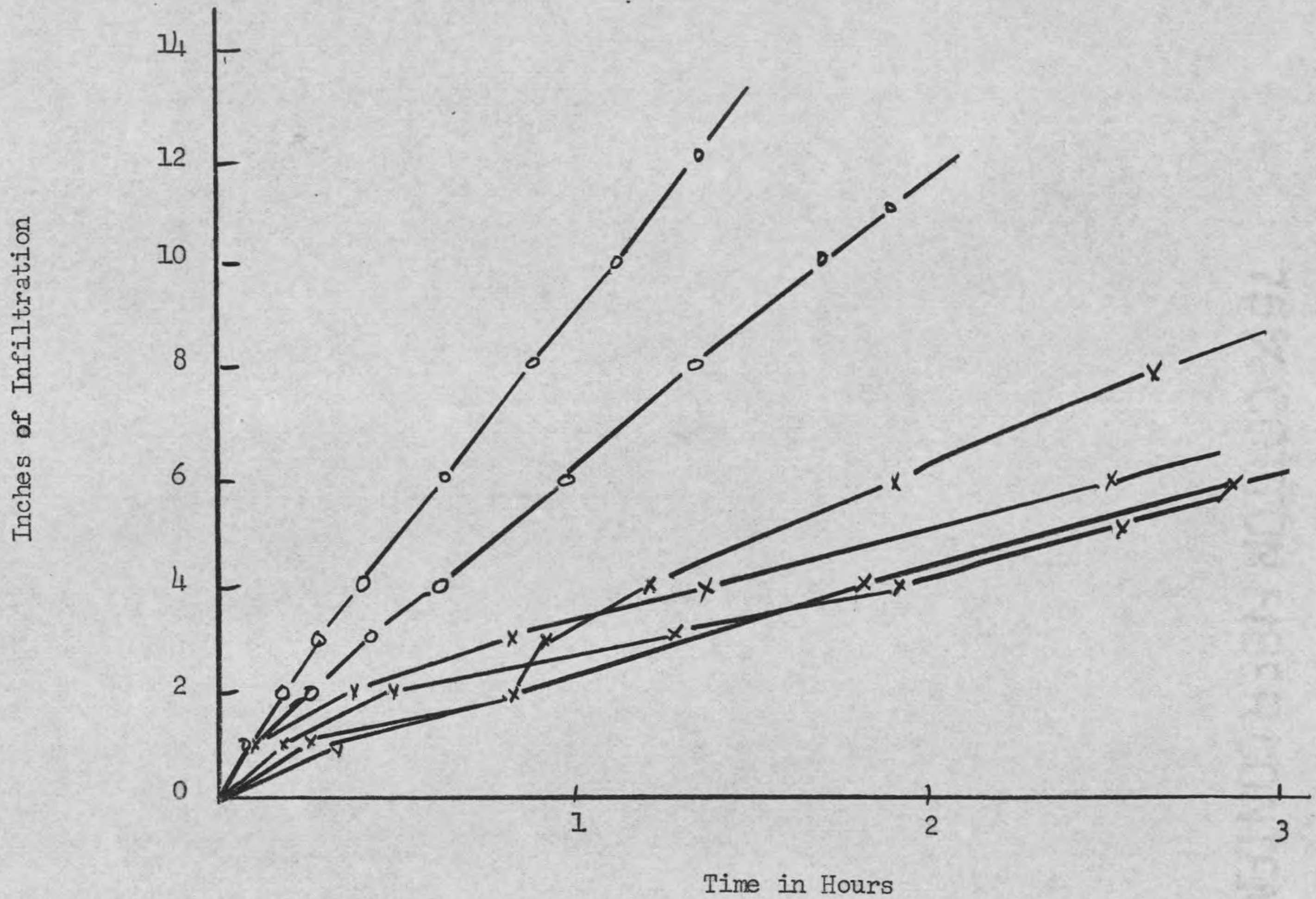


Figure 43. Cumulative infiltration plotted against time for Patent Silt Loam, Sandy, under pasture three miles west of Miles City, July 20, 1950. "x" indicates surface samples, "o" indicates subsurface samples.

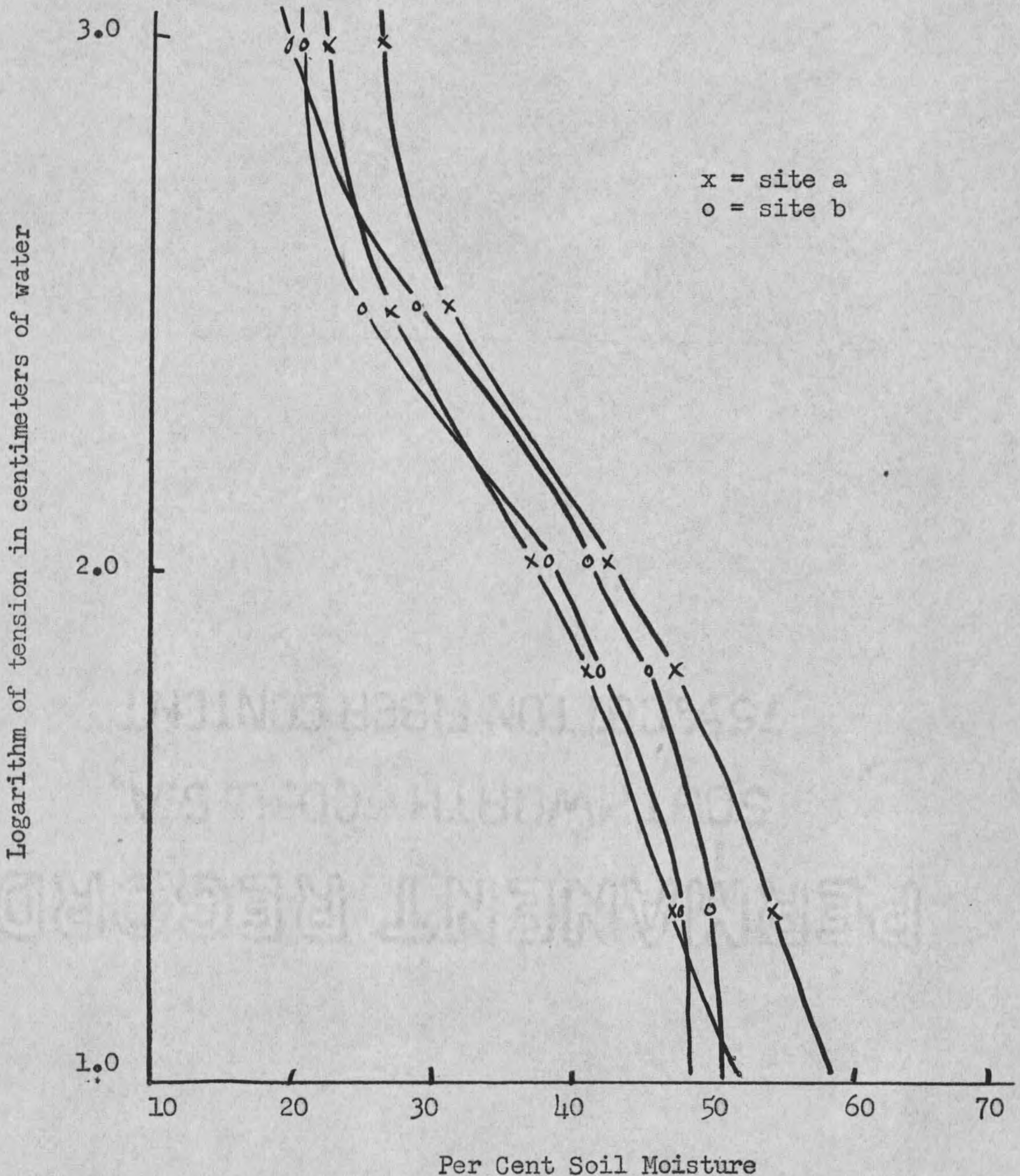


Figure 44. The relationship of moisture content to moisture tension for Amsterdam very fine Sandy Loam collected on June 30, 1950.

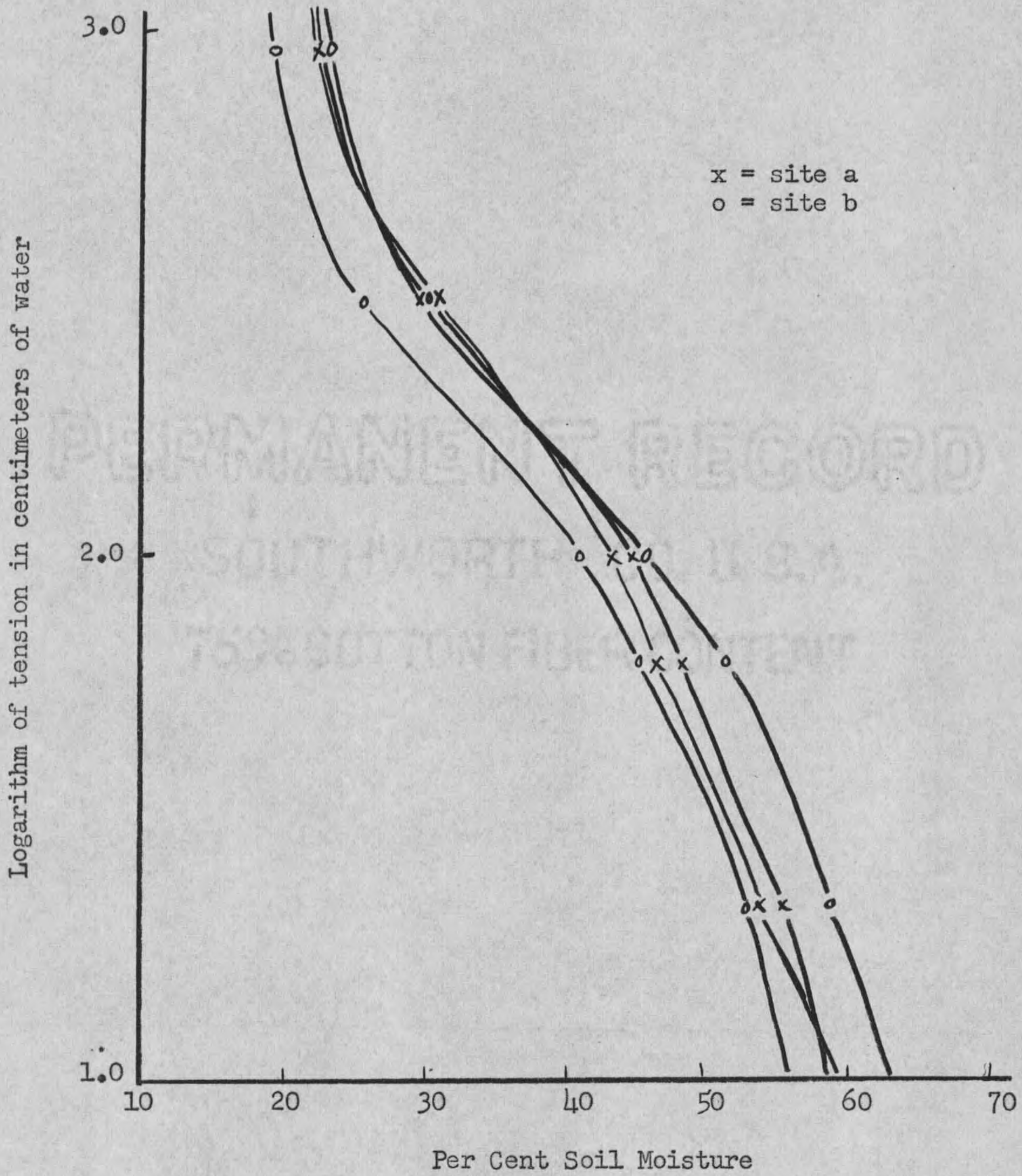


Figure 45. The relationship of moisture content to moisture tension for Amsterdam Silt Loam collected on June 28, 1950.

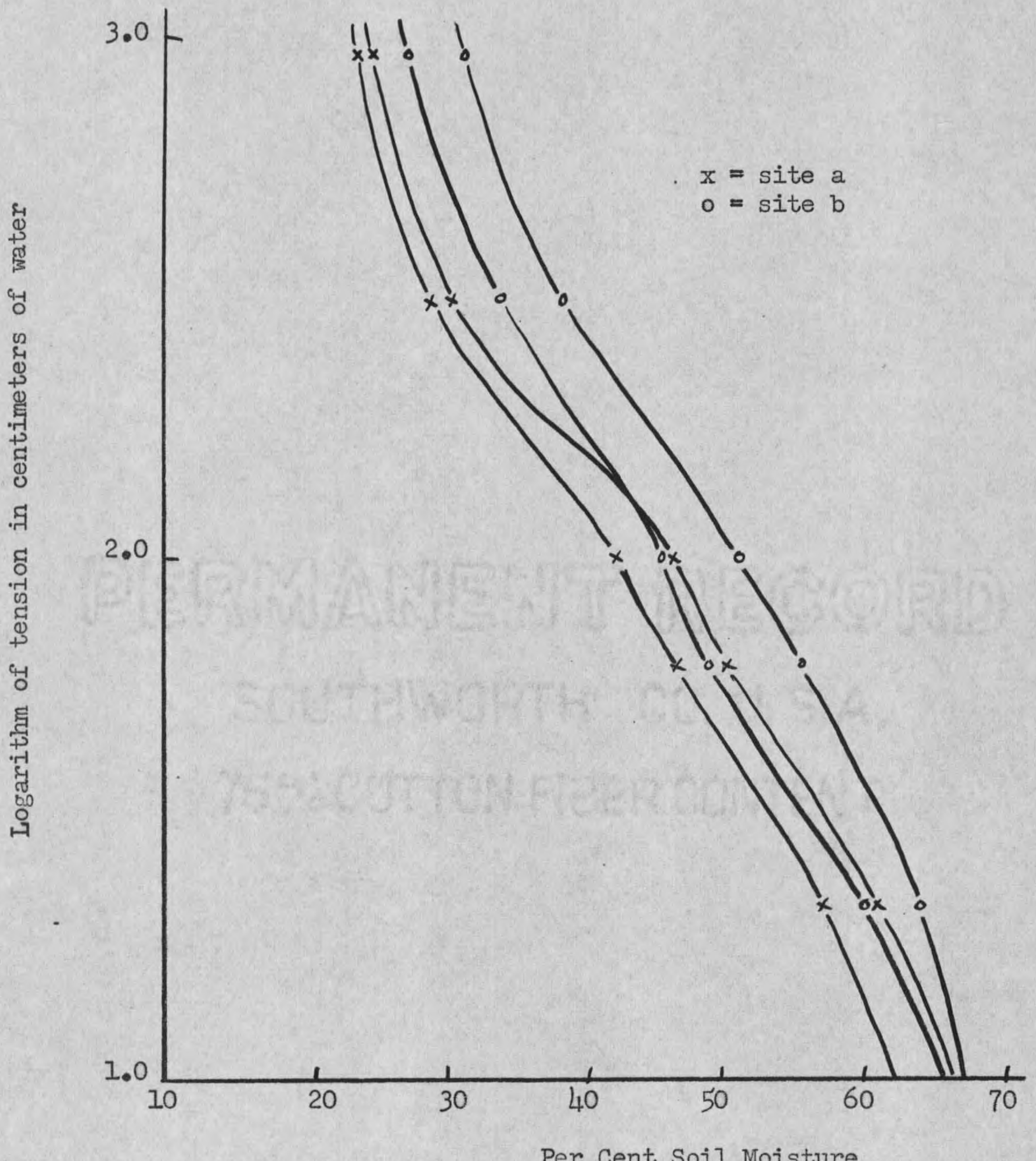


Figure 46. The relationship of moisture content to moisture tension for Bozeman Silt Loam collected on June 22, 1950.

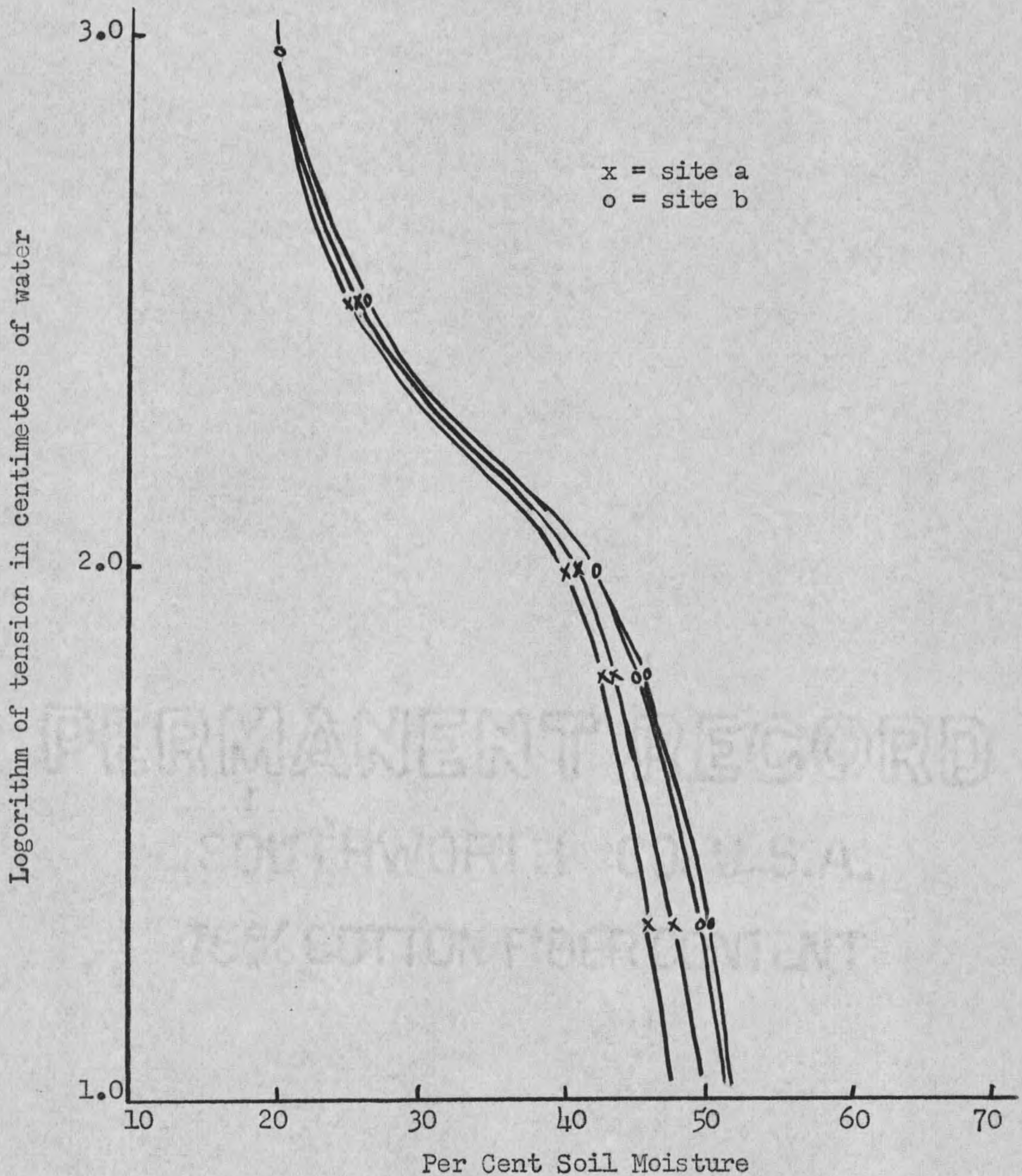


Figure 47. The relationship of moisture content to moisture tension for Manhattan very fine Sandy Loam collected on July 5, 1950.

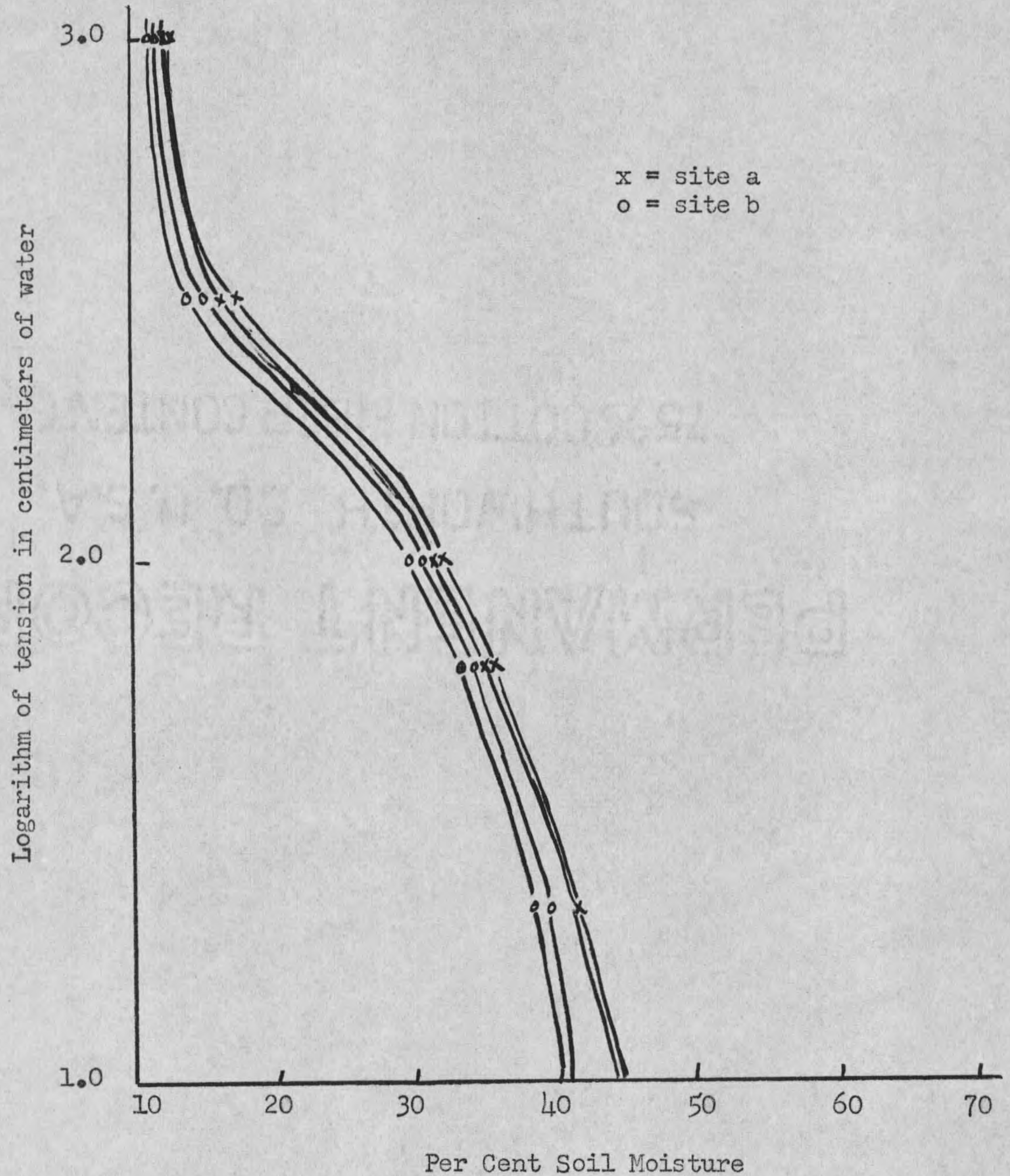


Figure 48. The relationship of moisture content to moisture tension for Manhattan very fine Sandy Loam collected on July 8, 1950.

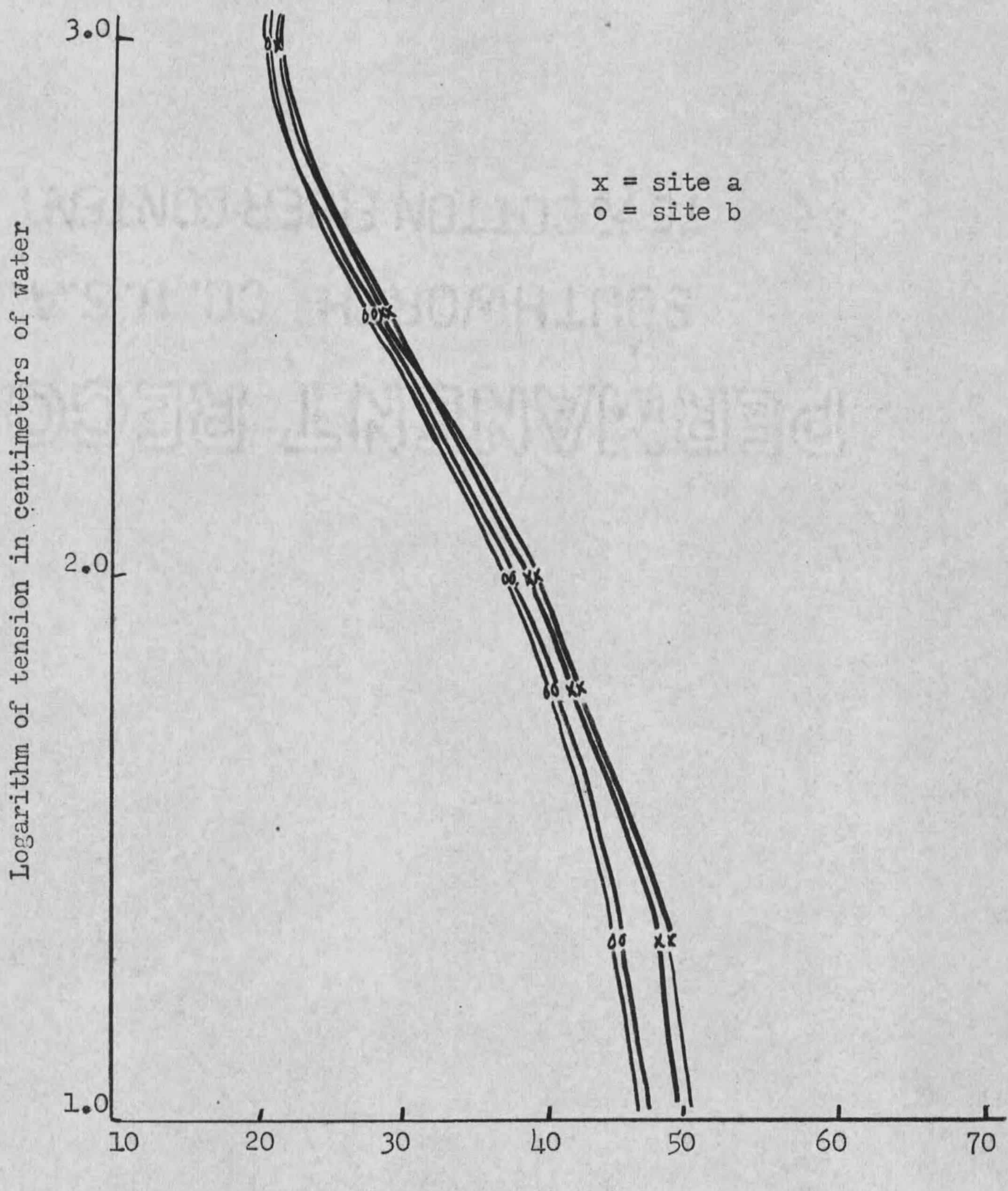


Figure 49. The relationship of moisture content to moisture tension for Amsterdam very fine Sandy Loam collected on October 10, 1950.

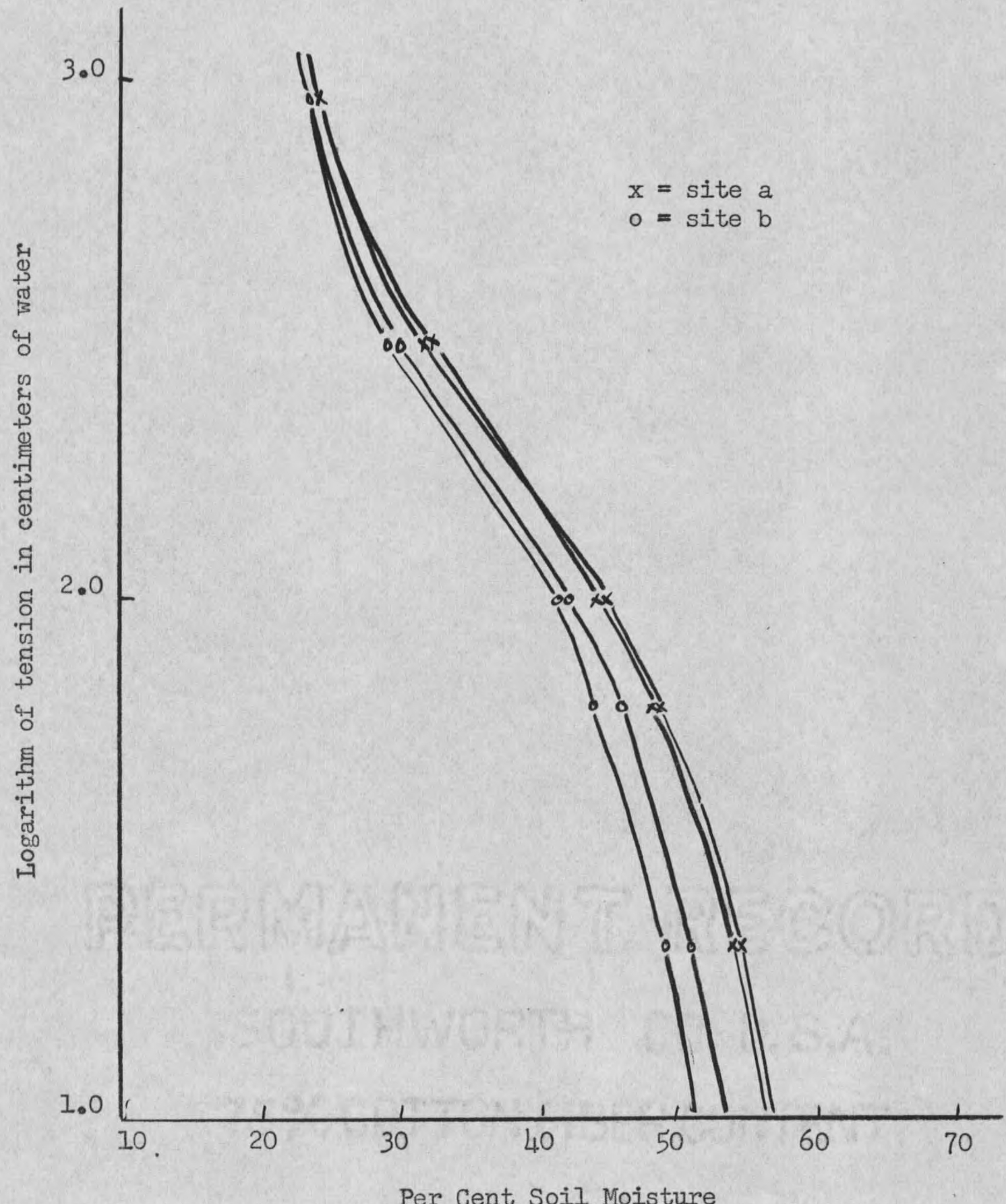


Figure 50. The relationship of moisture content to moisture tension for Amsterdam Silt Loam collected on October 9, 1950.

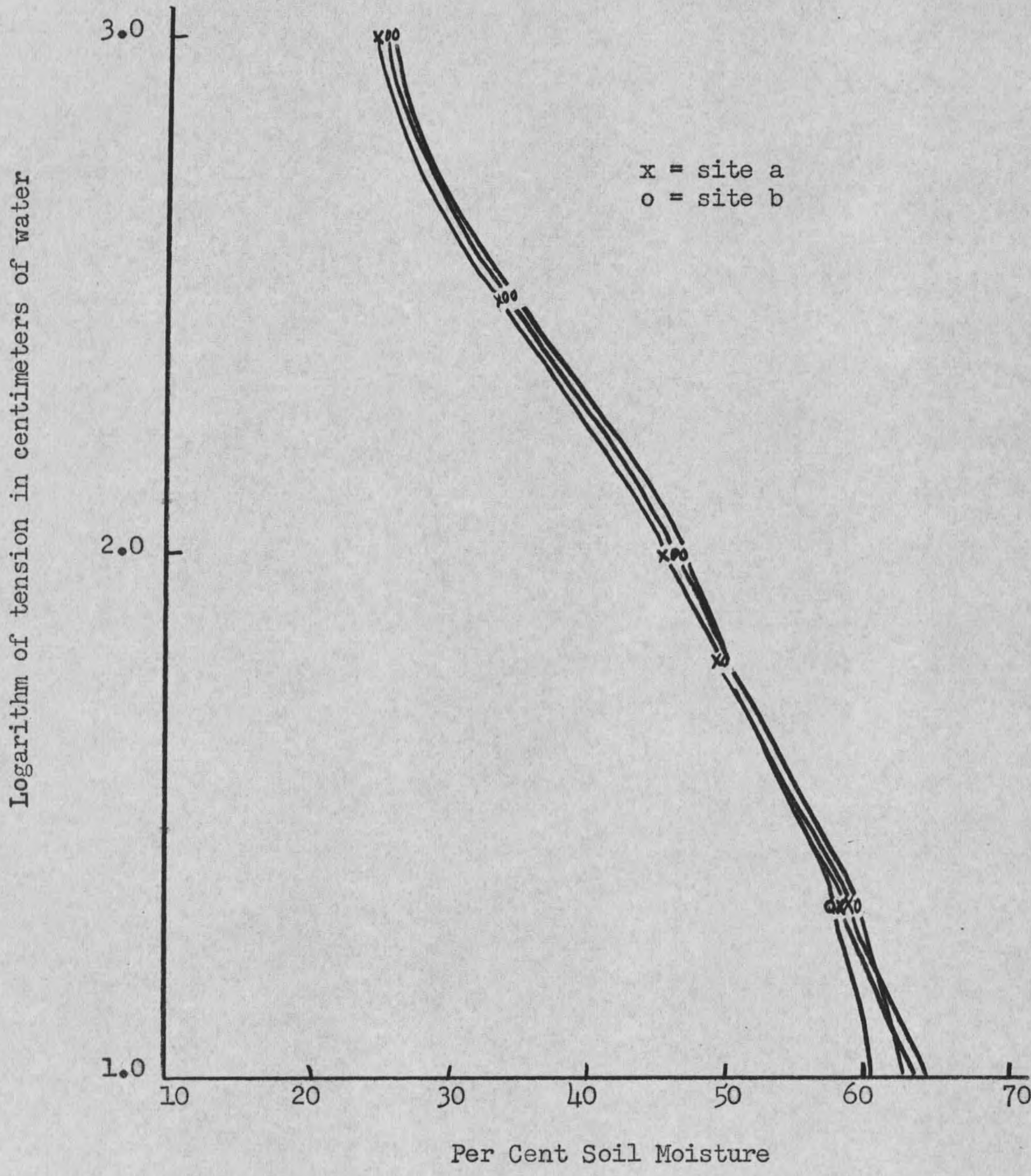


Figure 51. The relationship of moisture content to moisture tension for Bozeman Silt Loam collected on October 13, 1950.

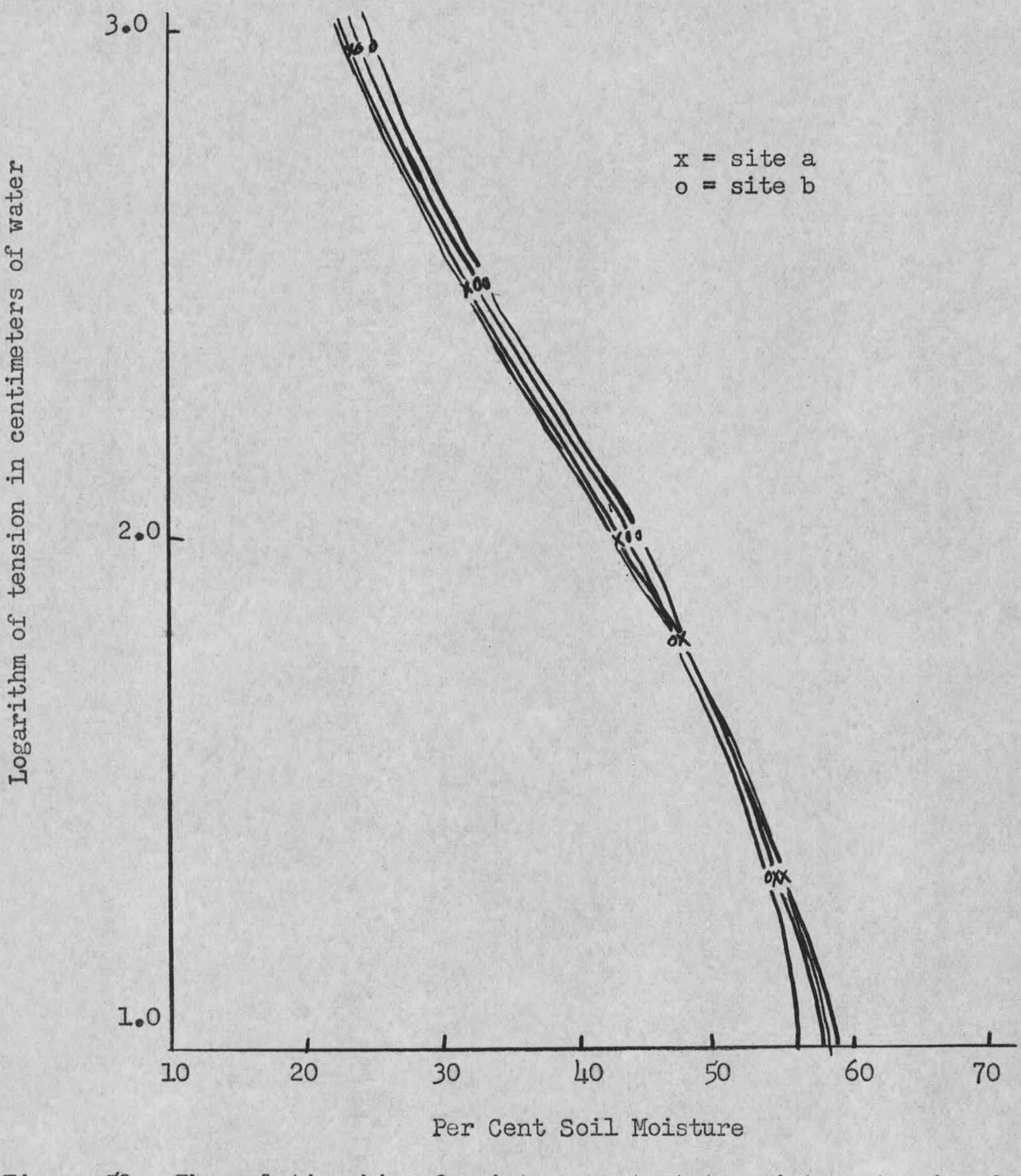


Figure 52. The relationship of moisture content to moisture tension for Bozeman Silt Loam, brown phase collected on October 11, 1950.

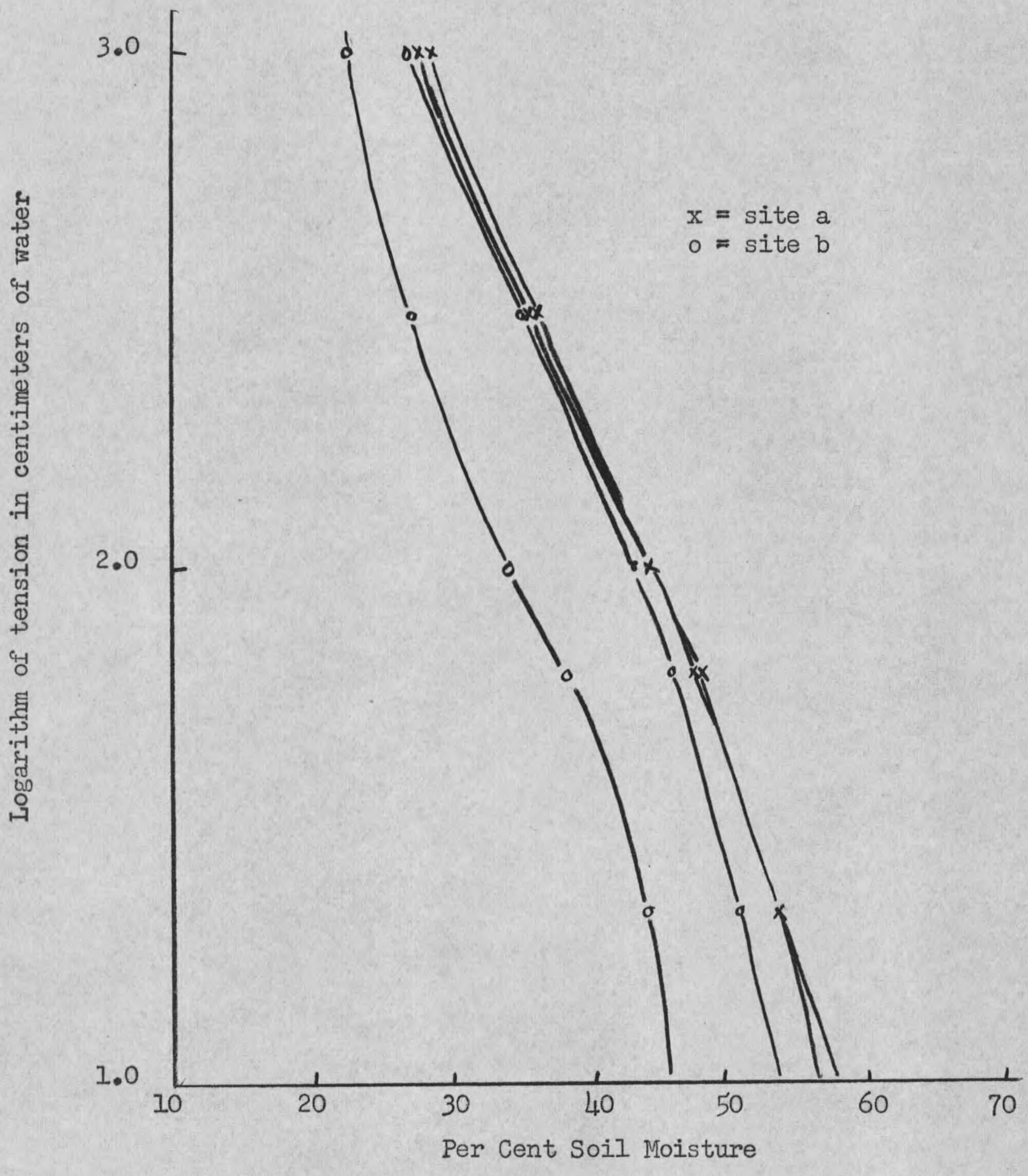


Figure 53. The relationship of moisture content to moisture tension for Huffine Silt Loam collected on October 16, 1950.

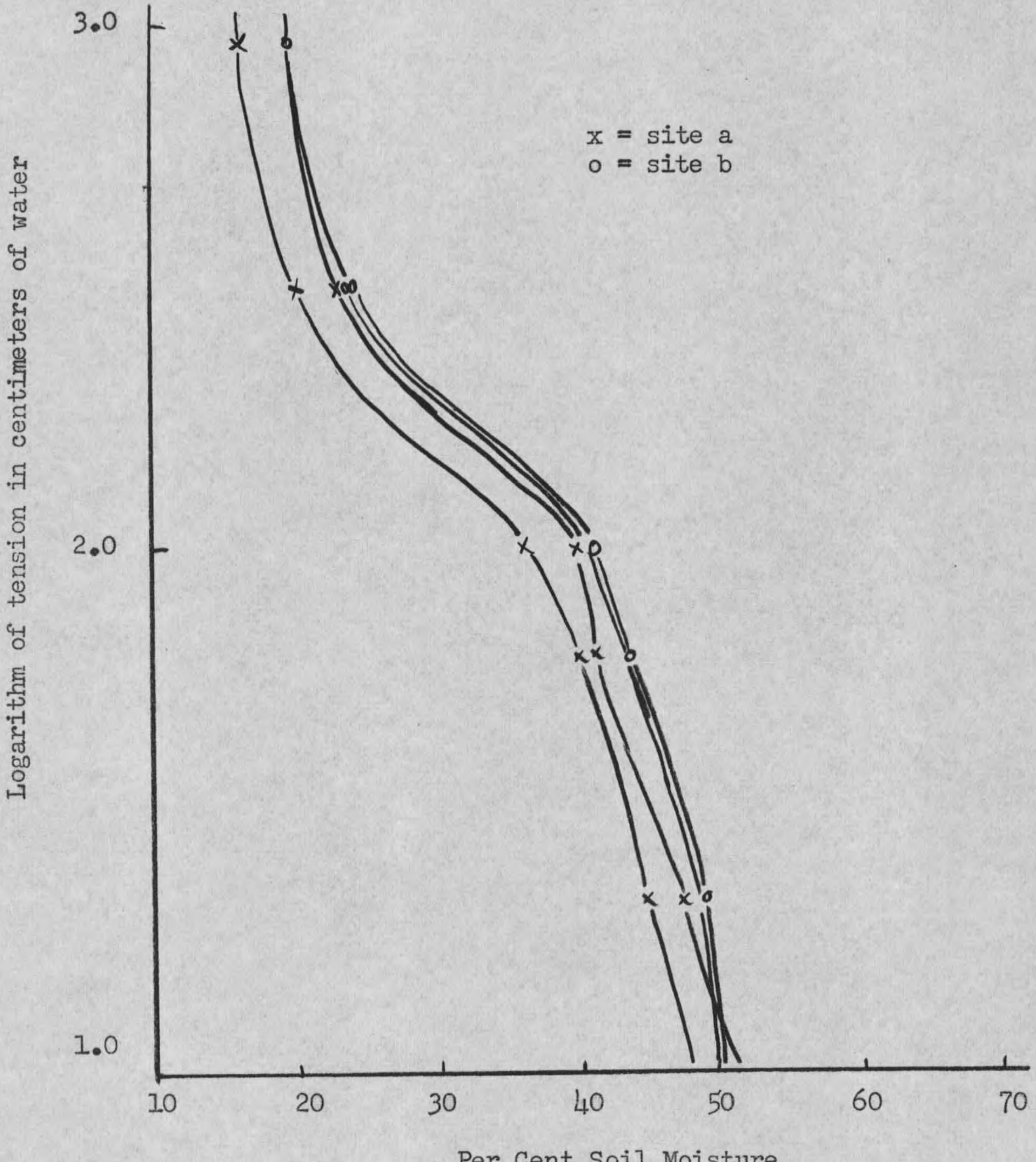


Figure 54. The relationship of moisture content to moisture tension for Manhattan very fine Sandy Loam collected on September 28, 1950.