A N N U A L R E P O R T

1959

Southwest Water Conservation Laboratory
Western Soil and Water Management Branch
Soil and Water Conservation Research Division
Agricultural Research Service
United States Department of Agriculture
Tempe, Arizona

ADMINISTRATIVELY CONFIDENTIAL

ANNUAL REPORT - 1959

Southwest Water Conservation Laboratory
Tempe, Arizona

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Staff of Laboratory

Professional

H. Bouwer, Agricultural Engineer
G. W. Frasier, Agricultural Engineer
L. E. Myers, Agricultural Engineer
F. S. Nakayama, Chemist
R. J. Reginato, Soil Scientist
C. H. M. van Bavel, Soil Scientist

Subprofessional

A. J. Frasier, Laboratory Technician
C. W. Kohli, Engineering Aid
J. L. MacIntyre, Agricultural Aid
R. C. McClain, Engineering Aid

Administrative, Clerical, and Maintenance

E. E. De La Rosa, Janitor
L. H. Dean, Clerk-Stenographer
A. V. Figueroa, Laborer
A. A. Garcia, Laborer
N. A. Johnson, Clerk-Stenographer
R. C. Klapper, Operations and Maintenance Supervisor
R. S. Miller, Clerk-Stenographer
A. M. Schreyer, Clerk-Stenographer

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INTRODUCTION

The Southwest Water Conservation Laboratory was dedicated October 19, 1959. Participants in the dedication ceremony included Senator Carl Hayden of Arizona; Governor Paul Fannin of Arizona; Dr. Byron T. Shaw, Administrator of the Agricultural Research Service; Wayne Akin, Chairman of the National Advisory Committee on Soil, Water and Fertilizer Research; Dr. R. K. Frevert, Director of the Arizona Agricultural Experiment Station; and a number of other leaders in the fields of agriculture and resource conservation.

Construction of buildings was essentially complete at the time of dedication but installation of specialized equipment was not. Much of the equipment, such as air handling units and controls in the controlled temperature laboratories, is decidedly different from commercial installations with which the sub-contractors are familiar. It has been necessary for several staff members to spend a considerable portion of their time in checking operational characteristics and assisting the sub-contractors in revising various systems and developing correct procedures to insure proper operation. With the exception of the controlled climate laboratory, which is now in the last phases of construction, the major problems have now been solved for all specialized facilities. A detailed description of the Laboratory facilities is presented in a following section of the report.

Eleven new staff members reported for duty during 1959. Their reporting dates are as follows:

6/8/59	R. S. Miller, Clerk-Stenographer
6/8/59	G. W. Frasier, Agricultural Engineer
6/15/59	R. J. Reginato, Soil Scientist
7/20/59	A. J. Frasier, Physical Science Technician
8/31/59	R. C. Klapper, Operations & Maintenance Supervisor
8/31/59	N. A. Johnson, Clerk-Stenographer
9/1/59	A. M. Schreyer, Clerk-Stenographer
10/12/59	E. E. De La Rosa, Janitor
10/12/59	A. V. Figueroa, Laborer
10/18/59	F. S. Nakayama, Chemist
12/28/59	H. Bouwer, Agricultural Engineer

Progress in the design and procurement or construction of specialized research equipment has been good and is described in the report section entitled "Project Development." Development of formal experimental outlines is now possible and is under way and by March 1, 1961, all research conducted by Laboratory staff members will be described and documented by such outlines.

Southwest Water Conservation Laboratory

PRINCIPAL INSTALLATIONS

The Laboratory proper consists of seven installations as follows:

(1) Main Laboratory Building: contains about 11,000 square feet of highly specialized work space which is described on following pages.

(2) Machine Shop and Storage Shed: a galvanized metal building which provides 1,800 square feet of open work area under roof and 900 square feet of heated and cooled enclosed space for rough shop work and equipment storage.

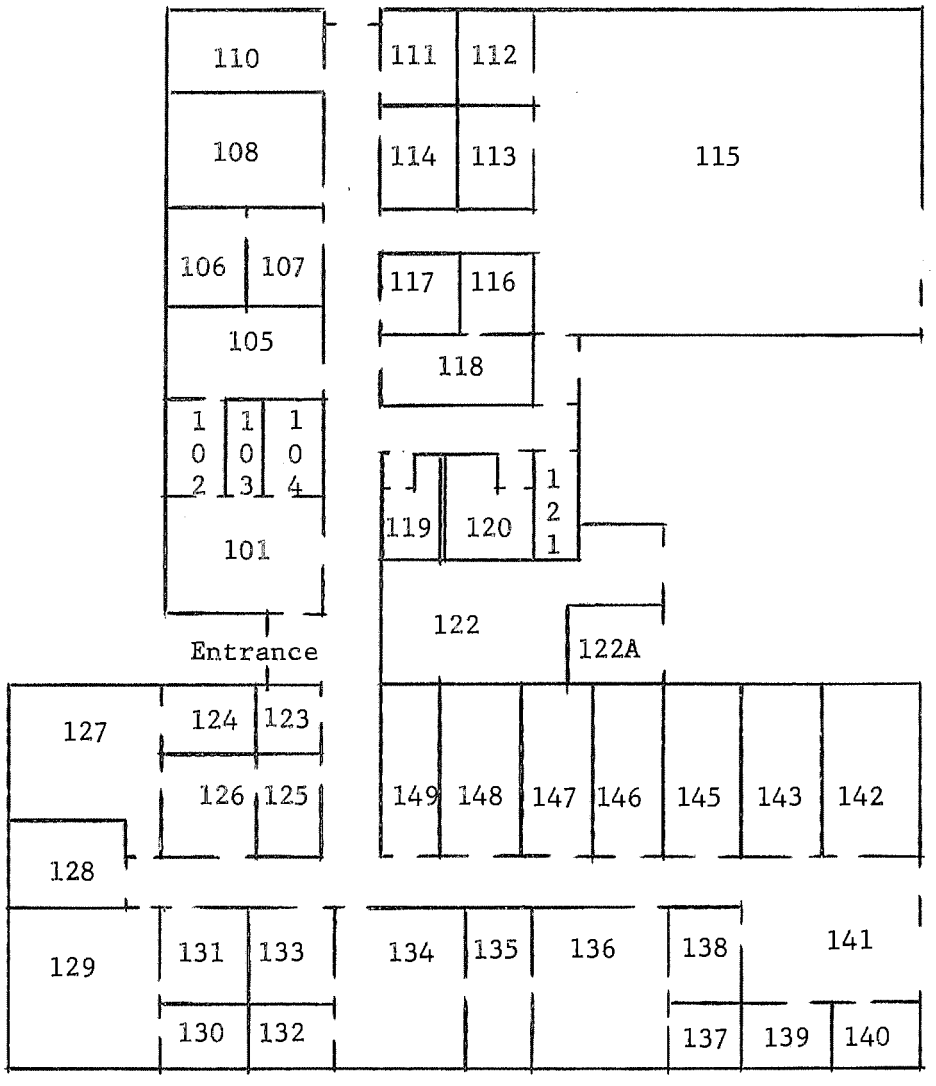
(3) Processing and Storage Building: a concrete block building which provides 960 square feet of open work area under roof and 960 square feet of enclosed space divided into three rooms; one storage room, one general work room, and the lysimeter instrument room.

(4) Lath House: an aluminum and redwood slat structure which provides 600 square feet of shaded plant growing area.

(5) Greenhouse: provides 1,700 square feet of plant growing space which can be heated or cooled as necessary.

(6) Hydraulic Test Slab: a 40 by 100 foot concrete slab which has a recirculating system including two low lift pumps and one centrifugal pump with a combined discharge of 6,750 gallons per minute and four 1,500 cubic foot storage tanks interconnected by underground pipe lines. These can be used as two independent recirculating systems if desired.

(7) Lysimeter Installation: this system will consist of three tanks, each 1 meter square and 1.6 meters deep, with porous tension plates in the tank bottoms to permit adjusting soil moisture conditions within the tanks to equal conditions in the soil surrounding the tanks. The electronic weighing system will record weight changes of 10 grams in a soil mass of 2400 kilograms. Weight change signals, together with signals from instruments measuring soil and climate phenomena, will be transmitted by cable to an instrument room where they will be recorded on punched tape. The tape will then be run through a tape-to-card converter to prepare punched cards ready for use in automatic computing machines.



FLOOR PLAN OF MAIN LABORATORY BUILDING

Southwest Water Conservation Laboratory

Tempe, Arizona

MAIN LABORATORY BUILDING

The main laboratory building contains about 11,000 square feet of air-conditioned space. The purpose of the different rooms in the main building is as follows:

Room 101 - Central stenographic and records office.

102 - Secretarial office.

103 - Office supply storage.

104 - Fire resistant vault for records and data storage.

105 - Office of the Director.

106 - Bookkeeping and personnel office.

107 - Duplicating and drafting.

108 - Central library.

110 - Combined office and Electric Analog Laboratory.
A variable resistance network analog of 675 nodes, arranged in 27 square panels of 25 nodes each, is under construction for use in solving a wide variety of difficult seepage and infiltration problems.

111 - Research office.

112 - Research office.

113 - Research office.

114 - Research office.

115 - Soil Mechanics and Hydraulics Laboratory.
This laboratory will be equipped for studies using large models and soil tanks. A recirculating hydraulic system is installed, which includes a 2,250 gallons per minute low lift pump, a three-inch centrifugal pump, and four 1,000 cubic foot tanks which are interconnected by underground piping. Laboratory benches and related equipment for soil mechanics work are also provided.

116 - Store room.

117 - Photographic processing room.

118 - Electronic Instruments Laboratory.
This laboratory will be equipped for the development and construction of experimental electrical devices for use in both laboratory and field research.

119 - Ladies' rest room.

120 - Men's rest room.

121 - Janitor's supplies.

122 - Central air conditioning system, power, and general machinery.

123 - Counting room.
This room will be equipped with highly sensitive and accurate equipment for detecting radiation from radioactive materials used as tracers in studies of the movement of water.

124 - Storage room.

125 - Secretarial office.

126 - Research office.

127 - Physics Laboratory.
This laboratory is equipped to conduct research on the physics and thermodynamics of climate factors which govern evaporation and transpiration. This laboratory will also be used to develop devices using radioactive materials for measuring soil moisture content and soil density.

128 - Storage room.

129 - Chemistry Laboratory.
A portion of this laboratory will be devoted to the use of tracer materials in studying the movement of water through soils and plants. The laboratory will also conduct routine soil chemistry and salinity work and will perform chemical analyses of experimental materials and compounds.

130 - Research office.

131 - Research office.

132 - Research office.

133 - Research office.

134 - Physics Laboratory.
This laboratory will be equipped to conduct research on the movement of water in the liquid and vapor states in connection with investigations of evaporation, infiltration and seepage.

135 - Storage room.

136 - Service Laboratory.
This laboratory will be equipped to carry out routine physical and chemical testing of experimental materials.

137 - Research office.

138 - Maintenance and operations office.

139 - Storage room.

140 - Grinding and sieving room.
This room is equipped with an exhaust hood and will be used for operations which create dust, such as grinding and sieving of soil and plant materials.

141 - General receiving and handling room.

142 - Precision Shop.
This room is equipped with a drill press, a lathe, and other equipment required for the construction of experimental devices.

144 - Machinery and duct room for the Climate Laboratory.

145 - Controlled Climate Laboratory.
This laboratory provides temperature control from 40 to 105 degrees Fahrenheit and relative humidity control from 5 to 95 percent. The lighting system will provide a minimum of 3,500 foot candles and is equipped with a dimming circuit to permit programming various light intensity schedules.

146 - Controlled Temperature Laboratory.
This is essentially a physics laboratory which provides controlled temperatures between 68 and 104 degrees Fahrenheit and will be used for experiments in which the laboratory temperature must be carefully controlled, or in which it is desirable to vary the laboratory temperature.

147 - Controlled Temperature Laboratory.
Essentially the same as Room 146, except that the temperature range is from 50 to 96 degrees Fahrenheit.

148 - Controlled Temperature Laboratory.

Essentially the same as Room 146, except that the temperature range is from 28 to 68 degrees Fahrenheit.

149 - Radioisotope Laboratory.

This laboratory will be used for the preparation and handling of radioactive tracer materials and is designed to permit safe handling of these materials. These design features include a special floor covering, stainless steel furniture tops, a special radioisotope hood, a sink which drains into a carboy instead of the main sewer system, and a special air exhaust system to prevent air from this laboratory entering any other part of the main laboratory building.

PROJECT DEVELOPMENT

Facilities and equipment development has progressed sufficiently to permit exploratory research and the initiation of planning for specific research projects. Project development progress to date is as follows:

Calibration of Pipe-Cap Orifices for Measuring Pump Discharge:

Pipelines on the hydraulic testing slab have been modified to permit testing and calibration of pipe-cap orifices for 8, 10, and 12 inch diameter pipe lines. Despite the relatively frequent use of these orifices to measure pump discharge their accuracy is often questionable. The Agricultural Engineering Department of the University of Arizona had used pipe-cap orifices during the summer of 1959 to evaluate well and pump performance and wished to calibrate them with the venturi meters available in the testing slab. Preliminary runs have been made and calibration of the University of Arizona orifices should be completed by June 1, 1960. Sparling meters are being checked during the same runs.

Plans are being developed to expand the pipe-cap orifice calibration into: (1) an investigation of the factors which reduce the accuracy of these orifices, and (2) the development of devices and procedures to improve the accuracy and reliability of pipe-cap orifices.

Personnel: L. E. Myers, G. W. Frasier, and W. G. Matlock, University of Arizona.

Electrical Resistance Network Analog:

The resistance network analog presently under construction at the Southwest Water Conservation Laboratory will have an ultimate capacity of 675 nodes, arranged in 27 square panels of 25 nodes each. The analog is approximately 15 feet long, two of the panel rows are mounted vertically, the third row is mounted horizontally as an inclined table. Using transverse wiring, a variety of system dimensions, including square and rectangular systems with considerable length to width ratios, can be obtained.

The resistors (Ohmite potentiometers) will be mounted on 2-inch round disks. To insure good electrical contact and easy interchangeability, jacks (in the disks) and bananaplugs (on the panels) will be used. Each mounted resistor will be equipped with a dial plate and a fluted knob for individual calibration. This will eliminate the need for disconnecting resistors and the use of a Wheatstone bridge in setting desired resistances on the board, which should considerably speed up the operation of the network for obtaining iterative solutions of problems involving unsaturated flow.

Various resistor capacities will be obtained so that a considerable range in values will be available for graded networks and/or partially unsaturated flow systems. The network will be surrounded on two sides (one long and short side) with "feed-in" or "take-out" strips for simulating uniform rates of moisture supply (rainfall) or moisture withdrawal (consumptive use, evaporation), respectively. Other major instrumentation will include a DC power supply with a high output

stability, current meters, and a high input impedance vacuum-tube-voltmeter with digital read-out to eliminate inaccuracy and operator fatigue during long periods of continuous measurement.

The completed network analog will be a highly versatile tool in water management research. The first project planned for the network is an evaluation of the effect of system geometry, boundary conditions, and unsaturated conductivity characteristics of the soil on canal seepage and the seepage distribution within the canal.

Personnel: H. Bouwer

Radioactive Tracer Studies:

One of the primary aims of the investigations in soil-plant-water relationships is the study of the rate of water uptake by plant roots from soils which are subjected to different moisture potentials. Emphasis will be placed upon the utilization of tritium as a tracer for water in these investigations. It is anticipated that multiple tracer and autoradiographic techniques will be applied in certain phases of the study. Greenhouse and field experiments will be utilized to determine moisture and nutrient removal patterns by roots and relate these to the growth and activity of the roots.

Special gas counting chambers have been fabricated and radio-isotope measuring instruments have been ordered which are compatible with other equipment on hand. When the components are assembled, it will be possible to measure the activity of solid, liquid and gas

samples of high and low decay energies at low levels of activities. Personnel safety equipment such as gloved boxes and monitoring equipment have been acquired and modifications in the physical plant have been planned to meet the basic health physics requirements.

A program has been undertaken to acquaint the laboratory technicians in methods of physical and chemical analyses of soils, plants and water which will be employed in the over-all program of the Laboratory. Analytical equipment and procedures are being checked and methods selected for future use.

Personnel: F. S. Nakayama

Lysimeter Construction:

Lysimeter design was completed early in 1959 following discussion with various authorities and possible suppliers. The final design calls for steel tanks, 1 x 1 x 1.5 meters, fully enclosed by an outer jacket. The weighing mechanism, based upon use of flexure pivots and a strain gage load cell, is entirely underground except for an access port for counterweights. Sensitivity of the recording mechanism is to be 10 grams and accuracy in weighing will be 50 grams. Automatic weighing range is 50 kg and total weight about 2700 kg. Sensitivity corresponds to 0.01 mm water (.0004 inch).

The construction contract was awarded on June 29 to Bytrex Corporation in Boston, Massachusetts, for three lysimeters and an electronic, remote weighing facility. Weights will be printed at regular intervals on punched paper tape together with other

pertinent information. Shop drawings for the lysimeters were completed and approved in November 1959 and the units are being assembled for factory testing in March 1960.

Model tests of the proposed method for filling and draining of the lysimeters were successfully conducted during July and August of 1959. Based upon these tests, the soil column will be supported by a half-inch layer of fire brick overlain by a layer of 50 micron glass beads. A suitable partial vacuum will be maintained in the air-filled pores of the fire brick.

Extensive determinations were made of the particle size distribution of the soil of the lysimeter site to a depth of 6 feet. Additional analyses are planned pending establishment of equipment and procedures. Studies were also made of hydraulic gradients during moisture redistribution after irrigation.

The entire site has been leveled to within 0.01 foot and provided with dikes and flooding gates. A protective climb-proof fence surrounding the site will be completed in March 1960. Construction of footings, conduits and other services will be completed by April 1, 1960. A special room in Building No. 2 for the data collecting system was remodeled and provided with air conditioning during December 1959. This room is about 300 feet from the lysimeter location. Barring complications, the lysimeters should be in operation for the 1960 season.

Personnel: C. H. M. van Bavel and R. J. Reginato

Micrometeorological Studies:

The major development in this area has been the design of an automatic data handling system. This system will program and measure the output of a large number of instruments of different kinds. It will also print results on punched tape and/or an automatic typewriter. With very few exceptions, no charts, data books or written notes will be required. The tape can be printed out in tabular form on an automatic typewriter for quick inspection. Visual display of data, while being collected, will also take place. However, the main burden of data evaluation will be on IBM cards produced from the tapes. A tape-to-card converter to accommodate future project requirements has been added to the facilities of the Numerical Analysis Laboratory of the University of Arizona at Tucson. It is expected that analysis of data by automatic computer will be carried out under a cooperative arrangement at this institution.

The variables to be recorded and analyzed include: net radiation, short wave radiation, wind direction, wind speed, air temperature (absolute and differential), air humidity, soil heat flux, and soil temperature.

Research on possible solutions and available equipment was concluded in January 1960 and specifications for competitive bids were developed. Bid will be awarded on March 15, 1960. The data handling system as specified can accommodate about 40 channels at a rate of 1 per second and will record data "words" of 4 digits plus symbols to identify the channel, time of day, etc. It will be located in the same room as the lysimeter control console.

Studies have been made of the best way to measure the moisture content of air. An infrared absorption method is under study, so far with discouraging results. An electrolytic hygrometer method will also be given a thorough examination.

Much preliminary work needs to be done and many problems will arise. Since a 6 months delivery on the data logger is anticipated there will be time to complete a substantial part of the necessary preparatory studies.

Personnel: C. H. M. van Bavel

Chemical Compounds for Reducing Infiltration and Seepage:

Exploratory tests have been made of chemical compounds which were thought to have possibilities for reducing or stopping the movement of water into or through soils. The tests appear promising and a full-scale project is being developed to investigate the use of these materials for reducing seepage losses from ponds and ditches and for increasing runoff from rainfall catchment areas for stockponds.

A number of compounds are under consideration, including: (1) metallic soaps, metallic salts and silicones which are water repellant, (2) sodium compounds which disperse soil clay fractions to seal soil pores, and (3) new emulsifiers which may increase the effectiveness of sealing materials such as asphalt. A preliminary laboratory test of a sodium soap applied directly to the surface of a sandy soil completely stopped infiltration at an application rate which would cost less than one cent per square yard for materials.

Laboratory testing procedures have been designed and plans for field tests are being developed. It is expected that during the summer of 1960, field tests at three locations in Nevada and Arizona will be established on rainfall catchment areas. Seepage reduction tests will be established at two locations in Arizona.

Personnel: L. E. Myers and G. W. Frasier

Tilting Flume for Water Measurement Studies:

Construction of a small tilting flume in the Soil Mechanics and Hydraulics Laboratory has been initiated. This is essentially an adjustable steel frame to support flumes or model ditch sections of various shapes and dimensions up to 4 feet wide, 3 feet deep, and 35 feet long. Slopes from zero to 10 percent can be attained. Maximum flow capacity will be 5 cfs. Present plans are for the flume to be used initially in the development of a simple, portable flow rate measuring device for farm irrigation ditches. Preliminary designs for the measuring device have been prepared.

Personnel: L. E. Myers and G. W. Frasier

Evaporation Suppression:

Preliminary investigations of evaporation suppression methods for small ponds were begun in 1959. Low-cost rafts for applying hexadecanol were designed and constructed and were placed in one pond in Nevada and three ponds in Arizona. The Nevada site is operated by

Bureau of Land Management personnel and the Arizona sites are operated by Watershed Technology Research Branch personnel of the Agricultural Research Service. Duplicate untreated sites were observed and the Arizona sites were instrumented with water stage recorders and rain gages. Sufficient data for reliable interpretation were not obtained due to our inability to devote an adequate amount of time to this project. Information was obtained which will be of great value in developing final plans for the project. For example, the application rafts performed very well except for a minor structural defect which has now been corrected.

Plans for 1960 include: the assignment of additional personnel to the project, expansion in number of sites, additional instrumentation including solar radiation measurements, evaluation of film coverage obtained with rafts, and consideration of alternate methods of applying evaporation suppressing films.

Personnel: L. E. Myers and G. W. Frasier

TITLE: Use of neutron scattering method to determine moisture content of soil.

NUMBER:

PERSONNEL: C. H. M. van Bavel, L. Erie (cooperating)

DATE OF INITIATION: January 1, 1960

DURATION: 3 years

OBJECTIVES: To improve and evaluate equipment and procedures to measure moisture content of soil with the neutron scattering method.

NEED FOR STUDY:

Present equipment and procedures for measuring soil moisture with the neutron scattering method suffers from several deficiencies. Most notable are the weight, complexity, and maintenance problems associated with available equipment. Another serious problem is the present uncertainty regarding the calibration; whether different soils require different calibrations and what factors enter into this question. If more or less individual calibrations are required, a method for obtaining such information should be worked out. Improvement in efficiency of neutron counting is also desirable so as to reduce the required source strength and to diminish exposure and shielding requirements.

Solution of these problems will enhance the general and economic applicability of the method to research and management.

PROCEDURE:

Note: For 1959 this report is concerned only with a field evaluation of the present method in a typical irrigation management experiment. Other phases of this project are just underway and will be reported in coming years.

Of the several water management treatments in a cotton irrigation experiment on the Cotton Research Center, two were selected for the present purpose. Treatment 3 consists of irrigating by the calendar: on June 15, July 15, August 15, and September 9. Treatment 4 consists of irrigating when 70 per cent of the available soil moisture in the surface 3 feet has disappeared. The proper time is judged from repetitive gravimetric moisture samplings.

Of each treatment, two replications, each four rows wide, were selected and two aluminum, 2-inch OD access tubes were installed on April 20, 1960 in each plot.

The land was plowed on January 8-10, 1960 and irrigated March 15-23, 1960. Cotton was planted April 8-10, 1960.

Development of the cotton on Treatment 3 was as follows:

April	30	2 inches high
May	14	6 inches high
May	29	8 inches high
June	19	11 inches high
June	25	26 inches high and flowering
July	9	31 inches high and flowering
July	23	36 inches high
August	10	Bolls opening

Measurements were made with a 2 mc neutron probe (Troxler Electrical Laboratory) and a portable scaler (Nuclear-Chicago) at a depth of 1 to 5.5 feet, every 0.5 foot. Prior and after each set of readings in an access tube a standard count was taken. With the aid of a calibration curve each count ratio was reduced to moisture content as volume fraction and these figures were averaged for each plot.

The volume fraction data were also converted to inches of water by multiplying with 6.

Measurements were taken every week but postponed 3 or 4 days if irrigation had just been applied.

An example of a typical data reduction sheet is appended.

RESULTS:

No difficulty was experienced with the neutron equipment. Standard counts were very uniform throughout the season without the benefit of any scaler adjustment.

About 4 hours were required to obtain the 80 readings that were made approximately once a week. This included getting equipment out and to the field, setting up, standardizing, and putting equipment away.

All work was done by one operator who received an accumulated dosage of about 60 mr on chest and 90 mr on ankle for the entire season - about 100 working hours with exposure.

Neutron probe counts were converted to ratio to standard and then to moisture content as volume fraction using the calibration curve shown in Figure 1. Approximately, this curve can be represented by

$$M_v = .732\ R - .031$$

in which:

M_v = moisture content as volume fraction

R = observed count divided by standard count

This relation applies for the standard bucket standing on the ground. For later and more accurate work the standard is raised at least 6 inches from the surface.

Moisture content versus date in Treatment 3 at depths of 1, 2, 3, 4, and 5 feet is shown in Figure 2. Total moisture in the soil in inches

versus date in Treatment 3 is given in Figure 3 for the soil layers between 9 inches and 21, 33, 45, 57, and 69 inches respectively. Rain and irrigation are also indicated.

Similar presentations for Treatment 4 are given in Figures 4 and 5, respectively.

The data were used to compute the changes in water content of the root zone. Since neutron measurements cannot be made very reliably above a probe depth of 12 inches, changes in moisture content were reliably known only from a 9-inch depth on downward. During the period April 30 through May 10 the depth characterized was 9-45 inches; from May 18 to June 17 it was 9-57 inches; from June 23 to November 20 it was 9-69 inches. This was based upon inspection of Figure 2 but it must be admitted that this is a rough guess.

Moisture losses were prorated to represent the profile from the surface on down and were extrapolated (after addition of any rainfall) up to, or from the date of irrigation as the case might be. The amount of irrigation water applied was not known.

Calculation, total seasonal, and period daily values for estimated evapotranspiration are shown in Table 1. Period daily values are also shown in Figure 6.

DISCUSSION:

1. There was no difficulty in obtaining reliable and reproducible data on soil moisture content with the neutron method. Data from duplicate sites and plots agreed well within one another.

2. Examples of successive soil moisture profiles in Treatment 4 are given in Figures 7, 8, 9, 10, and 11. These show that for an appreciable time period after irrigation, moisture contents are well above the long-time equilibrium shown in Figure 7. How much of this water is absorbed by roots and how much moves downward beyond the rootzone cannot be determined with certainty. Considerable error may thus be involved in the evapotranspiration estimates.

3. Figure 4 shows that high moisture contents prevail at almost all times in Treatment 3. As a result and also owing to the frequent irrigation it is concluded that no reasonable estimates of evapotranspiration can be made in this case.

4. Daily rates of estimated evapotranspiration are shown in Table 1 and Figure 6. They show a gradual rise to values around 0.3 inches per day during July and August and a decline toward the end of the season. Low values are associated with depletion of soil moisture (June 4-10, July 9-14, September 1-9) or rainy periods (July 30 - August 10).

Table 1. Evapotranspiration calculated for Treatment 4 - Cotton Irrigation - Cotton Research Center, 1959.

Period	Days	Depth	Loss	Factor	Prorated Loss	Rain	Total	Daily
4/30 - 5/ 7	7	9-45	.20	1.25	.25	.00	.25	.036
5/ 7 - 5/14	7	9-45	.14	1.25	.18	.00	.18	.026
5/14 - 5/28	14	9-45	.13	1.25	.16	.04	.20	.014
5/28 - 6/ 4	7	9-45	.33	1.25	.41	.00	.41	.058
6/ 4 - 6/10	6	9-45	.22	1.25	.28	.00	.28	.047
6/10 - 6/16	6	--	--	--	--	--	.28*	.047*
6/16 - 6/18	2	--	--	--	--	--	.49*	.244*
6/18 - 6/25	7	9-57	1.44	1.19	1.71	.00	1.71	.244
6/25 - 7/ 2	7	9-57	1.24	1.19	1.48	.00	1.48	.211
7/ 2 - 7/ 9	7	9-57	1.16	1.19	1.38	.00	1.38	.197
7/ 9 - 7/14	5	9-57	.71	1.19	.84	.00	.84	.168
7/14 - 7/15	1	--	--	--	--	--	.17*	.168*
7/15 - 7/23	8	--	--	--	--	--	2.62*	.328*
7/23 - 7/30	7	9-69	1.58	1.15	1.82	.48	2.30	.328
7/30 - 8/10	11	9-69	.87	1.15	1.00	1.01	2.01	.183
8/10 - 8/13	3	9-69	.44	1.15	.51	.47	.98	.327
8/13 - 8/18	5	--	--	--	--	--	1.64*	.327*
8/18 - 8/23	5	--	--	--	--	--	1.48*	.296*
8/23 - 9/ 1	9	9-69	2.04	1.15	2.35	.31	2.66	.296
9/ 1 - 9/ 9	8	9-69	1.27	1.15	1.46	.00	1.46	.182
9/ 9 - 9/10	1	--	--	--	--	--	0.18*	.182*
9/10 - 9/15	5	--	--	--	--	--	0.92*	.184*
9/15 - 9/29	14	9-69	2.23	1.15	2.56	.02	2.58	.184
9/29 - 10/ 7	8	9-69	1.10	1.15	1.26	.32	1.58	.198
10/ 7 - 11/20	44	9-69	.48	1.15	.55	2.48	3.03	.069
			15.58			5.13	31.11	

* Interpolated

EXAMPLE OF DATA SHEET

Moisture Content Under Cotton

Cotton Development 36" high

Last Irrigation 7/15/59

Date: 7/30/59 Time: 0815 By: MacIntyre Plot: T3 R5

	North	Ratio	Mv.	South	Ratio	Mv.	Ave. Mv.	Inches	Acc. Inches
Standard	10,903			10,807					
1.0 ft.	3,748	.348	25.9	3,746	.350	26.0	22.7	1.36	1.36
1.5 ft.	3,503	.326	24.2	3,749	.350	26.0	22.1	1.33	2.69
2.0 ft.	3,181	.296	22.0	3,619	.338	25.1	20.6	1.24	3.92
2.5 ft.	3,286	.305	22.7	3,447	.322	24.0	20.6	1.24	5.16
3.0 ft.	3,339	.310	23.1	3,665	.342	25.4	21.2	1.27	6.43
3.5 ft.	3,721	.346	25.7	3,825	.357	26.6	22.9	1.37	7.81
4.0 ft.	3,838	.357	26.6	3,868	.361	26.8	23.2	1.39	9.20
4.5 ft.	3,899	.362	26.9	3,987	.372	27.6	23.7	1.42	10.62
5.0 ft.	3,893	.362	26.9	4,045	.378	28.1	23.7	1.42	12.04
5.5 ft.	4,375	.407	30.3	4,540	.424	31.5	26.6	1.60	13.64
Standard	10,613			10,615					
Ave. Standard	10,758			10,711					

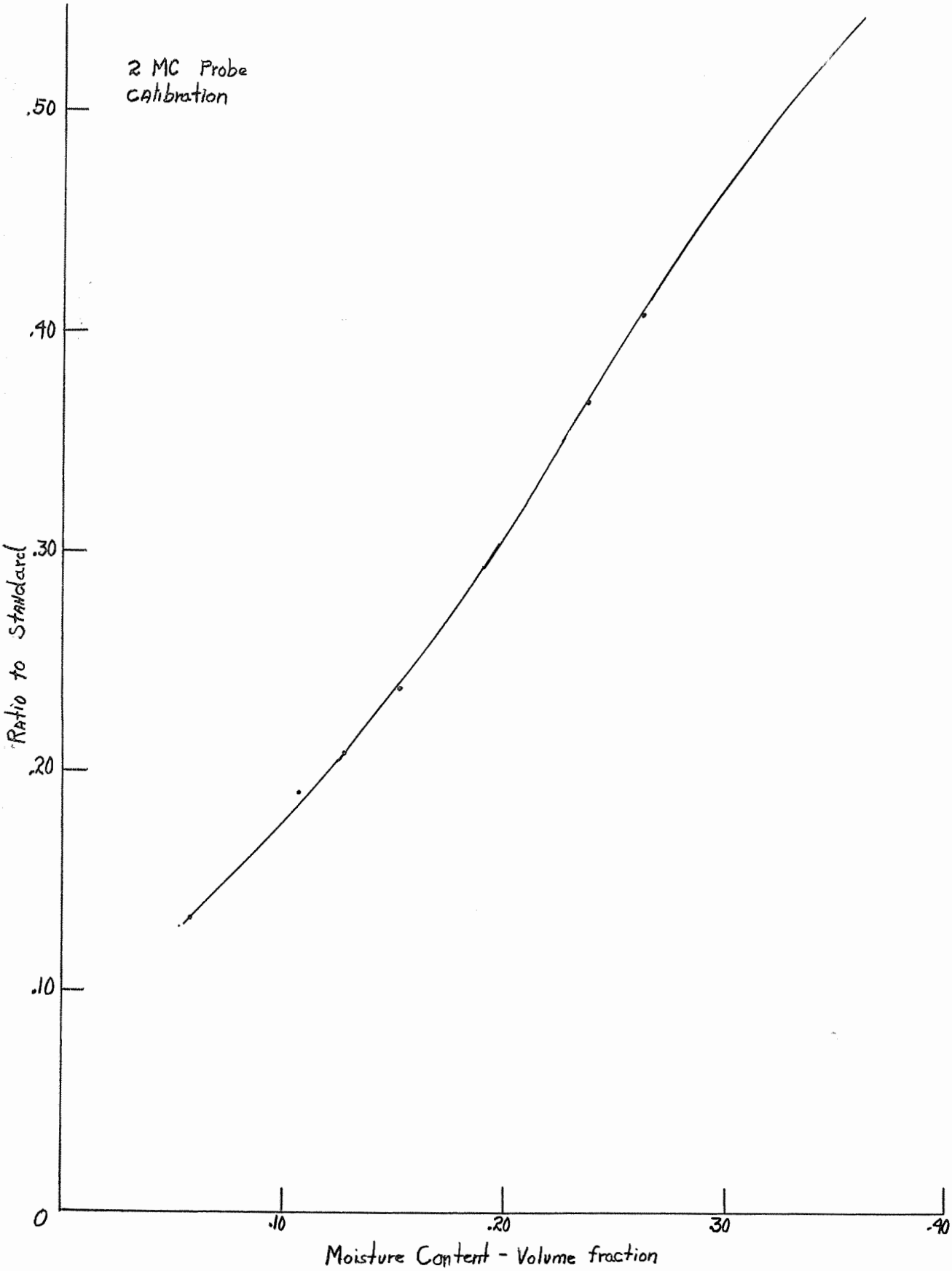


Figure 1. Calibration of neutron meter (2 mc Ra Be - Troxler Electrical Laboratory). Standard placed on soil surface.

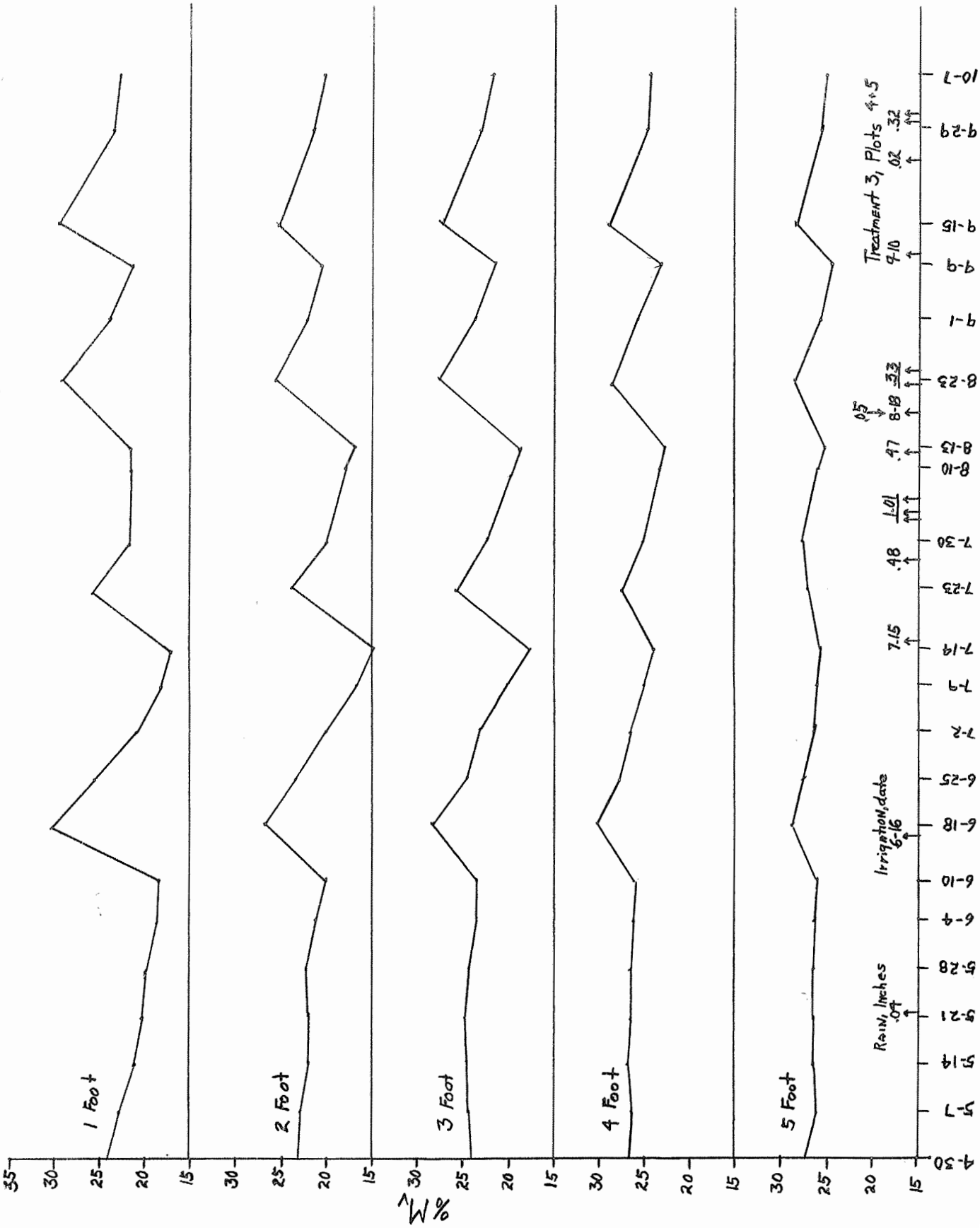


Figure 2. Moisture content in per cent by volume of soil in cotton irrigation experiment at depth indicated. Treatment 3.

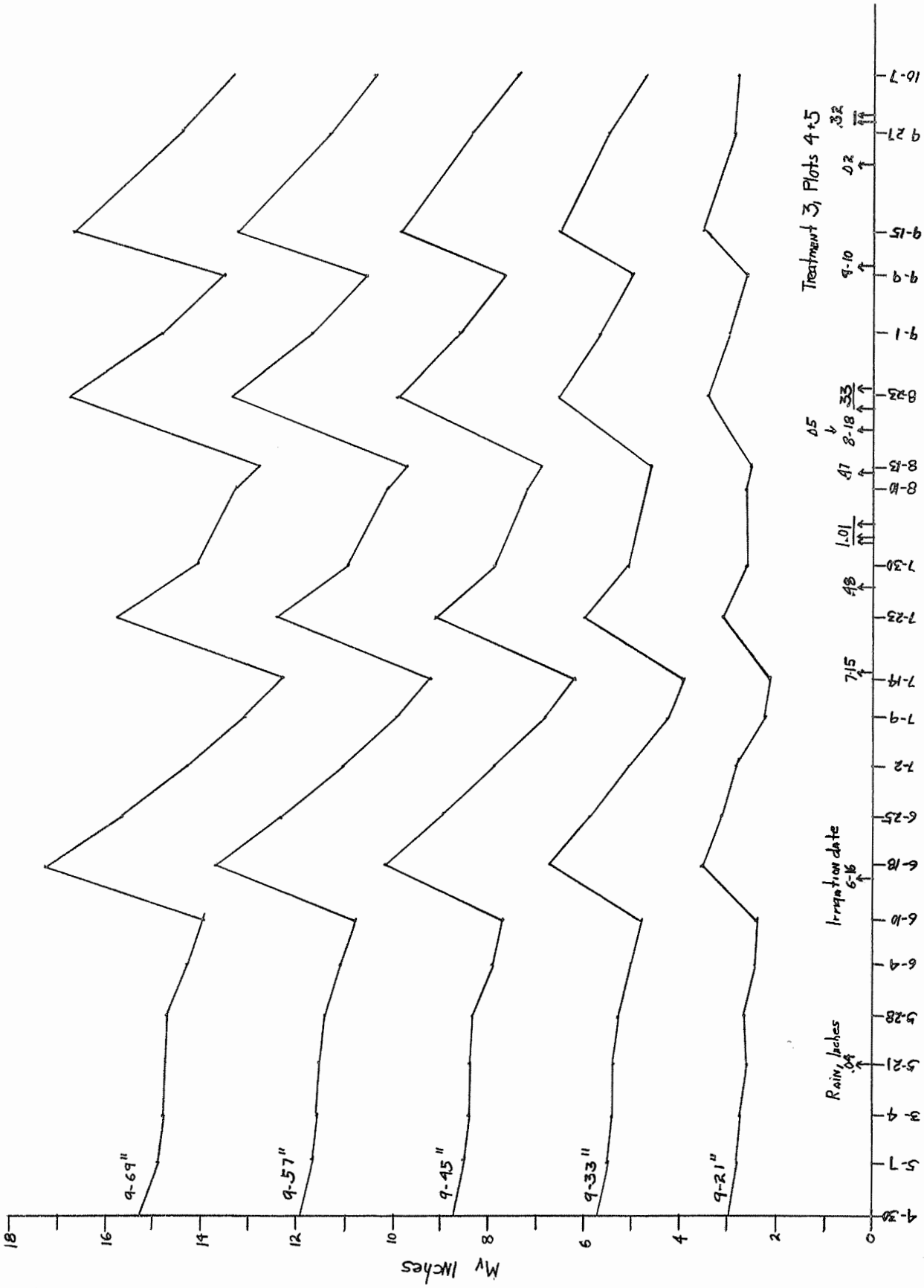


Figure 3. Moisture content in inches in profile layers as indicated in cotton irrigation experiment. Treatment 3.

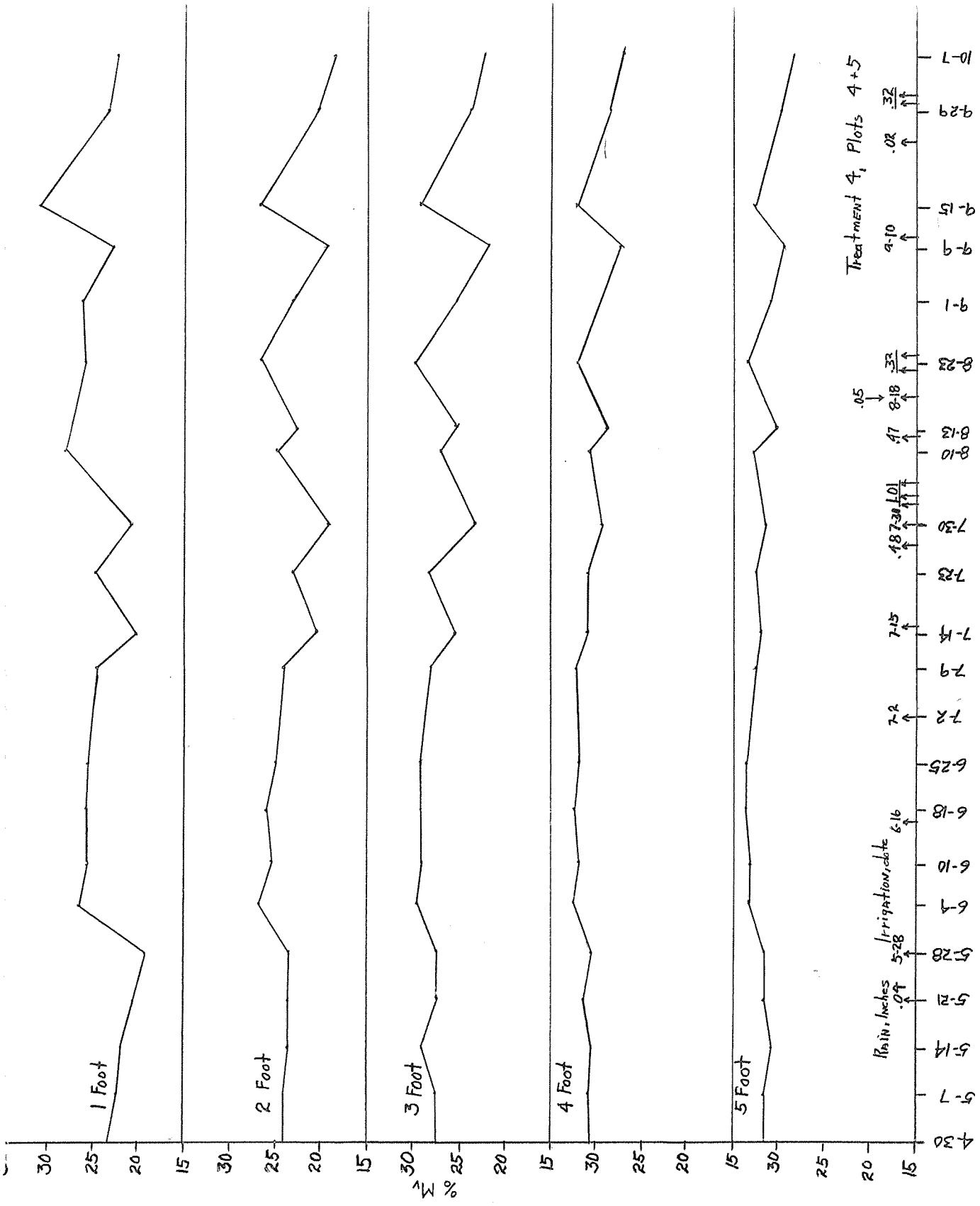


Figure 4. Moisture content in per cent by volume of soil in cotton irrigation experiment at depth indicated. Treatment 4.

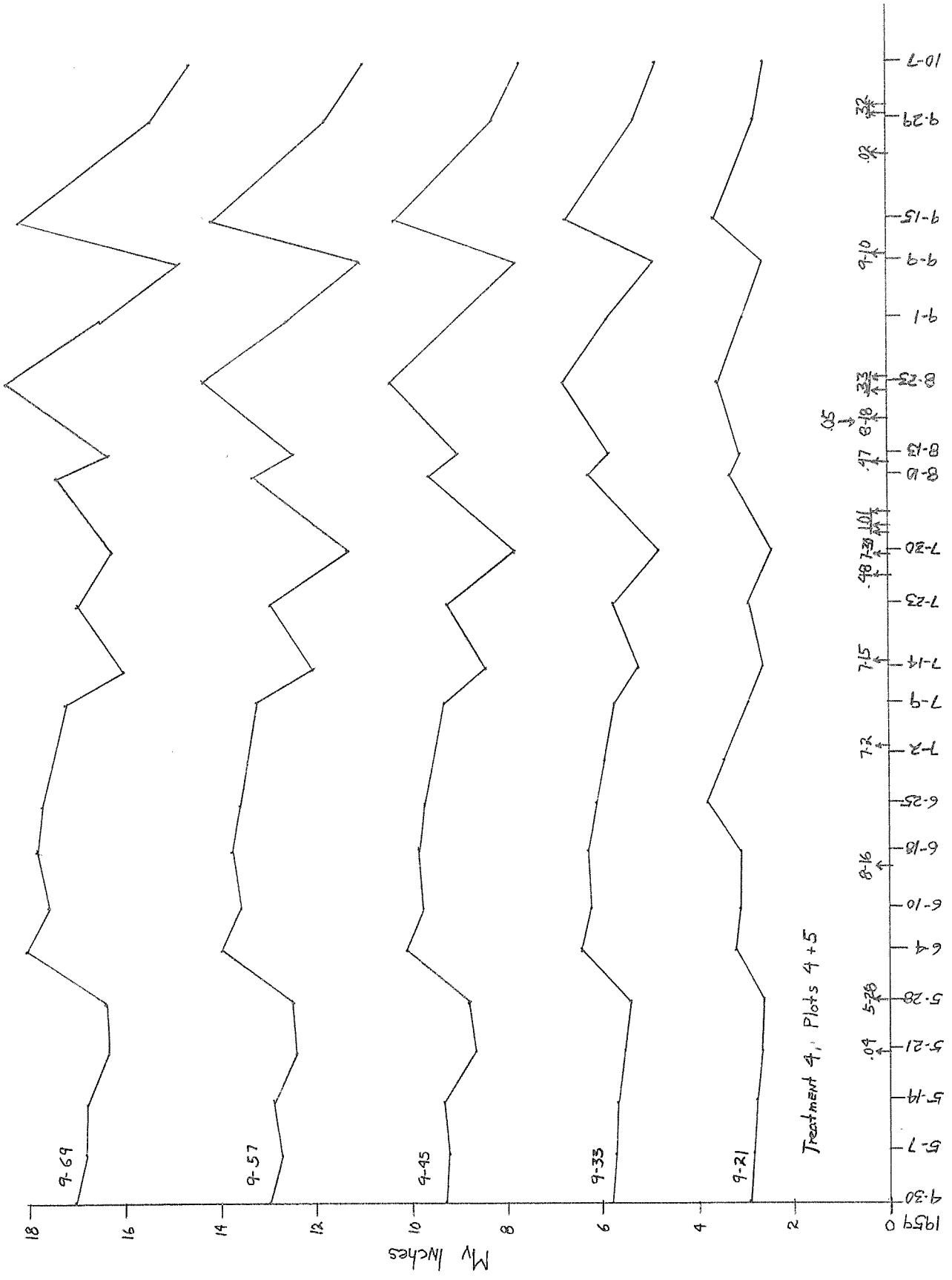


Figure 5. Moisture content in inches in profile layers as indicated in cotton irrigation experiment. Treatment 4.

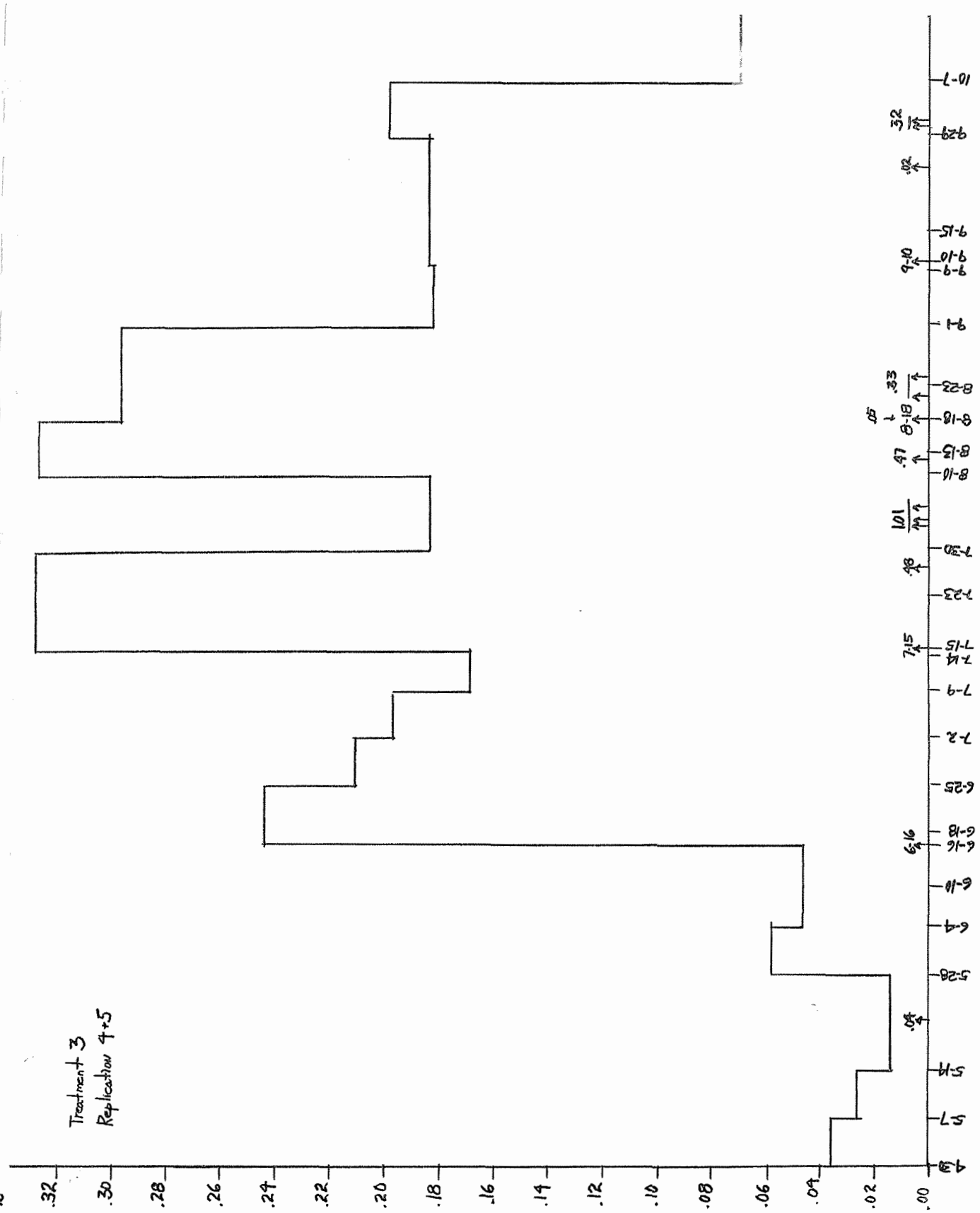


Figure 6. Daily rate of consumptive use of water by cotton. Treatment 3.

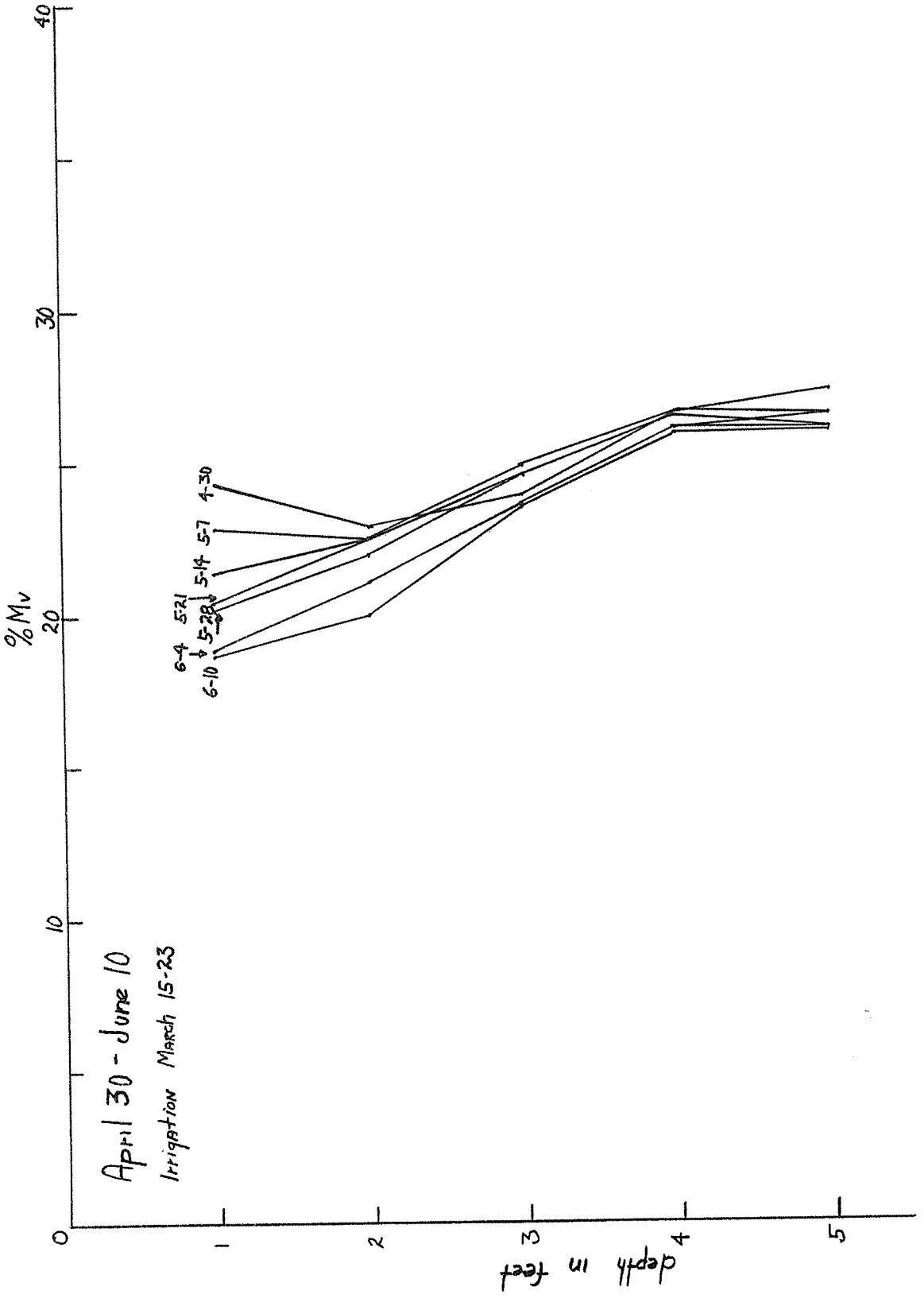


Figure 7. Successive soil moisture profile in Treatment 3 under cotton.

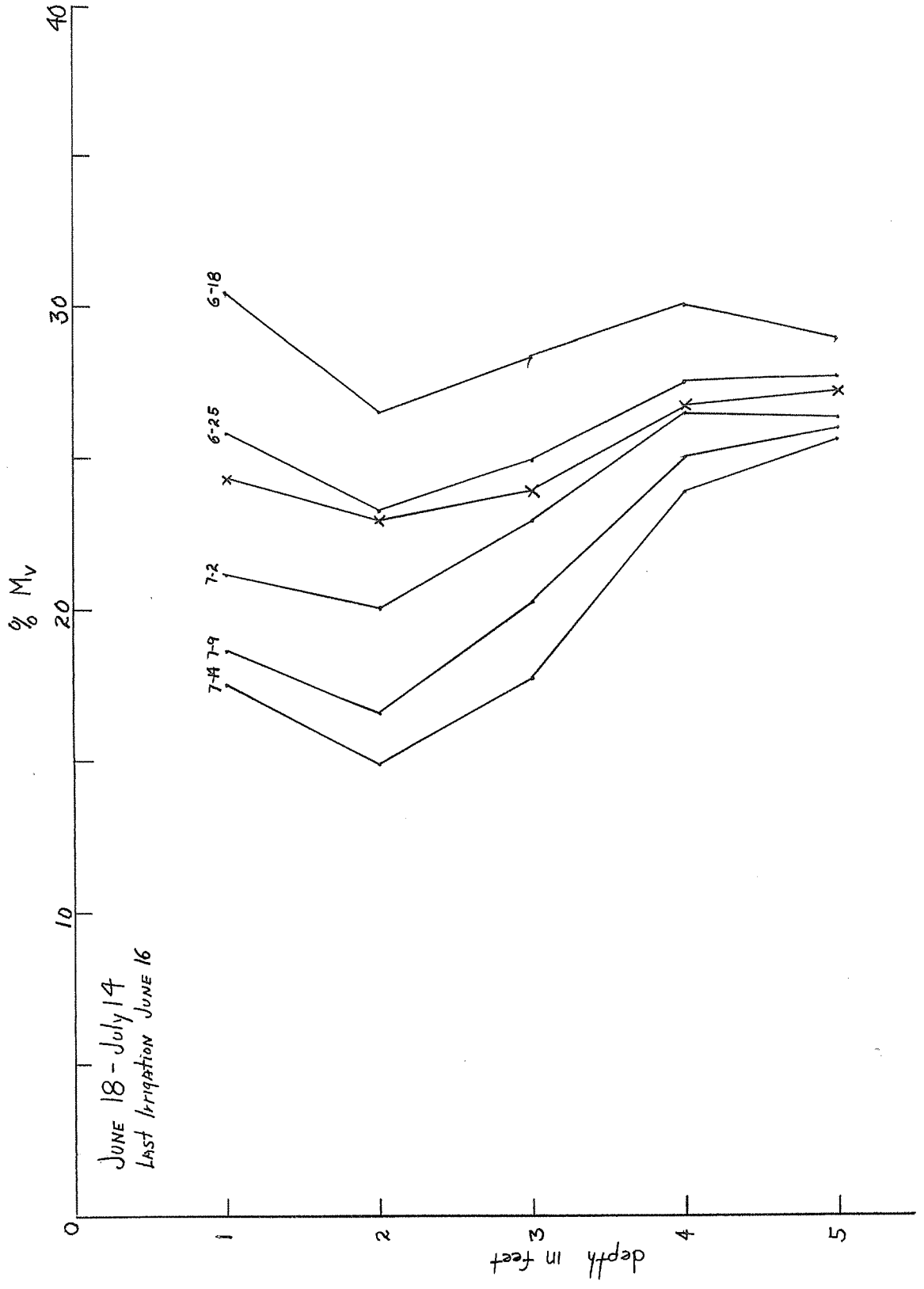


Figure 8. Successive soil moisture profile in Treatment 3 under cotton. Crosses indicate "field capacity." (April 30 values.)

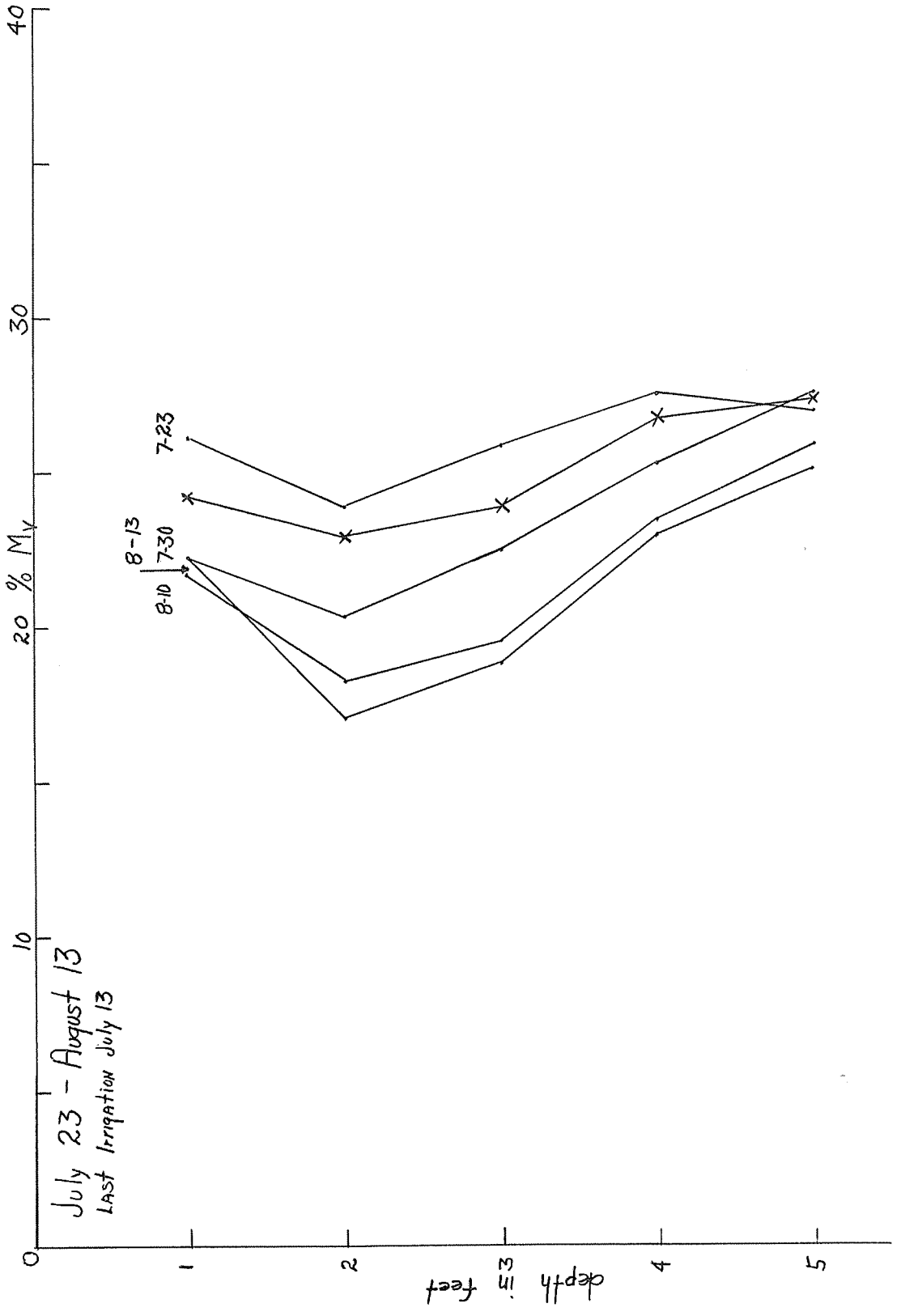


Figure 9. Successive soil moisture profile in Treatment 3 under cotton. Crosses indicate "field capacity."

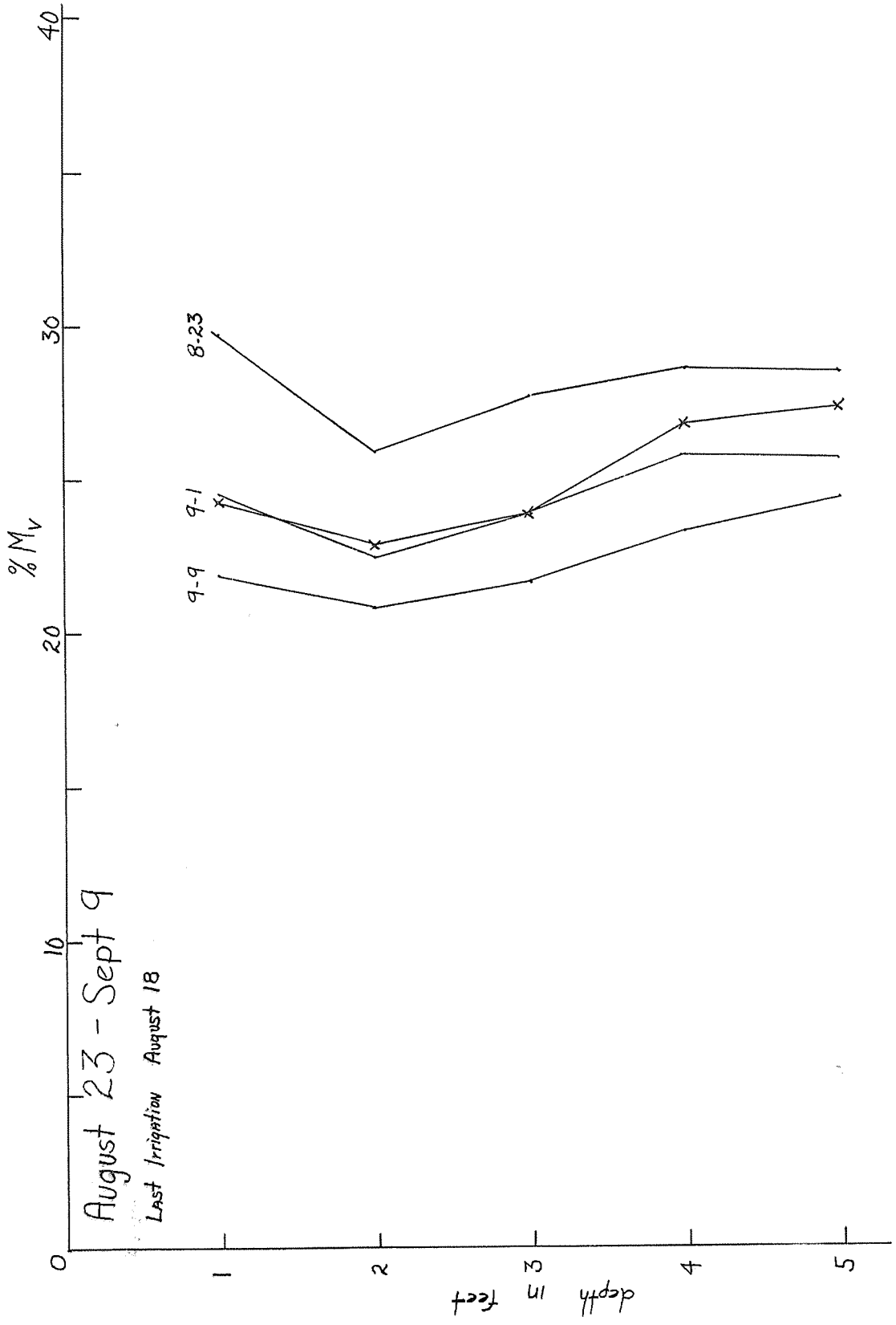


Figure 10. Successive soil moisture profile in Treatment 3 under cotton. Crosses indicate "field capacity."

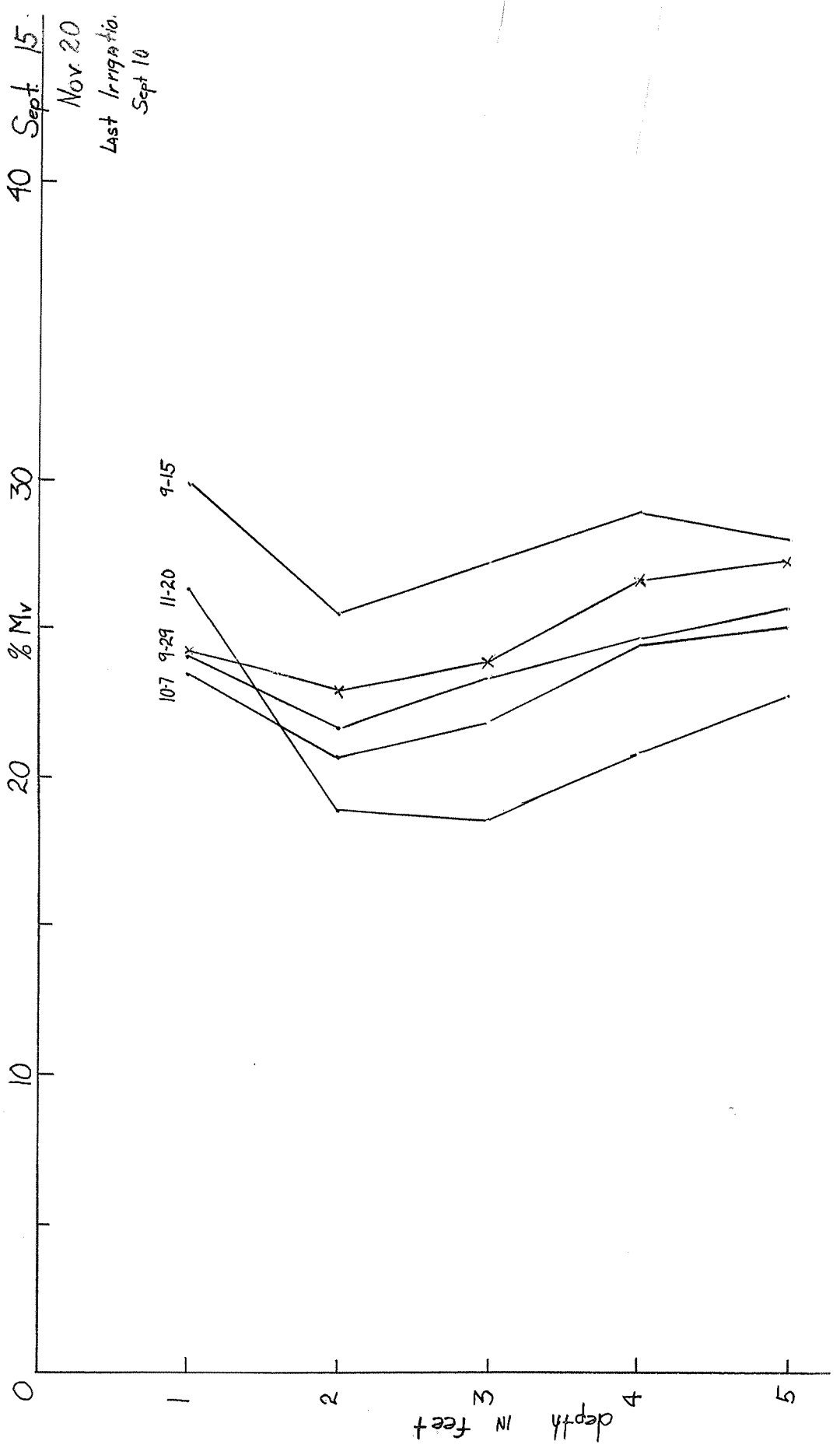


Figure 11. Successive soil moisture profiles in Treatment 3 under cotton. Crosses indicate "field capacity."

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