QUARTERLY REPORT

April 1 to June 30, 1980

EGYPT WATER USE AND MANAGEMENT PROJECT

Submitted By

R. H. Brooks, Project Technical Director
Cairo, Egypt

E. V. Richardson, Project Coordinator
Colorado State University
Fort Collins, Colorado

Contract No.
AID/NE-C-1351 (Egypt)
Project No. 263-017

Consortium for International Development
Executive Offices
5151 East Broadway
Suite 1500
Tucson, Arizona 85711

TABLE OF CONTENTS

QUARTERLY REPORT

April 1 to June 30, 1980

EGYPT WATER USE AND MANAGEMENT PROJECT

Contract No. AID/NE-C-1351

(Egypt)

PROJECT STATUS

Introduction

At the beginning of this quarter, all new American field staff personnel were housed and the final new member of the field team, Dr. James Layton, arrived in Cairo. Dr. John Wolfe returned in April to Cairo from home leave and extended sick leave due to knee surgery. Therefore during April the entire American field team was on the job and actively engaged in project work.

A workshop on water requirements and evapotranspiration was conducted by Engineer Eldon Hanson for personnel from the Water Management and Irrigation Technologies Research Institute. Mr. Hanson also conducted training for EWUP personnel on the significance of the crop production function, and the consideration that must be given to it when making consumptive use estimates.

In general, the work of searching for solutions to problems in both Mansouria and Kafr El Sheikh proceeded during the quarter with increased momentum and data analysis from several field trails, and other work are beginning to form the basis for recommending pilot studies in these two areas. The problem identification work at El Minya is nearly complete and some field trials in search for solutions have been implemented.

The general agronomic conditions during the quarter was one of converting from winter crops to summer crops. This generally took an extended period to accomplish and show some resourcefulness of the farmer in getting things done. The harvest of some winter crops appeared considerably delayed. Frequently berseem was not removed in time for optimal maize planting. In some areas the maize was often planted directly into the winter crop stubble without any land preparation. However, the plant population was exceptionally low. Observations were made of the use of long furrow irrigation on some very narrow parcels, and the use of a variety of bedding sizes largely depending on crop to be grown. Vegetables usually, were on wide beds, while maize remained on single furrows. Some of the significant findings will be discussed in this report under the appropriate field location headings below.

Another rather significant milestone in project progress was the holding of the water management short course in Egypt. In previous years, this 6 week short course was held in Colorado using American farm conditions. Bringing this short course to Egypt was a major accomplishment both from the logistics of moving personnel, equipment and vehicles from the states to Egypt as well as establishing the facilities and making the arrangements for the course in Egypt. Every indicator of success of this training effort in Egypt was positive. The details of this training effort are discussed in the section on training of this report.

To conclude this introductory section, it is worthwhile to draw attention to an economic analysis of the use of various water lifting devices. In an earlier analysis, the project indicated that farmers could benefit economically by shifting from Sakias or Tambours to diesel or electric driven pumps. This analysis was based upon subsidized prices for electricity, diesel fuel and distribution systems for distributing electrical energy. Subsequent analysis during this quarter indicates there may be an actual economic loss to Egypt as a nation in making a shift from traditional water lifting devices to the mechanically drive pumps. These findings are very significant in developing pilot programs for implementation throughout Egypt.

Mansouria

Significant Accomplishments

1. The first comprehensive calculation of the water budget for Beni Magdoul was completed under the leadership of Mr. Ree. To fill in missing data, the team installed more observation wells, measured surface flows crossing the boundary and the contribution from wells, and made empirical calculations of ET for each half month. Inflow measurements and changes in groundwater storage were calculated on the HP 9825.

2. At least a partial solution to the water supply problem in meska 3 R.S., Beni Magdoul was sought by cleaning the meska, raising the water level in the B. M. Canal two days per week, encouraging the

farmers to keep the meska clean through the village, and to schedule irrigation turns.

3. A pre-pilot area was established on 40 feddans served by meska 6, L.S., Beni Magdoul. Observation wells were installed, and plans made to measure all the water pumped by the three sakias. A drain ditch on the north side was re-excavated. Several corn trials were established, involving seed variety, plant population, fertilization, and pest control. The largest one also included water management by land leveling, extablishing long furrows, and irrigation scheduling by tensiometers. Economic and sociological surveys were begun. A survey of the meska and of the field boundaries was completed. Designs made for structures to measure drainage outflows.

4. There was continuous cleaning of weeds and algae from the Beni Magdoul Canal. The El Hammami Canal and its Shimi branch were being cleaned by heavy equipment, but the cleaning is not yet complete.

5. Crops were harvested from the winter field trials and the yields measured.

6. Assistance with seedbed preparation was given on several sites, using such machines as a chisel, plow, disk, harrow, furrower, and bed shaper.

7. Selected sites were sprayed for pest control.

8. Sweet corn was introduced in two sites in El Hammami.

9. A water budget proposal was prepared for meska 6, Beni Magdoul.

10. A survey and preliminary design for evaluating and lining meska 10, Beni Magdoul is partially completed.

11. A new calibration of the Nyrpic gate, Beni Magdoul is partially completed.

Significant Findings

1. The preliminary calculation of the water budget for Beni Magdoul for the period September 1, 1979 to April 30, 1980 suggests that the groundwater outflow is only 4.5% of the total inflow. However, this figure is subject to errors in the estimation of consumptive use and in the estimation of specific yield, a very important component of the groundwater storage calculation.

2. In field trials where zinc was applied to wheat, there was no significant increase in yield due to zinc.

3. The timing of the first two irrigations on the corn trials on meska 6 was established by tensiometer readings. Each time it coincided within one or two days with the "calendar" irrigation schedule recommended by the Ministry of Agriculture. Thus this trial is so far adding credence to both methods of scheduling, i.e., by soil moisture depletion and calendar rotation.

General Comments

Irrigation and Agronomic Conditions

Except for the water shortage felt by farmers near the far end of a poorly maintained meska, the water supply in Beni Magdoul has been fairly reliable this year. Any real shortage noted by the farmers has been usually corrected within one or two days, without any spill over the tail escape into the drain. Farmers on El Hammami, on the other hand, repeatedly suffer great water shortage when the canal is in need of cleaning. Data is being assembled to quantify the economic benefit of using lined branch canals or branch canals of controlled cross sections.

It is interesting to note here that the inflow to Nahia Canal (a canal serving an area similar to Beni Magdoul, one kilometer north) was found to have an inflow of 86% greater than Beni Magdoul during the last six months of 1979. The restricted or reduced inflow of Beni Magdoul has been acceptable to most farmers because water is available at all times.

Review of fertilizer use from Mansouria farm record studies indicated a tremendous inconsistent use of N on all crops. This varied from essentially none to several times the recommended rates. The reasons for this variation need some further interdisciplinary studies.

Farmers continue to show interest in adopting agronomic practices that will give them more net profit. Insect control has proven to be extremely profitable for farmers.

Economic and Sociological Conditions

The feeling is growing among our professional workers that perhaps the farmers on one meska, for example, can find a satisfactory organizational structure to manage a community investment in the meska delivery system.

Kafr El Sheikh

Work accomplished at the Kafr El Sheikh Project site was focused on the completion of one set of field trials for winter crops and the beginning of summer field trials on rice, cotton and corn.

Significant Accomplishments

1. Work plans were devised and implemented for search for solution activities on cotton, rice and corn for summer season, 1980. All the field trials are based on the concept of a 4 by 4 design: four strips on each site to study four different management schemes. These include: a) traditional farmer practices, b) traditional farmer irrigation practices with the addition of agronomic practices (i.e., pest control, fertilization, improved varieties, etc.), c) improved irrigation practices (i.e., level border or level furrow design with irrigation scheduling with traditional agronomic practice, d) both improved agronomic and irrigation practices. Field trials on rice include one extra strip to introduce to the farmer the method of mechanical transplanting of rice after growing rice seedlings in a specialized nursery.

Three cotton trials, 2 rice trials and one corn trial are being conducted on El Manshia Meska. Two cotton trials are being conducted on Om'Sen Meska. One replicated rice trial and one corn trial are being conducted on Hammad Meska. The entire team has been actively involved in the formulation and implementation of the work plans for these trials.

2. Winter season 79-80 field trials were concluded with the harvesting of crops in April and May. Yield data were collected and analysis of all the data collected has been an on-going activity since the completion of the season. At the present time, final analysis are being completed and a summary report being written.

3. In addition to their economic analysis of the wheat field trial data, the economics team has prepared machinery cost tables for all implements at the site, has prepared maize and flax enterprise budgets and are working on a sugar beet enterprise budget.

Significant Findings

1. Trials on Rice Planting Alternatives. Four methods of seeding rice, (a) traditional manual transplanting; (b) seeding in dry soil;

(c) seeding in wet puddled soil and (d) machine transplanting were tried at Kafr El Sheikh. The returns above costs were highest in treatment (d) with (c), (a) and (b) following in that order. Water requirements were highest for treatment (b) with treatment (c), (a) and (d) respectively. The saving in water between (b) and (d) was 3,000 m^3 per feddan for the season. From this field trial it appears there are viable alternatives for transplanting rice which will reduce production costs by substituting machine transplanting for transplanting by traditional methods. More work needs to be done to find out if machine methods of transplanting rice will generally fit in the farming system of the Kafr El Sheikh area.

An inter-office staff paper was written giving details of progress on Rice Planting Trials for 1979.

2. Wheat trials were conducted at six sites in the Kafr El Sheikh study area to compare the performance of recommended production practices with that of typical farmer practices. It was expected yields could be increased and water applications reduced through improved management. This occurred, but an economic analysis of the experimental results indicates that average net returns were reduced by nearly L.E. 4.00 under the recommended production practices. The added returns and cost reduction associated with higher yields and water savings are not yet enough to offset the cost increases incurred when the improved practices are adopted. It appears that the introduction and use of the Sakha #8 variety in the field trials was the main factor contributing to the increased yields measured. The data do indicate, however, that a certain level of improved water management (less water applied with higher efficiency) was achieved.

3. Substantial response to foliar spray of zinc sulfate was measured on wheat.

4. According to recent analysis of soil water data for wheat from previous data collection periods during problem identification clearly shows over irrigation occurring with observed farmers causing high water tables. The reason for the over irrigation appears to be unlevel land.

General Comments

Irrigation and Agronomic Conditions

Cotton was planted in early April and at least 3 irrigations have been applied by this time. Corn was planted mid-May and has received at least 2 irrigations. Rice nurseries were started in May and transplanting of the seedling is nearly complete by now. During the critical period of transplanting when farmers need a larger volume of water to submerge their basins, a general water shortage in the area was felt. Unequal distribution of water throughout the delivery system is a major contributing factor to this occurrence.

Farmers are generally very happy with the work of the project. This is evident from observations made by our sociologists concerning the results of the winter field trials. All of the farmers were impressed with the results obtained and very willing to cooperate with the project in future activities. It was evident that farmers are learning from the project during last seasons field trails as they waited to irrigate at the same time as the team did. It is felt that the farmers are ready and willing to receive more formalized methods of information exchange, such as group meetings, field trips, films, etc.

Improved Management

The water management practices package recommend by the project for the winter season (79-80) field trials resulted in significant increase of grain yield production as well as decrease of the depth of irrigation water applied to farmer's wheat fields. The water use efficiency on farmer managed strips was 0.33 kg. of wheat grain yield per cubic meter of water applied. With the improved practices on the same farms the water use efficiency was increased to 0.52 kg/m^3.

Land Productivity and Water Supply

The production from upland crops, in this case, wheat, varied significantly among selected sites throughout the Kafr El Sheikh area. This variation is easily observed from data obtained from field trials conducted during the 1979-1980 winter season. The grain yield of wheat produced from cultivated land varied from 1.060 to 2.155 tons/feddan. Accumulated irrigation water applied (including rainfall) to different sites varied significantly from 57 to 87 cm. depth. It should be noted that the highest grain yield production was associated with the lowest water application depth.

It appears that sites served by Manshia Meska were over-irrigated as compared to those served by Hammad Meska. Data show the average productivity of different selected farms on both meskas irrespective to management or any other treatment tested that the yield of wheat grain produced from the selected areas served by Hammad Canal is greater than that produced from areas served by Manshia. The yield of straw also was greater on Hammad than on Manshia, but the difference is not significant. The results indicate that more water is applied to farms served by Manshia Meska than those served by Hammad, and that farms located near the head of the meska have greater access to water than those at the end. It is interesting to note that farmers, on Hammad Meska, who consistently complain from a water shortage, applied a smaller depth of water and achieved the highest grain yield.

The supply of irrigation water more than any other single factor limits the land values. The price per feddan (L.E. 3000/feddan) of land is nearly the same on both meskas, although the data indicate that land productivity is greater on Hammad Meska due to its proximity to a large common drain (drain No. 7). For this reason one would expect land values to be greater on Hammad Meska. The limiting factor is the water supply to an area as a result of uneven distribution of irrigation water in the delivery system.

El Minya

Problem identification work continued during the quarter and some irrigation agronomic field trials were initiated as well. The following are some of the more significant accomplishments.

1. The agronomic field trails for corn during the 1979 summer have been analyzed and reported in an inter-office staff paper.

2. The Abueha Canal flume was re-designed by Mr. William Ree on TDY assignment so that the floor elevation would be at 40.26 m to reduce the submergence.

3. Plans were prepared and procurement initiated for the installation of 22 additional observation wells. Some will be installed close to the meskas, canals and drains while others will be located to observe the hydraulic gradients at these boundaries.

4. Basic data have been assembled which will permit a determination of whether or not water can be supplied to the Abueha Canal from the Ibrahimia feeder canal on a continuous flow basis without serious consequences to other parts of the delivery system. In addition, to determine whether or not a level in the Abueha canal can be maintained

high enough to supply water by gravity to all the land served by the canal.

General Comments

In addition to measuring water delivered to selected farms, soil samples have been taken before and after irrigation to determine the irrigation efficiency. Where the agronomic practice is for berseem to follow cotton, after the second irrigation, farmers increased their irrigation efficiency nearly 20% when they irrigated according to EWUP recommendations. Soil water analysis of winter crops in El Minya showed good values of soil water depletion that could be used as an estimate of consumptive use. Additional analysis show possible aeration problem at below 30 cm even though there was no water table at less than 1.5 m.

When farmers followed agronomic practices recommended by EWUP for winter wheat, they obtained significant increases in yield of wheat grain. Likewise, significant increases in broad bean yields were obtained when farmers obtained the corect plant stand density. An earlier crop survey of broad bean production showed a strong relationship between yield and plant stand density.

During the past quarter, in order to acquaint more farmers with the purposes of the project, the El Minya EWUP team called a meeting of all farmers in the Abueha village to explain project goals and objectives and to solicit cooperation. A similar meeting was held before the project started work at Abueha, but it was found that other follow-up meetings are need from time to time.

Personnel (field)

Dr. R. H. Brooks, Technical Project Director
Dr. M. E. Quenemoen, Senior Agricultural Economist
Dr. John Wolfe, Senior Agricultural Engineer
Dr. Richard Tinsley, Senior Agronomist
Dr. James Layton, Senior Extension Sociologist
Dr. Erwin Nielsen, Technical Advisor El Minya
Dr. William Braunworth, Technical Advisor Mansouria
Dr. Thomas Ley, Technical Advisor Kafr El Sheikh

BACKSTOPPING

Planning & Coordinating Committee

The P & C Committee continued the work on the water management alternatives study, the water budget studies, development of the training course, recruitment of personnel to work TDY in Egypt and replacements for Brooks, and Wolfe next year, backstopping each discipline in the field, and supervision of the Egyptian's taking academic training.

Dr. Dotzenko, Dr. Knop and Ms. Adams worked on finalizing several papers of their work in Egypt. In addition Ms. Adams will help in putting on the On-farm Water Management short course in Egypt this summer.

The design of the buried pipeline system for the El Hammami area continued. Mr. Michael Moodie and Sritharan Subramaniaiyer are working on it.

A three day orientation was provided May 12-14 for the American trainers who will be conducting the On-farm Water Management course in Egypt this summer. The orientation program and evaluation of the orientation is attached.

Mr. Eldon Hanson, as part of his TDY, put on a workshop for water requirements and evapotranspiration, June 24 to 26. Dr. Mona El Kady helped put on the workshop by serving as an interpreter for Mr. Hanson's lecture and presenting some of the material in Arabic. The outline and notes for this short course are attached.

TDY's

Mr. A. R. Robinson, Professor of Civil Engineering, (February 6, 1980 - April 13, 1980); to help in the design of improved irrigation water delivery systems. The period of time between March 20 and April 8 was spent in China on another project.

Mr. William Ree, Professor of Civil Engineering, (March 2, 1980 - June 1, 1980); to help project personnel in surface water measurements and analysis of water measurements for the water budget study.

Mr. Ernest N. Biggs, Ph.D. Student Civil Engineering, (March 16, 1980 - April 29, 1980) to collect data on water budget for the Mansouria project area for the water management alternative study.

Dr. Willard Schmehl, Professor Agronomy (April 8, 1980 - May 6, 1980); to help Richard Tinsley and Bill Braunworth assume their duties as project agronomists and to review the agronomy now underway.

Dr. E. V. Richardson, Project Coordinator, (June, 1980 - July, 1980); to verify project status as project directors, and to start work on Mid Term Project Report.

Dr. Edward Knop, Professor of Sociology, (May 5, 1980 - June 9, 1980); to help with temporary training duties in Cairo.

Ms. Nancy Adams, Research Associate Irrigation Engineering, (May 19, 1980 -); to participate as a trainer in irrigation engineering in Kafr El Sheikh for the training program.

Dr. Al Madsen, Professor of Economics (May 19, 1980 - June 29, 1980); assist as trainer of Economics in training program at Kafr El Sheikh.

Dr. Dave Redgrave, Professor of Agronomy, (May 14, 1980 - July 17, 1980); training coordinator to the training course put on in Kafr El Sheikh from May 18 - July 15, 1980.

Dr. Jim Layton, Professor of Sociology, (April 19, 1980 -); to help assist in training as sociologist trainer, then to stay 2 years as the Extension Sociologist.

Mr. Eldon Hanson, Professor of Agricultural Engineering, (May 19, 1980 - July 2, 1980);to work on evaluation of ET approaches.

Mr. James Mayfield, Professor of Civil Engineering, (June 24, 1980 - July 24, 1980); to help in civil engineering TDY.

Dr. Robert King, Professor of Economics, (June 20, 1980 - July 23, 1980); to work on water management alternatives.

Mr. Thomas Edgar, Instructor of Civil Engineering, (May 19, 1980 -); to work as trainer in civil engineering in Kafr El Sheikh on the training program.

Mr. Norm Illsley, Research Associate Agricultural Engineering, (March 17, 1980 -), to instruct the Egyptian personnel in the use of farm machinery in seed bed preparation and planting of crops.

Mr. Mohammed Haider, Ph.d. Student Economics, (April 22, 1980 -); to work as trainer in Economics on training program held in Kafr El Sheikh.

Mr. Gale Dunn, M.S. Student in Agronomy, (May 19, 1980 -); to work as trainer in Agronomy for training program held in Kafr El Sheikh.

Dr. Yack Moseley, Professor of Agricultural Engineering, (May 19, 1980 -); to work on training program as trainer in agricultural engineering in Kafr El Sheikh.

Dr. Larry Nelson, Professor of Agronomy, (May 19, 1980 -); to work as agronomist trainer for the training program in Kafr El Sheikh.

Ms. Joyce Ham, Ph.d. Student in Sociology, (May 19, 1980 -); to work as sociologist trainer for the training program in Kafr El Sheikh.

Mr. Roger Slack, M.S. Student in Ag Engineering, (May 19, 1980 - to work as ag engineering trainer in the training program for Kafr El Sheikh.

Training

A. On-farm Water Management Short Course

The 1980 EWUP training program was conducted at Kafr El Sheikh, Egypt during the period May 25 to July 4, 1980. Nineteen participants started the course and eighteen finished.

The training staff was in Egypt for the week prior to training for orientation and final preparations and the week post for trainee evaluations, course review and modification and preparation of the final report material. The training staff presented a verbal review of the program to the project directors both before and after the program. A bi-weekly report was also furnished, to the directors, copies of which are in the appendix.

The training program was a continuation of programs that have been presented at Colorado State University in prior years and represented the first time that the program had been conducted in Egypt. Some modifications were made to the program to incorporate the experiences of prior years and to facilitate the transfer of the program to Egypt.

The program is conducted in two phases. The first phase being the on-farm water management training that was held in the Kafr El Sheikh area. The second phase is a field study tour of irrigation methods, research, and facilities in the western U.S. This second phase will be conducted during the latter part of August and the first part of September.

A report on the training will be prepared after the second phase is completed. The final report will also include an evaluation of the training program and suggestions for it's improvement and a full evaluation of the trainees performance and accomplishments. In the appendix, the training outline, training staff, trainees, and the field study tour, and tour participants are given.

B. Participant Training

The following Egyptians continued with their academic training at Colorado State University this quarter.

Mr. Abdel Fattah Metawie	Engineering
Mr. Farouk Abdel Al	Economics
Mr. Mohamed Naguib	Sociology
Mr. Tarek Tewfik	Agronomy

Their individual programs for spring semester were given in the last quarterly report. It was decided that Metawie, Naguib and Tewfic will continue with academic course work during the summer session in order that they might complete additional course work.

Water Management Alternatives

Mr. Niel Biggs spent part of this period in Egypt working on the project and collecting data in the Mansouria Area to be used in the water scheduling study portion of the Water Management Alternatives studies.

Dr. Robert P. King spent the period June 21 through July 23 in Egypt collecting data and working with project personnel on the Water Management Alternatives model. A copy of his TDY report is attached.

Water Budget

Drs. Ruff and Sunada and Mr. Ree worked on the Water Budget. A draft report on Water Budget for Beni Magdoul branch canal was completed by Mr. Ree in Cairo. A final report for Beni Magdoul will be completed next quarter.

Equipment

Requests for equipment from the field were processed.

WORK PLANS

July 1, 1980 to December 31, 1980

I. July 1, 1980 to September 30, 1980

A. Cairo

Mansouria

Continue applied research program in Search for Solution, data collection on water budget and planning of pilot projects. The closed pipeline for El Hammami will go out for bids. Specifically, plans will include the following:

a. Problem Identification

1. Continue to assemble data to verify or quantify over-irrigation.

2. Continue water budget measurements.

3. Complete data analysis.

b. Search for Solutions

1. More field trials for tomatoes in El Hammami.

2. Attempting to obtain insect control by chemical sprays.

3. Initiate more on-farm water management trials

4. Complete data analysis on completed trials.

5. Write inter-office staff papers.

6. Continue plans for Hammami pipeline.

c. Pilot Implementation

1. Continue to increase the number of water management field trials on meska 6. Develop plans for organizational structure for scheduling irrigations among farms. Analyze cost and benefit of improvements.

2. Plan future pilot areas on meska 10 and meskas 5, Beni Magdoul, or other places.

3. Prepare mid-term report.

4. Prepare plan for controlling the equitable distribution of water from the proposed Hammami pipeline.

Kafr El Sheikh

a. Problem Identification

Complete reorganization and summary of all data files at the site is occurring to facilitate preparation of data for the mid-project report seminar to be held at Kafr El Sheikh site August 4 - 8. 1980. There is continuing analysis of new data to substantiate problems already identified.

b. Search for Solutions

A summary report of the initial search for solution field trial (winter 79-80) will be completed. Continued work associated with the 1980 summer season field trials will be carried out. Data is being analyzed as it is collected. Outlines for future field trials shall be formulated as a result of data analysis and interpretation.

c. Pilot Programs

In conjunction with review and summary of all data for the mid-project report, feasible pilot project proposals will be outlined. It is expected that at least one feasible program will be implemented during the coming winter cropping season (80-81).

El Minya

The draft of the problem identification report will be finalized. Continued work on adaptive research in the Search for Solutions will continue. Water Budget measurements will continue. A draft report on the village soil fertility study will be completed. A preliminary evaluation of what type of water management program should be implemented in El Minya will be written for the mid-term report. It will be tentative in that El Minya is one year behind the other areas.

Main Office - Cairo

Major activity will be the completion of the mid-term report. This will involve working with each of the field teams and Fort Collins. A series of seminars of one week duration will be held at each field site to review and discuss accomplishments since the beginning of the project. These discussions will serve as a basis for developing a pilot study area for each project site.

Four individuals will be processed to go to the States to receive formal academic training. In addition 28 persons will be processed to take the field trip on irrigation in the States.

1. Forrest Walters and Osman El Kholy will study livestock marketing and cost of using animals for power. They will prepare a report of their findings.

2. Rob King will establish a working computer model for evaluating irrigation investment alternatives and water-crop response functions.

3. Continue analysis of problem identification data and prepare appropriate reports.

4. Continue water budget measurements and data analysis.

5. To work with Dr. James Mayfield in examining local organizational relationships (both formal and informal) in preparation for organizing farmers on meska 10, Mansouria site.

6. To prepare and initiate work on farmer organizations and implementation activities for the upcoming pilot projects.

7. Analysis of farm records will utilize methods and procedures developed by Mr. Farouk Abdel Al while on special training at Colorado State University. Two years of data will be analyzed and reported as an inter-office staff paper.

B. Fort Collins

Backstopping

The design for the buried pipeline for El Hammami will be completed.

Recruitment for Water Budget Engineer and replacement for Dr. Brooks will continue.

A Water Budget report will be completed for Beni Magdoul. An outline of the water budget program is given in the appendix.

The Mid Project Report will be completed this quarter.

The Water Management Alternatives study will continue with activities centered in Egypt.

Training

The four Egyptians taking academic training will complete their course work and return to the project.

Four more Egyptians will arrive on campus in August to start two semesters of academic training.

The On-farm Water Management short course and field trip will be completed this period.

Arrangements will be made for President Karl Abdel and four members of the Salt River Project Senior Staff to visit Egypt to establish an exchange program between the Ministry of Irrigation and Salt River Project.

C. Personnel

Field Team

No change

TDY's

Bill Ree	Agricultural Engineering
Ed Knop	Sociologist
Bill Schmehl	Agronomist
James Mayfield	Sociologist
Eldon Hanson	Agricultural Enginering
Robert King	Economist
E. V. Richardson	Civil and Irrigation Engineering
Forrest Walters	Economist
Trainers (11)	

II. October 1, 1980 to December 31, 1980

A. Cairo

Mansouria

a. Installation of Hammami pipeline.

b. Develop plans for any water measuring or control structures to be installed during the closure period. Also plan for annual canal maintenance.

c. Continued development of the Meska 6 pilot area.

d. Prepare plans for the next pilot area to be implemented.

Kafr El Sheikh

a. Summer 1980 field trials shall be completed and complete data analysis and summary reported.

b. Winter season field trials as suggested or deemed necessary from previous data analysis shall be implemented.

c. Pilot program planning and implementation.

d. Continued planning and implementation for future pilot programs.

El Minya

a. Continue search for solution to problems.

b. Set up a study to evaluate gravity irrigation methods with lift.

c. Conclude problem identification work and finalize report.

Main Office - Cairo

a. Assist field teams in planning and implementation of pilot areas for El Mansouria and Kafr El Sheikh.

b. Continue with water budget work with emphasis on developing preliminary reports for the project areas of Kafr El Sheikh and El Minya.

c. Reports will be prepared of farm record surveys which will contain data useful for analysis of problem solution alternatives.

d. The computer model for evaluating irrigation alternatives will be used to help design and analyze field trials.

e. The paper on water lifting costs should be reviewed with policy makers and EWUP computer facilities should be placed at their disposal for considering national investment strategies.

f. The leadership of the project will be shifted to Dr. Gene Quenemoen who will begin to act as Technical Project Director. Dr. Brooks will work with Dr. Quenemoen during the last quarter to make the transition as smooth as possible. Dr. Brooks will spend time working in Kafr El Sheikh on technical aspects of the project dealing with drainage.

B. Fort Collins

Backstopping

Selection, orientation and transfer of the Water Budget Engineer.

Selection, orientation and transfer of Dr. Brooks replacement.

Take part in the Mid Project Review and establishment of pilot programs.

Calibration of Water Management Alternatives computer program. Completion of Mr. Biggs, Ph.d. dissertation.

Continue with water budget studies. Dr. Ree will be in Cairo to work on the field phase. If possible the Water Budget Engineer will go TDY during this period.

Training

Revision of the On-farm Water Management training manual will be completed.

Planning for putting the On-farm Water Management short course in Egypt in February will be done.

Advise and supervise the 4 Egyptians taking academic training.

C. Personnel

Field Team

No change in personnel, but Dr. Quenemoen will take over for Dr. Brooks as Technical Project Director. Dr. Brooks will stay on the project until January working on the groundwater and drainage problems.

TDY's

E. V. Richardson	Civil and Irrigation Engineering
E. G. Hanson	Agricultural Engineering
William Ree	Agricultural Engineering
Niel Biggs	Civil Engineering
Parviz Soltanpour	Agronomy
Tim Gates	Agricultural Engineering

Appendix

1. Orientation On-Farm Water Management Trainers
2. EWUP Workshop for Water Requirements and Evapotranspiration
3. On-Farm Water Management Short Course Summer 1980
4. Robert P. King's TDY Report - Water Management Alternatives
5. Water Budget Outline

EVALUATION OF ORIENTATION FOR EWUP TRAINERS
May, 1980

The EWUP Orientation met its goals of helping to prepare participants for successful survival in a new culture; and for productive functioning for the duration of the training program. This was accomplished by 1) three days of orientation sessions (Attachment I); and 2) advance distribution of readings; and 3) audiotapes dealing with stress (Attachment II). As can be seen from the schedule, the contributions of many people made the orientation possible. In addition, the training group was enthusiastic and eager about their task and had visibly benefitted from the skilled leadership and team building involved in the weeks of planning together.

The formal measure of meeting the objectives of orientation was an evaluation form which was completed by seven of the nine participants (Attachment III). Following is a summary of responses to the form: The "Introduction to Egypt" was "a valuable starting point (4)"; "a useful perspective (2)"; and "a great amount to absorb in a short time (1)". Greater understanding of the cultural differences between Egyptians and Americans was one result. The session on cross-cultural communication was "informative (5)"; and "helpful for specific concerns (3)". Respondees mentioned becoming more aware of men/women relationships; food/drink offerings at social functions; transportation; communications; and interpersonal communications. Ideas gained: "It will be fun to work with them!"; "Appreciation and desire to strive for more empathy"; "The idea that these people will receive us openly does make me feel more comfortable." Generally, the group felt that sufficient information was given on living conditions and items available in Kafr el Sheikh. Responses indicated that culture shock had not been over-stressed. Several indicated that they had coping mechanisms from previous over-seas experience. Others felt that the orientation tapes and sessions had helped them identify some strategies for coping in times of depression and stress.

While one person felt he was well informed about the project, the balance found the Overview gave them a much clearer picture of the entire project and where training fits. One person stated, "I have a much clearer picture of the entire project and also my part in it. Especially I now feel more like a representative of my country and my culture instead of just doing a job." It was also remarked that the orientation had helped explain the complicated relationships of superiors and inferiors in Egypt though someone added, "Although I do not feel too comfortable with my own ability to identify the best methods for myself to work within this relationship." Team building understandings were enhanced; one person observed that much had been gained by the team approach to preparation for training which had been going on for three months. A TDYer noted, "I was impressed by the great mass of team building ideas and the enthusiasm that the 'people' who are to be 'trainers' in Egypt received them." And another, "From a cultural point of view, I now realize some of the typically American approaches I've used in the past were probably counterproductive." The candid and good humored observations of some of the Egyptian EWUP personnel also contributed to increased understandings.

With the exception of "Cairo Health Notes" (not very accurate according to other information the participants had received), the readings were ranked as medium to high in perceived usefulness. Highest were "Islam and the West," "Manners and Customs of Egypt," and "Welcome to Egypt". Those that read the short stories found they showed many possible frustrations for Americans (Egyptians too!) but also similarities between the peoples. The tape recordings were felt to have been worthwhile listening.

Some suggestions: While the group termed the orientation "generally excellent", several stated that much of the information would have been more helpful had it been given earlier in advance of the departure date. If only the trainer group had been involved (and no TDYers), it may have been more effective to spread the sessions out over several weeks. One participant noted, "Knowing more (and having more time to assimilate) about Islam and how this culture spreads out from it would have given the training course planning a different direction."

Additional information on life in villages and farms as well as the role of women and family life was desired though it was realized that time constraints limited the amount of information that could be covered. One person wanted housing and cooking arrangements for the Americans to be explained more fully; information on money and banking added another.

The Student Center rooms were cost free. Another time having coffee and tea available in the room should be considered (approximately $10.00/day). This would contribute to the informality of the sessions as well as facilitating the give and take that occurs in a social setting.

The concept of distributing the readings a few per week seemed good; in practice the orientation readings got mixed up (and lost?) among all the other material the trainers were given. Preparing a notebook of selected readings early as possible and giving to the participants is recommended.. A book of readings should also be made available to TDYers. This could be a book that is circulated.

In conclusion, it was my pleasure to work on this orientation with both presenters and participants. The experience reconfirms my conviction that the people involved with the Egypt Water Use and Management Project (Egyptians and Americans) are its most important resource.

Faith L. Skold

Faith L. Skold
Assistant Coordinator
Office of International Training Programs
Colorado State University

ATTACHMENT I

EGYPT WATER USE & MANAGEMENT PROJECT ORIENTATION SCHEDULE

May 12 - 14, 1980
Colorado State University

All sessions will be held in Room 206, Lory Student Center unless noted otherwise.* Phone: 491-6395. Sessions will begin promptly.

MONDAY, MAY 12, 1980

8:00 - 11:00 a.m. *Room C140, Clark Building	Introduction to Egypt Videotape: "The Long Search: 'There is no god but God'"	Dr. William J. Griswold Department of History
2:00 - 4:00 p.m.	Cross-cultural Communication	Ms. Jean Griswold Office of International Services Ms. Nadia Henin Mr. Jim Griswold

TUESDAY, MAY 13, 1980

2:00 - 3:00 p.m.	Living in Kafr el Sheikh	Ms. Nancy Adams
3:15 - 5:00 p.m.	Coping in Another Culture	Dr. Max Lowdermilk
7:00 - 9:00 p.m.	Team Building	Dr. Douglas Benton Director of Special Programs College of Business

WEDNESDAY, MAY 14, 1980

8:30 - 9:30 a.m.	Overview: The EWUP Project	Dr. Melvin D. Skold
9:45 - 11:45 a.m.	Communication Network Within EWUP Organizational Structure	Ms. Nancy Adams Dr. Max Lowdermilk
1:30 - 3:30 p.m.	Panel: Expectations of Egyptians in Working with Americans	Ms. Faith L. Skold, Moderator Mr. Farouk Abdel Al Ms. Omnia El-Hakim Mr. Abdelfattah Metawie Mr. Mohamed Naguib
6:00 p.m. * At Lowdermilks, 1901 W. Mulberry	Potluck Supper	

OFFICE OF INTERNATIONAL TRAINING PROGRAMS
315 Aylesworth NE
Colorado State University
491-5917

ATTACHMENT II

List of Readings and Short Stories given to EWUP Trainers, Spring 1980

Culture Shock
Intercultural Adjustment Cycle
Present Shock, and How to Avoid It Abroad
Seven Concepts in Cross-cultural Interaction
Cultural Assumptions and Values Affecting Interpersonal Relationships
Islam and the West by William J. Griswold
Egypt's Fellahin: Part II by Richard Critchfield
Local Government in Egypt: Some New Change Strategies and Training Opportunities (especially Chapters 1 and 5) by James B. Mayfield
Welcome to Egypt by Micheline Brown
Cairo Health Notes
Manners and Customs of Egypt by Margaret Omar

A Child's Paradise by Nagib Mahfuz
Farahat's Republic by Yusuf Idris
The Lost Suitcase by Abdel-Moneim Selim

List of Audiotapes (from Psychology Today)

Coping with Change
How to Handle Depression: Tapes I & II
How to Overcome Discouragement
Solving Personal Problems
Two Techniques for Treating Stress Disorders

Office of International Training Programs
315 Aylesworth NE
Colorado State University
491-5917

ATTACHMENT III

Office of International Training Programs
315 Aylesworth NE
491-5917

EVALUATION OF EWUP ORIENTATION, May 12 - 14, 1980

Your responses to the questions will be helpful in our assessing the orientation and strengthening future ones. Our goals for the orientation were to prepare participants: 1) for successful survival in a new culture; and
2) for productive functioning for the duration of the training program.

*Did you find the presentation on "Islam in Egypt" (underline which) a review of what you already knew? a great amount to absorb in a short time? confusing? a useful perspective? valuable as a starting point?
*What are some of the ways in which your understanding of Islam has increased?

*Considering the amount of available time, what other information about Egypt's history/culture/religion would you have liked covered?

*How did the short stories, "The Lost Suitcase," "Farahat's Republic," and "A Child's Paradise," give you insights into the Egyptian culture and character?

*Was the discussion of "Cross-cultural Communication" (underline which) repetitive of what you already knew? helpful for specific concerns? too broad? informative?
*What behaviors/problems/ideas are you more aware of which may affect both successful survival and productive functioning?

*Did you receive sufficient information on living conditions? Any other areas you'd have liked covered?

*Do you feel that culture shock was overstressed?
Have you determined what you plan to do in times of depression and stress?
Has the orientation program helped you identify some of these?

*Has the orientation increased your understandings of the significance of the Egypt Water Use and Management Project and your part in it? If yes, in what ways?

*Has the orientation program helped explain the complicated relationships of superiors and inferiors in Egypt? And useful ways of dealing with them?

*Did you gain new insights into team building among Americans and Egyptians? Elaborate, please.

The following lists the readings sent to you during the past month. Please check those you read. Then circle the level of perceived usefulness of that article for yourself: (1 = High; 5 = Low)

	High				Low
___ Culture Shock	1	2	3	4	5
___ Intercultural Adjustment Cycle	1	2	3	4	5
___ Present Shock, and How to Avoid it Abroad	1	2	3	4	5
___ Seven Concepts in Cross-Cultural Interaction	1	2	3	4	5
___ Cultural Assumptions and Values Affecting Interpersonal Relationships	1	2	3	4	5
___ Islam and the West by William J. Griswold	1	2	3	4	5
___ Egypt's Fellahin: Part II by Richard Critchfield	1	2	3	4	5
___ Local Government in Egypt: Some New Change Strategies and Training Opportunities by James B. Mayfield (Especially Chapters 1 and 5)	1	2	3	4	5
___ Welcome to Egypt by Micheline Brown, US Embassy in Cairo	1	2	3	4	5
___ Cairo Health Notes	1	2	3	4	5
___ Manners and Customs of Egypt by Margaret Omar	1	2	3	4	5

Any general comments regarding the readings?

Any summary comments/suggestions/observations you'd like to make regarding any or all parts of the orientation program?

Thank you for your cooperation.

Cairo, Egypt

EWUP Workshop for Water Requirements and Evapotranspiration

June 24, 25, and 26, 1980

Topics to Be Discussed

1. Introduction and brief overview of Water Requirements Research and Units involved. (By Dr. Gene Quenemoen). (Encl. 1)

2. Objective of workshop.[1/] (Encl. 3)

3. Irrigation Requirements - Research on Influence of irrigation treatments or practices on yield.
   - Desirable to include a check treatment representative of local farm practice.
   - Plot layout to allow for analyses of results.
     - Randomization of treatments by blocks (Encl. 4).
   - Methods of scheduling irrigations for irrigation treatments.
     - Soil sampling and determination of moisture depletion.
       - Available moisture = Field capacity minus wilting percentage.
     - Tensiometers and range of usefulness. (Encl. 5)
       - Relationship of soil moisture tension to available moisture by soil types.
       - Available moisture levels at which tensiometers break suction by soil types.
     - Plant stage and crop appearance.
     - Electrical resistance blocks and limitation.
     - Neutron probe and limitations.
     - Evaporation pan--coorelated to irrigation treatments/ practices.

4. Measuring soil moisture and computing quantity of moisture depletion.
   - Elimination of excesssive sampling. Ten 9-cm samples compared to six 15-cm samples in 90-cm depth.
   - Gravimetric method - weighing soil samples before and after drying, and use of formula

$$d = \frac{PA_sD}{100} \quad \text{where}$$

A_s = Apparent Specific Gravity (bulk density)
d = depth of water in soil, cms
P = moisture percent in soil, dry weight basis
D = depth of soil sampled, cms

   - Plotting data as in Encl. 6.
     - Plotted allows for depletion betweeen date of irrigation and date of sampling.

1/ Eldon G. Hanson and Mona El Kady will present the remainder of the workshop.

Enclosure B

Depletion data will probably include some deep drainage losses where:

Water table is within 2 or 3 meters from the ground surfa
Soils have not drained between irrigation date and sampling date after irrigation. (Encl. 7).

Depletion curves may exclude upward flow from high water tables which is shown in Encl. 8. Some soils have an upward flow of 1 mm per day with a water table deeper than 1 meter below the root zone.

Soil moisture depletion is equal to consumptive use only where deep drainage and/or upward flow are omitted.

5. Consumptive use defined. (Is essentially equal to evapotranspiration; cite difference). (Encl. 9)

6. Importance of consumptive use

Used in farm-irrigation planning.
Size of channels for peak demands.
Used in irrigation-water management.

$$1R = \frac{100\ ET}{E} \qquad \text{(Encl. 10)}$$

$$1R = \frac{100\ (E_t + LR - r_e - M_c - M_g)}{E} + L_c \qquad \text{(Encl. 11, 12)}$$

7. Measuring Consumptive Use

Sprinkler line source method (cannot have influence from a water table, W.T.) (Encl. 13, 14)
Lysimeter method (needed if high W.T. is present)
Weighing type
Drainage type (non-weighing) (Encl. 15)

ET = I + R - D + SMD, where
ET = evapotranspiration, cms
I = Irrigation water applied, cms
R = Rainfall, cms
D = Drainage water, cms
SMD = Soil moisture depletion, cms

8. Measure yield simultaneously with consumptive use.
Needed to determine crop-production functions showing relationship of consumptive use to yield. (Encls. 16 & 17

Crop-production function needed to determine normal consumptive use. (Encl. 18)
Normal consumptive pertains to evapotranspiration that occurs with average yields on farms in a valley or in an irrigation project.

9. Measuring yield on experiment plots.
   Crop growth or yields near the edge or border of a plot may be 30 percent greater than yields at the interior of the plot. Official plot yields should exclude yields from border areas. Two meters should provide sufficient width of buffer area. This buffer area width also applies to the ends of rows in a plot.

10. Measuring irrigation water on experimental plots.
    Measure stream to one plot at a time.
    Reasons why each plot may not receive half of the stream if the stream is discharged to two plots simultaneously. (Encl. 19)

    In measuring with weirs having suppressed end contractions, the head H should be measured at a distance of 4H upstream. Measured H at the weir will be approximately two-thirds of the correct H. (Encl. 20)

    Where long channels exist between the weir and the plots, a change of water depth during measurements causes errors due to channel storage changes. Channels in the system which are not being used during measurements to plots should be blocked off with gates or dams from the part of the system in use. (Encl. 21)

11. Relating pan evaporation to consumptive use and yield.
    Pan evaporation (Epan) is a "reflection" of all climatic factors influencing consumptive use.

    Epan may be used effectively as a base to which irrigation treatments and scheduling may be related as shown in Encl. 22.

12. Analyses of crop yields by treatments. Submit to Mr. Helal, soon after yields are tabulated, a copy of plot yields and treatments.
    A computer program will analyse results which will be recorded in a form similar to Encl. 23.

    Researcher should provide statement summarizing the objectives, procedure and results. A copy of the statement and computer analyses will be reproduced for:

    Dr. Wahby
    Dr. Brooks
    Nadia Wahby
    Researcher

13. The EWUP Workshop is to end by 11:30 a.m. June 26. At 12:00 Noon, workshop participants are to attend a seminar by Dr. Robert King entitled "Yield Responses to Water". The seminar will deal with crop yield responses to water and a general model for evaluating the economic consequences of water management alternatives.

WATER MANAGEMENT AND IRRIGATION TECHNOLOGIES RESEARCH INSTITUTE

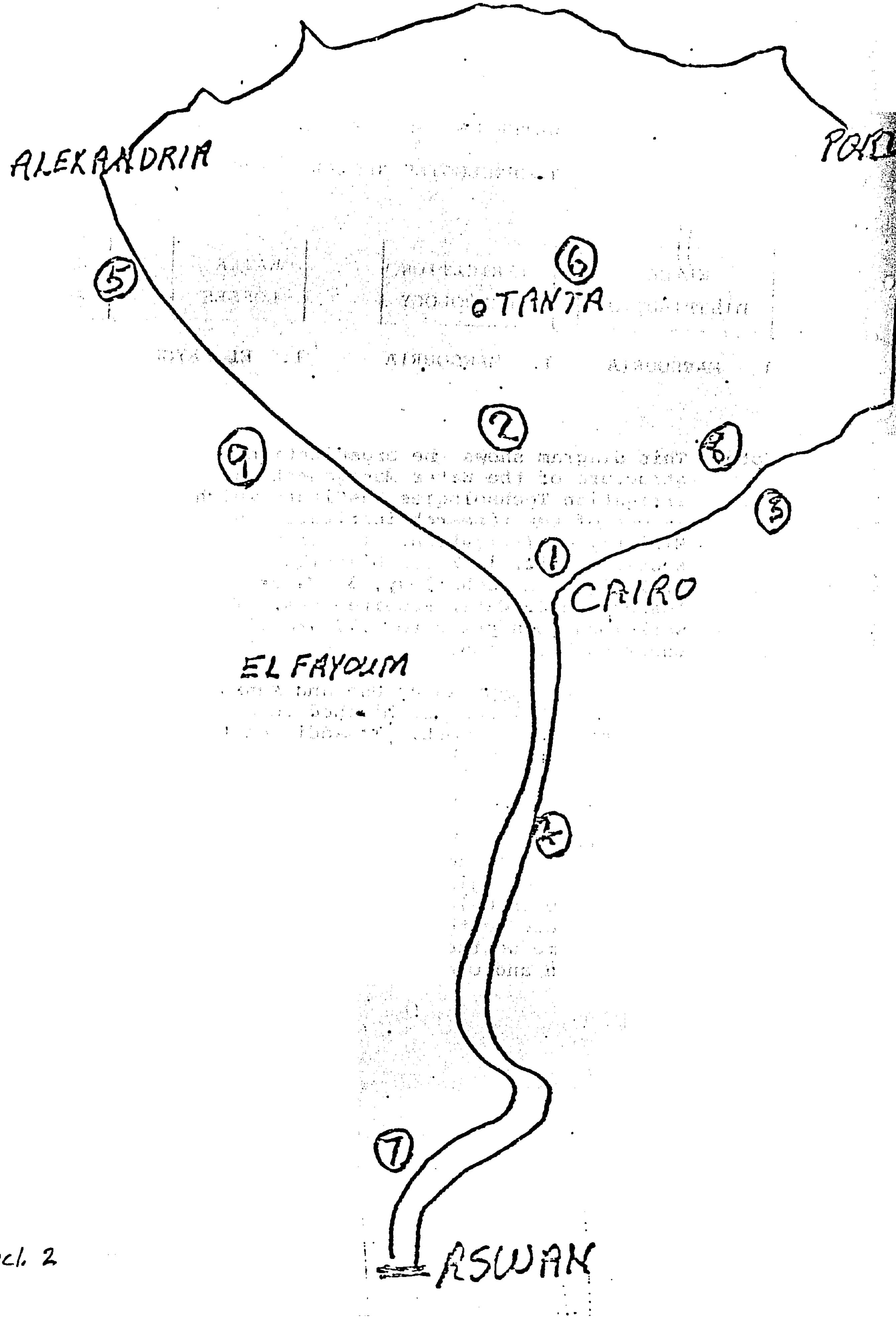
WATER DISTRIBUTION	IRRIGATION TECHNOLOGY	WATER LOSSES	WATER REQUIREMENT
1. MANSOURIA	1. MANSOURIA	1. EL FAYOUM	1. BAHTEEM
			2. SHIBEEN EL KO
			3. ANSHAS
			4. MALAWI
			5. MARIOUT (KING OSMAN
			6. SAAKA
			7. KOM OMBO
			8. EL ZANKALOON
			9. WADI EL NATRO

Note: This diagram shows the organizational structure of the Water Management and Irrigation Technologies Institute which is one of ten research institutes in the Ministry of Irrigation. It has four sections, viz. 1. Water Distribution, 2. Irrigation Technology, 3. Water Losses and 4. Water Requirements. The work locations prior to 1977 are listed under each section.

In 1977 the Egypt Water Use and Management Project (EWUP) was established to do on-farm water management work. In addition to Mansouria, sites for this work were added at Kafr El Sheikh and El Minya. All four sections are important for on-farm water management.

Each Water Requirements station is operated by an agricultural engineer who is supervised by a staff of five engineers from the Institute's main office in Cairo. Anshas and Wadi Natroon have complete weather stations. The others collect some weather data in addition to water application and crop yield data.

Encl. 1



Encl. 2

Objectives of this workshop are to aid researchers to improve technology in:

- Determining when to irrigate.
- Determing how much water to apply.
- Measuring soil moisture tension.
- Measuring soil moisture status & depletion.
- Measuring water to research plots.
- Measuring consumptive use.
- Measuring crop yields.
- Recognizing sources of errors and making adjustments to minimize errors.
- Reporting research findings so that the information becomes available to people who may benefit from the results.

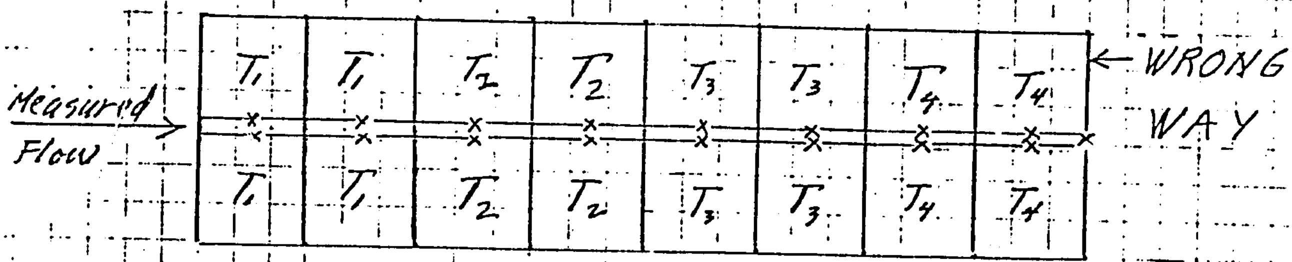
An over-riding objective is to develop in the participants of the workshop more appreciation of the importance of their research program and the need to be honest in reporting factual information, free from bias or predetermined conclusions.

Encl. 3

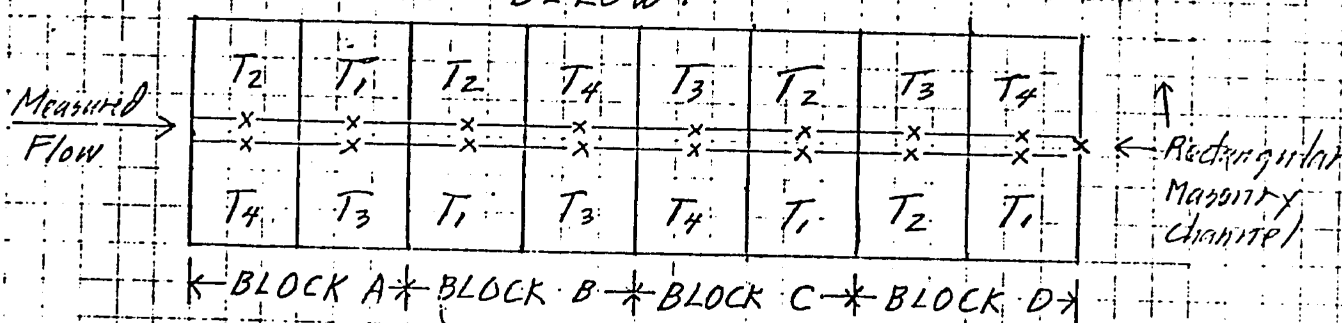
INFLUENCE OF IRRIGATION PRACTICES OR TREATMENTS ON COTTON YIELDS

Experiment Station Project XXX.

1980



TREATMENTS SHOULD BE RANDOMIZED BY BLOCKS AS SHOWN BELOW.



TREATMENT	PLOT No.	WATER APPLIED CMS	YIELD Kg/fed
T2	A 1	60.00	430.000
T1	A 2	50.00	400.000
T2	B 3	60.00	425.000
T4	B 4	80.00	330.000
T3	C 5	70.00	385.000
T2	C 6	60.00	330.000
T3	D 7	70.00	370.000
T4	D 8	80.00	355.000
T4	A 9	80.00	435.000
T3	A10	70.00	450.000
T1	B11	50.00	370.000
T3	B12	70.00	420.000
T4	C13	80.00	365.000
T1	C14	50.00	355.000
T2	D15	60.00	360.000
T1	D16	50.00	350.000

EXAMPLES OF TREATMENTS USING TENSIOMETERS & PAN EVAPORATION

TREATMENT DESCRIPTION	
T1, IRRIGATE AT 20 CENTIBARS Epan CMS (*)	T1, IRRIG. AT 40 CENTIBARS AND 0.4 Epan
T2, IRRIGATE AT 40 CENTIBARS Epan CMS	T2, IRRIG AT 40 CENTIBARS AND 0.8 Epan
T3, IRRIGATE AT 60 CENTIBARS Epan CMS	T3, IRRIG AT 40 CENTIBARS AND 1.0 Epan*
T4, IRRIGATE AT 80 CENTIBARS Epan CMS	T4, IRRIG. AT 40 CENTIBARS AND 1.2 Epan

(*) Epan CMS = Total CMS of PAN EVAP. SINCE LAST IRRIG.

Encl. 4

Max. tension at sea level = 85 centibars, approx

Moist. Depletion of Avail
Water % when tensiometer
breaks suction
15± % in clay
65± % in loam
75± % in sandy loam
~~85± % in fine sandy loam~~

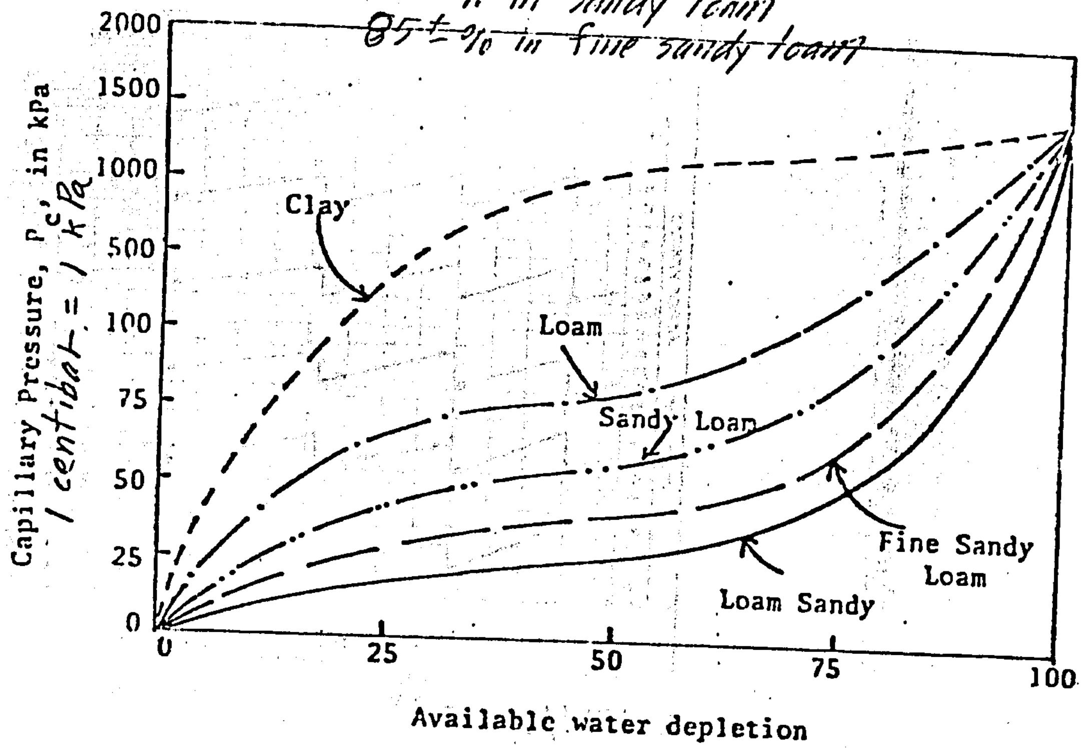


Figure 6-3. Soil water retention curves for soils of different textures (Richards and Marsh, 1961). See References, Page

Encl. 5

a given soil when permanent wilting is attained, a common factor to evaluate the amount of water which remains in soils at permanent wilting cannot be used."

The seasonal moisture percentage variations of the soils of different

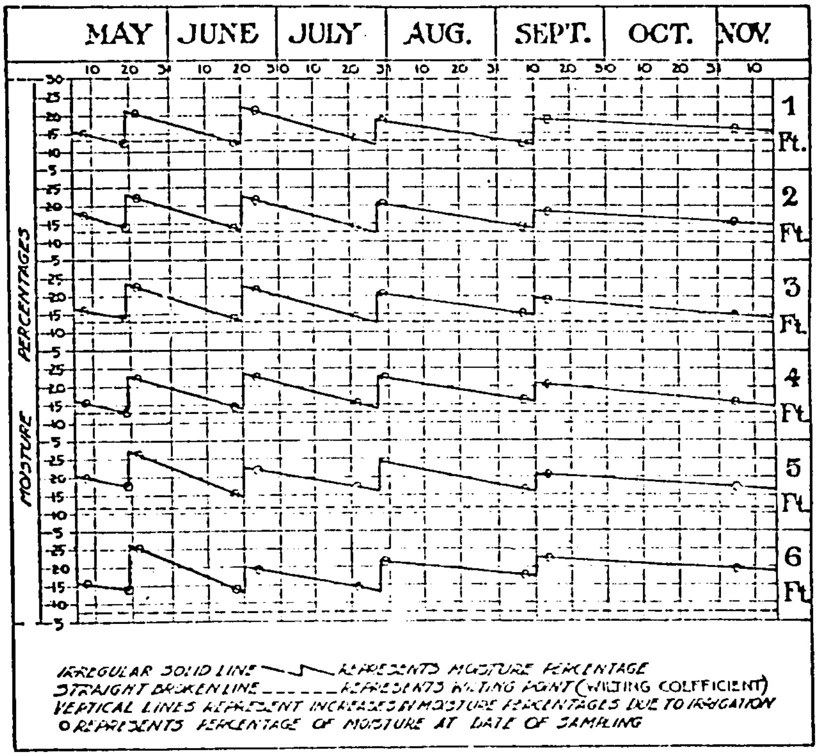


FIG. 155. Showing seasonal variation in soil moisture percentages. Wigno alfalfa field, Los Molinos, 1914. (*Calif. State Dept. of Eng. Bul.* 3.) See References Page 33

experimental plats at Delhi, California, under various irrigation treatments are presented in Fig. 156.

The average depths of water applied in each of the four treatments, or groups of treatments, were as follows:

Treatments *A* and *F* received the greatest depths of water, an average of 25.3 acre-inches per acre during each year; treatment *D* received the next largest, an average annual application of 19.8 acre-inches per acre; and treatment *B* received less water than *D*, or 13.4 acre-inches per acre; and treatments *C*, *G*, and *E* received only approximately one-half the depths applied on *A* and *F*, or 11.1 acre-inches per acre each year.

Encl. 6

Encl. 7

11

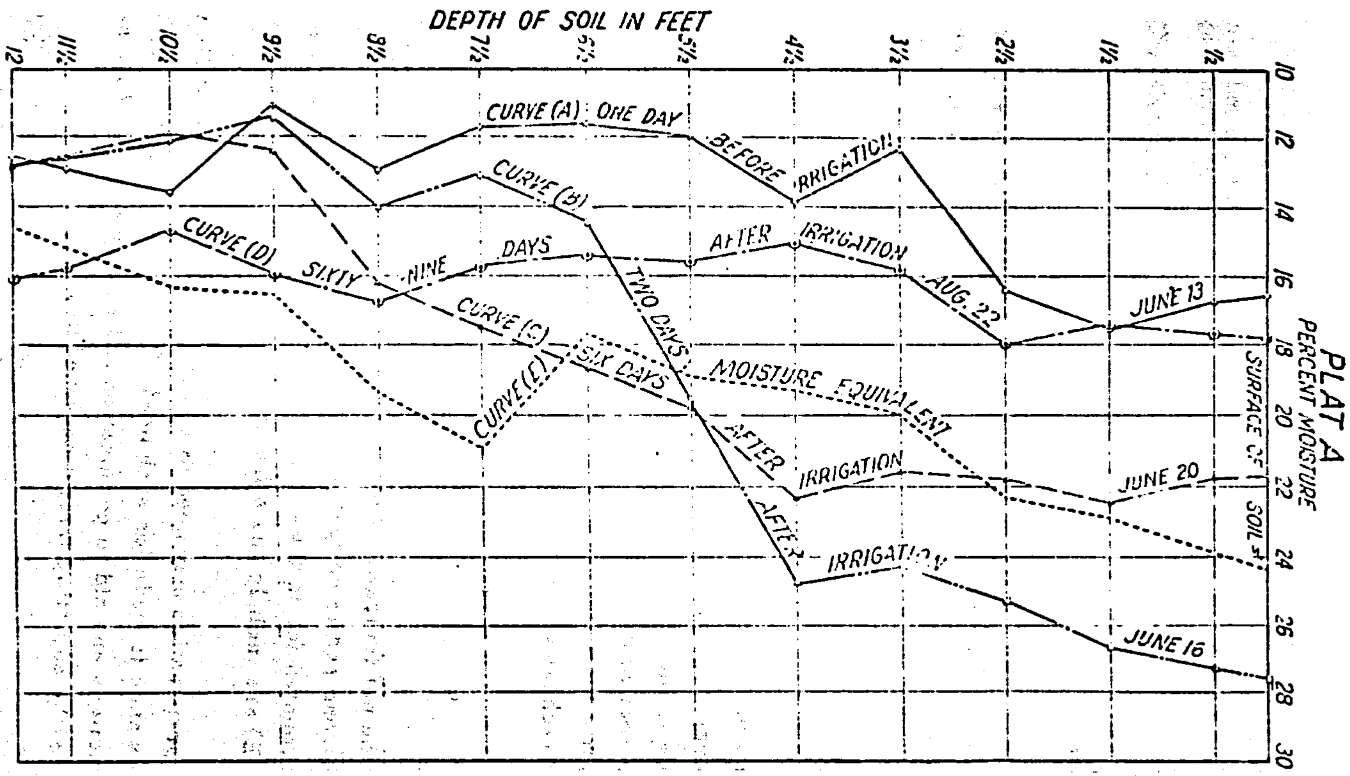
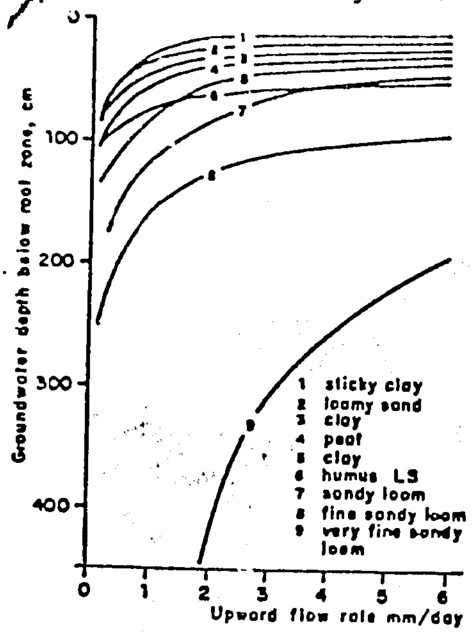


FIG. 118. Distribution of moisture in soil at different periods after a 12-in. irrigation. (Calif. Agr. Exp. Sta. *Hilgardia*, Vol. 2, No. 14.) See References Page 33

mm/day for different depths of groundwater below the root zone and various soil types assuming the root zone is relatively moist.



EXAMPLE:

Given:

Sandy loam soil; groundwater depth below root zone in December and January is 80 cm.

Calculation:

Using Fig. 18 a first estimate of groundwater contribution to ETcrop is some 1.5 mm/day.

Fig. 18 Contribution of groundwater to moist root zone in mm/day

See References, Page 33

(iii) Stored soil water (Wb)

Winter rains, melting snow or flooding may cause the soil profile to be near or at field capacity at the start of the growing season, which may be equivalent to one full irrigation. Also some water may be left from the previous irrigation season. It can be deducted when determining seasonal irrigation requirements. Excess winter rain will leach salts accumulated in the root zone in the summer season and as such can be assumed effective.

Water stored in the root zone is not 100 percent effective. Evaporation from the wet soil surface is equal to open-water evaporation, but this rate decreases as the soil dries. Evaporation losses may remain fairly high du to the movement of soil water by capillary action towards the soil surface. Water is lost from the root zone by deep percolation where groundwater tables are deep. Deep percolation can still persist after attaining field capacity. Depending on weather, type of soil and time span considered, effectiveness of stored soil water may be as high as 90 percent or as low as 40 percent.

1.2.3 Irrigation Requirements

Other than for meeting the net irrigation requirements (In), water is needed for leaching accumulated salts from the root zone and to compensate for water losses during conveyance and application. This should be accounted for in the irrigation requirements. Leaching requirements (LR) and irrigation efficiency (E) are included as a fraction of the net irrigation requirements.

Water needed for land preparation may need to be considered in the case of rice. At the planning stage normally no allowance is made for such needs for other crops; this applies similarly to water needs for cultural practices and aid to germination and quality control of the harvested yield. They are usually covered by adjusting irrigation schedules.

Encl B

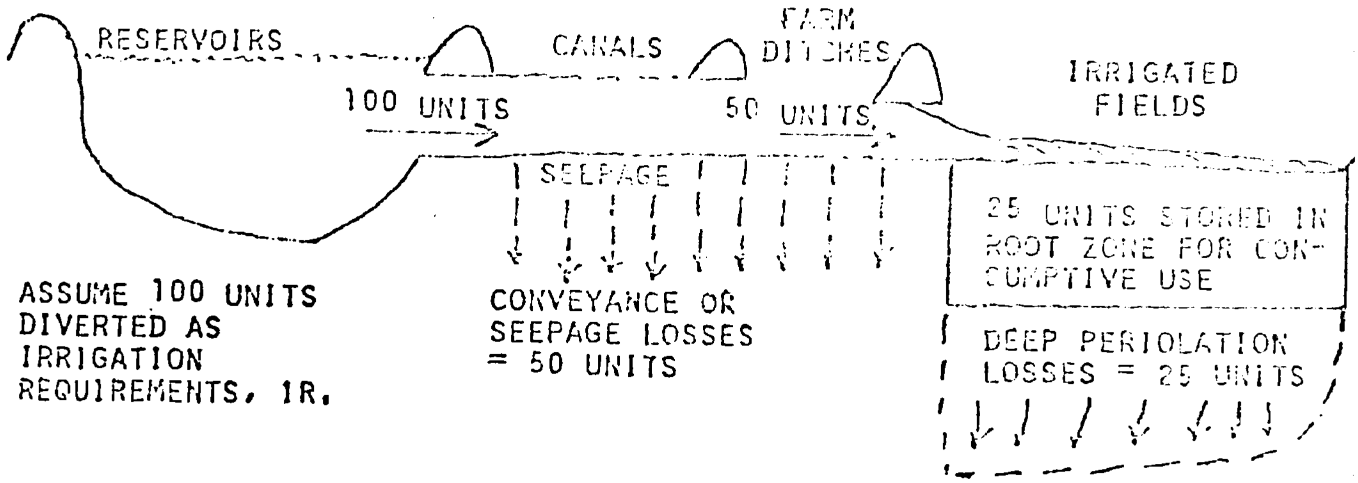
DEFINITION OF CONSUMPTIVE USE (EVAPOTRANSPIRATION, ET): THE QUANTITY OF WATER TRANSPIRED BY PLANTS, RETAINED IN PLANT TISSUE, AND EVAPORATED FROM ADJACENT SOIL SURFACES IN A SPECIFIED TIME PERIOD. USUALLY EXPRESSED IN DEPTH OF WATER. AS USED HEREIN, CONSUMPTIVE USE IS SYNONYMOUS WITH EVAPOTRANSPIRATION.

NORMAL CONSUMPTIVE USE PERTAINS TO THE EVAPOTRANSPIRATION THAT OCCURS WHEN CROPS PRODUCE AVERAGE YIELDS.

DETERMINATION OF NORMAL CONSUMPTIVE USE REQUIRES CROP-PRODUCTION FUNCTION WHICH SHOW THE RELATIONSHIP OF EVAPOTRANSPIRATION TO YIELD.

Encl. 9

KNOWLEDGE OF CONSUMPTIVE USE OR ET IS IMPORTANT IN THAT IT IS USED AS A BASE IN DETERMINING IRRIGATION REQUIREMENTS OF CROPS AS SHOWN IN THE FOLLOWING FIGURE AND EXAMPLE.



$$\text{IRRIGATION EFFICIENCY} = \frac{\text{25 UNITS STORED IN ROOT ZONE}}{\text{100 UNITS = IR (RESERVOIR DIVERSION)}} = 25\%$$

$$\text{CONVEYANCE EFFICIENCY} = \frac{\text{50 UNITS DELIVERED}}{\text{100 UNITS DIVERTED}} = 50\%$$

$$\text{FIELD APPLICATION EFFICIENCY, } E_a = \frac{\text{25 UNITS STORED}}{\text{50 UNITS APPLIED TO FIELDS}} = 50\%$$

$$\text{IRRIGATION EFFICIENCY} = (E_c = 50\%)\ (E_a = 50\%) = 25\%$$

IRRIGATION REQUIREMENTS, IR, MAY BE COMPUTED IF CONSUMPTIVE USE AND IRRIGATION EFFICIENCY ARE KNOWN THUS:

$$IR = \frac{\text{25 UNITS OF CONSUMPTIVE USE}}{\text{IRRIGATION EFFICIENCY = 25\%}} = \frac{25}{.25} = \text{100 UNITS}$$

Encl. 10

$$1R = \frac{100(E_t + LR - r_e - M_c - M_g)}{E} + L_c$$

Where: $1R$ = Irrigation water requirements

E_t = Evapotranspiration

LR = Leaching requirements

r_e = Effective rainfall

M_c = Carryover soil moisture

M_g = Groundwater contribution

E = Field application efficiency

L_c = Conveyance and operations losses

Evapotranspiration and Farm Irrigation Planning and Management

Dell G. Shockley See References, Page 33

AN irrigated farm is, in effect, a small irrigation project. In some cases use of the adjective "small" might even be debatable. Many individual farms have several hundred acres of irrigated land, and individual farms with over a thousand irrigated acres are not uncommon. Also, according to the 1959 census of agriculture, 59 percent of the irrigated acreage in the United States is served from water sources on the farm. Only 41 percent is irrigated with water received from irrigation organizations. It thus appears likely that the evapotranspiration data needed for irrigation planning on individual farms may not be greatly different than needed for planning an irrigation project. However, more detailed data may be expected to be needed for on-farm irrigation-water management than usually is required for project management purposes.

The role of evapotranspiration in farm irrigation planning and in on-farm irrigation water management can be portrayed best by describing and discussing the various uses of evapotranspiration data in planning and management. However, first it should be noted that evapotranspiration data generally are used indirectly. The factor directly used in irrigation planning, and in most water-management decisions, is "irrigation water requirement." Evapotranspiration is only one component of the irrigation water requirement equation, which might be written as follows:

$$IR = \frac{100(E_t + LR - r_e - M_c - M_g)}{E} + L_c$$

where

IR = irrigation water requirement
E_t = evapotranspiration
LR = leaching requirement
r_e = effective rainfall
M_c = carryover soil moisture
M_g = groundwater contribution
E = field application efficiency
L_c = conveyance and operations losses

The importance of the separate components of the equation varies from place to place, and design values are largely empirical. The leaching requirement, for example, can vary from zero in areas where irrigation waters are relatively pure and rainfall is sufficient to prevent any buildup of salinity, to over half the consumptive-use requirement in arid areas where salty waters must be used.

Effective rainfall has less significance in arid areas, where total growing season precipitation is light, than in the more humid areas where rainfall may be sufficient, or nearly sufficient, to meet crop needs. The actual amount of rainfall that can be considered effective in any area depends, not only on the soil's ability to absorb and store the water in the crop root zone, but also upon the selected probability of occurrence of the rain. Since there are no records of effective rainfall available, the designer must estimate these values from an analysis of the records of total rainfall.

Carryover soil moisture also varies greatly. It depends on the moisture-holding characteristics of the soil, the crop root zone depth, the moisture content of the root zone profile at the end of the growing season, and the amount of nongrowing season precipitation available for storage. In some desert areas no carryover soil moisture can be relied upon, but in other areas a substantial portion of the consumptive-use requirements of deep-rooted crops may be furnished by this carryover moisture.

The groundwater contribution to consumptive use depends on the relative position and stability of the water table, the capillary characteristics of the soil, the type of crop being grown, and the quality of the groundwater. Static water tables that are more than a few feet below the effective root zone of the crop, and widely fluctuating water tables, usually are of little benefit. On the other hand, water tables that have stabilized at depths within easy reach of the crop roots may furnish all, or nearly all, of the crop consumptive-use requirements.

Field-application efficiencies are not only extremely variable, they also are difficult to estimate with any degree of reliability. They depend not only upon the physical conditions of the site but also upon the desires and management skill of the irrigator. Physical factors that can affect or influence efficiencies include such things as intakes and water-holding characteristics of the soil, the adequateness of land preparation and irrigation facilities, and the method of water application employed. Under especially favorable circumstances, irrigators of only moderate skill may commonly achieve efficiencies of over 90 percent. On the other hand, with unfavorable physical conditions, even the most skilled irrigators may fail to achieve an average efficiency level of 50 percent.

Conveyance and operations losses may vary from practically zero in closed-pipeline distribution systems to amounts far in excess of evapotranspiration needs in extensive open-ditch systems with inadequate water regulation and control facilities.

If the significance of the various components of the irrigation-water requirement equation is kept in mind, it will help in placing the role of evapotranspiration in its proper perspective. It is an important part of the overall water-requirement problem, and accuracy in its determination is desirable. However, the relatively indeterminate nature of most of the other factors involved indicates that complex and time-consuming procedures to achieve extreme precision seldom will be justified for farm-irrigation planning or for on-farm irrigation water management.

Use of Evapotranspiration Data in Farm-Irrigation Planning

One of the most common uses of evapotranspiration data is as a basis for estimating the acreage of various crops, or combinations of crops, that can be irrigated with a given water supply. For example, a farmer has a flowing stream or a well on his farm and he wants to know how much of his land he should develop for the production of irrigated crops. A satisfactory solution for this kind of problem usually can be obtained by comparing the monthly volumes of irrigation water demand per acre with the corresponding monthly supply volumes. For this purpose monthly values of evapotranspiration are needed. These volumes have to be modified to reflect the effects of the other components of the irrigation-water requirement equation. In addition, the planner must consider the reliability of the water supply. A well usually may be considered to have a constant potential production rate, but the flows of most natural streams vary considerably from year to year. The

The author—DELL G. SHOCKLEY—is irrigation engineer, engineering and watershed planning unit, SCS, USDA, Portland, Ore.
* Numbers in parentheses refer to the appended references.

Encl. 12

planner must decide whether a supply adequate say 5 years out of 10 is satisfactory, or if a smaller, more reliable supply, should be used to determine the acreage.

In situations such as described above, where the irrigation water is obtained by direct diversion from a stream or a well, the supply-demand relationship in one of the months usually will be found to be limiting. For example, if the water supply is from a well with a constant production rate, the area that can be irrigated will be limited by the acreage that can be served during the month of peak demand. In fact for some crops and some soils the critical period may be less than a month.

There are many variations of this water supply versus water demand problem. If the water supply is a stored volume, available for delivery to the fields as needed, the acreage that can be served can be computed by dividing this volume by the total seasonal volume of water required per acre. In this case, monthly or other short-period values of evapotranspiration are not needed. Total seasonal values are sufficient.

Sometimes a reverse type of problem is involved. A farmer desires to irrigate given acreages of certain specified crops and needs to know how much water will be needed. If he expects to use stored water, or water from any source that will be available at the field as required, he needs only information as to the total seasonal irrigation-water requirements of the specified crops. However, if he expects to develop the needed water supply by drilling wells, he needs to know the maximum demand rate.

In many irrigated areas of the world, growing seasons are essentially continuous. Crops may be planted at different times of the year depending on market conditions or other factors not necessarily related to irrigation. Also, in many such areas it is common to double-crop land, and in some instances as many as three separate crops are grown in a single year. Consumptive use of water and irrigation need for a fall or winter-grown crop may be greatly different from the requirements for the same crop grown in the spring or summer. In order to determine water supply requirements or to plan cropping patterns to best utilize available supplies, the planner must be able to estimate evapotranspiration needs and irrigation-water requirements for any appropriate crop growing season.

Another planning need for evapotranspiration data is in determining farm irrigation-system capacity requirements. Irrigation systems must be capable of supplying water to a cropped area at the rate needed to maintain soil moisture conditions required for optimum plant growth. The period used for computing capacity requirements is the period between normal irrigations during which the average daily rate of consumptive use is at a maximum. The length of the period is the number of days the readily available water stored in the crop-root zone will last under this peak rate of use. The length of the peak-use period in a given area thus is a function of the soil as well as of the crop. Where only a limited amount of readily available moisture can be stored in the root zone profile, the peak-use period between irrigations may be no longer than 3 or 4 days. On other sites, where greater amounts of moisture can be stored, the minimum interval between irrigations may be several times as long. For capacity design then, the planner must be able to estimate maximum evapotranspiration use for periods varying from 3 to perhaps 30 days.

Use of Evapotranspiration Data in Irrigation-Water Management

A growing use of evapotranspiration data is for scheduling irrigations. In the eastern United States, for example, many farmers are using a moisture accounting method to determine when to irrigate and how much water to apply. Stucky (3) has described this moisture accounting method as follows:

"The moisture accounting method is similar to the bank account record used in keeping a personal checking account. Available moisture stored in the effective root zone is like a bank balance on hand. Irrigation and effective rainfall are deposits to the account, and daily evapotranspiration is a withdrawal from the account. The maximum balance is the available moisture holding capacity of the effective root zone. Normally the minimum balance is 50 percent of the total available moisture in the effective root zone. As the daily balance approaches the minimum figure, the need for irrigation is indicated."

In order to use the moisture-accounting method, the irrigator must be able to make reasonably accurate estimates of daily rates of evapotranspiration. Starting with the soil moisture at a known level (usually field capacity), the irrigator each day subtracts the amount of water consumptively used by the crop and adds whatever rainfall occurs until his balance sheet shows the soil moisture depleted to the point where an irrigation is applied which should return the soil moisture to field capacity. If an irrigation increases the soil moisture to field capacity, then the balance sheet is in effect started over again and errors in estimating evapotranspiration are cumulative only from one irrigation to the next. Rainfall sufficient to return the root-zone profile to field capacity also provides a new starting point and reduces cumulative errors.

The moisture accounting method has, so far, had greatest use in relatively humid areas. There are several reasons why this has happened. In general, evapotranspiration rates are more variable and precipitation rates are greater in these areas than in arid areas. Consequently irrigations are required at more irregular intervals. Also, the generally shallower effective root zones in humid areas require more frequent irrigations when precipitation does not occur.

More irrigators, including many in the arid and semiarid western United States, would use the moisture accounting method for scheduling irrigations, if they had an easy way to make relatively accurate determinations, or estimates, of daily evapotranspiration. In the northeast, the Soil Conservation Service furnishes farmers with generalized tables which provide for daily adjustments based on observations of sunshine hours. This procedure has worked well in that area. However, new tables and different adjustment factors, or possibly an entirely new kind of estimating procedure, will be needed in the arid western areas. For effective use in scheduling irrigations, evapotranspiration estimates should be sufficiently accurate that cumulative errors between individual irrigations generally will not exceed about 10 or 15 percent. Variations and uncertainties regarding the amount of available moisture held in the root zone profile usually are of sufficient magnitude to make greater precision in estimating evapotranspiration unnecessary.

In several of the western states attempts are being made to use evaporimeters to schedule irrigations. These evaporimeters vary from a 12-in. square, double-bottomed pan, developed at Oregon State University for use in scheduling pasture irrigations, to standard U.S. Weather Bureau pans, used in Hawaii and Washington for a wide variety of crops. The Oregon State University pans are designed for a pasture crop coefficient of 1.00, so when a given amount of water has evaporated from the pan, it is assumed that the same amount has been extracted from the soil profile. However, all evaporation pans, provide only indirect measurements of evapotranspiration. Soil moisture losses may be more or less than the measured evaporation, depending on the crop and its stage of growth, and site conditions of the pan. The successful use of these evaporimeters depends on the development of reliable crop coefficient curves.

One of the main advantages of the use of Weather Bureau pan-type evaporimeters is that one properly designed installation can serve several hundred, or even perhaps several thousand, acres of irrigated lands. Information on daily rates of evaporation and cumulative totals can be published in local newspapers and broadcast by local radio stations. Individual farmers, then, can compute the evapotranspiration of their particular crops by multiplying the evaporation values by appropriate crop coefficients or by using the Irrigation Scheduling Board developed at Washington State University (1, 2).

Another important use of evapotranspiration data is to evaluate the over-all efficiency of irrigation water use on a field or on the entire farm. Usually the efficiency of an individual irrigation is determined by comparing the volume of water delivered to a field to the volume needed to replenish the measured or estimated soil moisture deficiency in the crop root zone. This procedure, however, is not suitable for a determination of over-all seasonal irrigation efficiency unless an evaluation is made of each individual irrigation. The best way to appraise over-all efficiency is to compute the ratio of the total net irrigation water requirement of the crop, or crops, to the total volume of water applied on the field or delivered to the farm. The validity of this appraisal is, of course, entirely dependent upon the accuracy of the data used in the computations. Seasonal evapotranspiration values usually will be adequate.

Summary

An irrigated farm is, in effect, a small irrigation project and evapotranspiration data needed for planning and irrigation water management purposes on individual farms likely are not greatly different from the data needed for irrigation project planning and management.

Evapotranspiration data generally are used indirectly in farm irrigation planning and on-farm irrigation water management. The factor directly used is *irrigation water requirement*. Evapotranspiration is only one component of the irrigation-water requirement equation. It is an important component and accuracy in its determination is desirable, but because of the relatively indeterminate nature of the other factors involved, complex procedures to achieve extreme precision seldom will be justified.

In farm irrigation planning, evapotranspiration data are used as a basis for estimating the acreage of various crops, or combinations of crops, that can be irrigated with a given water supply or as a basis for estimating the amount of water that will be required to irrigate a given acreage. If the water is stored or is otherwise available at the field as required, total seasonal evapotranspiration requirements only will be needed. However, if the water is supplied by direct diversion from natural streams or from wells, monthly values of evapotranspiration will be required.

Another planning need for evapotranspiration data is in determining farm-irrigation system capacity requirements. For this purpose the planner must be able to estimate maximum evapotranspiration use for periods varying in length from 3 to perhaps 30 days.

A growing use of evapotranspiration data is for scheduling irrigations. In the humid areas of the eastern United States, many farmers are using a moisture accounting method to determine when to irrigate and how much water to apply. To use this method, irrigators must be able to make reasonably accurate estimates of daily rates of evapotranspiration. Cumulative errors between individual irrigations usually should not exceed about 10 or 15 percent.

In several of the western states evaporimeters are being used to tell when to irrigate. Some are designed for a crop coefficient of 1.0. All, however, provide only indirect measurements. Their successful use depends on the development of reliable crop-coefficient curves. Their main advantage is that one evaporimeter can serve a large area of irrigated land.

Evapotranspiration data are used as a basis for evaluating the overall efficiency of irrigation water use on a field or on an entire farm. For this purpose total seasonal values are all that are required.

References

1 Jensen, M. C., Middleton, J. E., and Pruitt, W. O. Scheduling irrigation from pan evaporation. Sta. Cir. 386, Wash. Agr. Exp. Sta., Washington State Univ., Pullman, May 1961.

2 Pruitt, W. O. Irrigation scheduling guide. Agricultural Engineering 38:(3)180-181, March 1956.

3 Stucky, G. E. Operational use of evapotranspiration values in the Northeast. ASAE Paper No. 66-213, ASAE, St. Joseph, Mich. 49085.

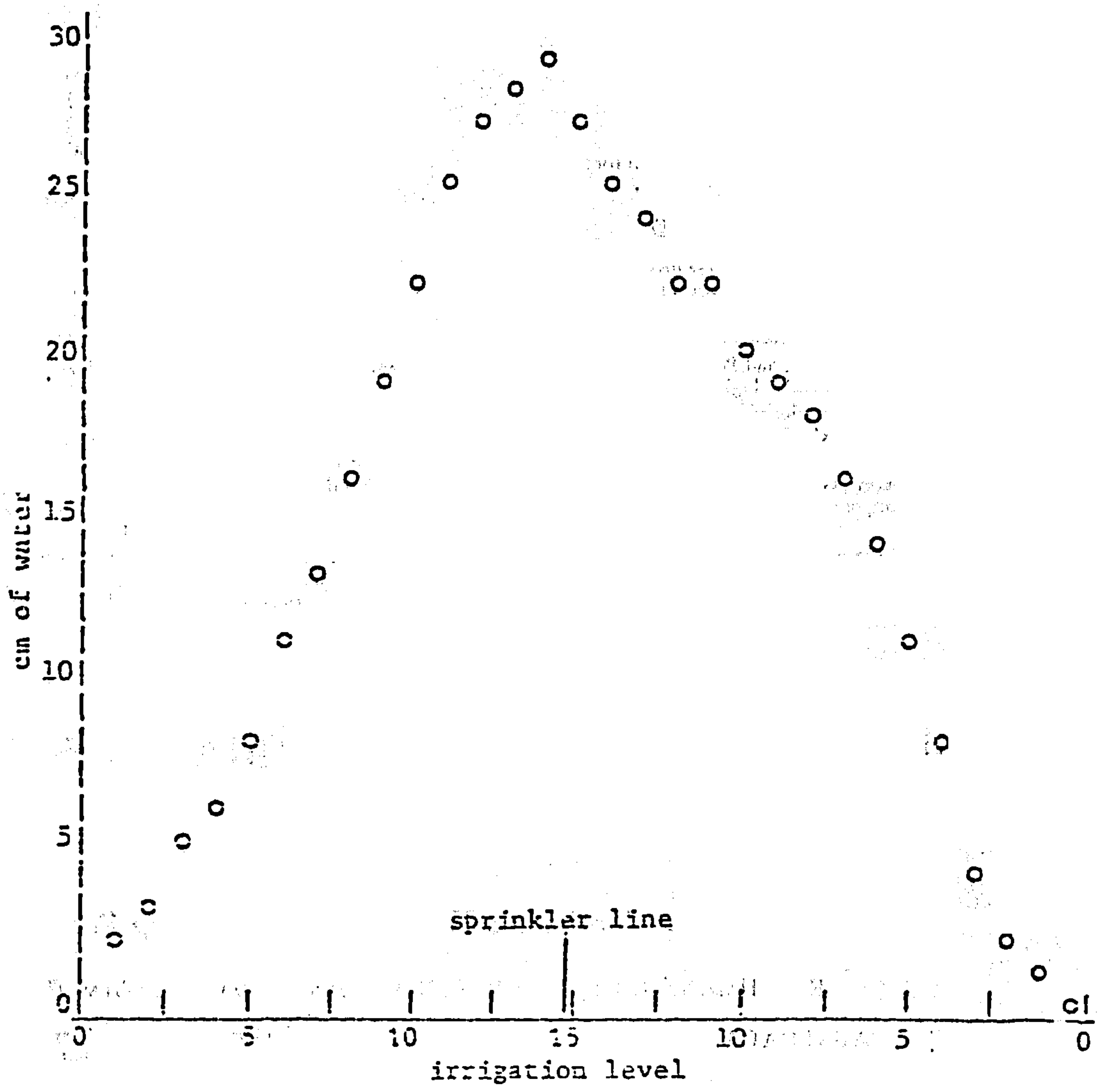


Figure 5. Total seasonal applied water to the cotton plot (1978) using a sprinkler-line source excluding 16.9 cm (6.7 in.) of rainfall.

See References, Page 33

Encl. 12

grasses was observed in some sites and may be the result of the increased base status.

During the inactive stage of this cycle, the absence of protective vegetative cover, the collapse of the surface mound, the increased macropores and the subangular blocky structures, could all contribute to a rapid redistribution of soil constituents.

Although it is difficult to evaluate the total effects of biosynthetic alterations in this area, it is apparent that ants do in fact retard or alter the "normal" leaching and horizonation of the soils studied. It is apparent, however, that following desertion of the colonies, the soils tend toward a steady state with the environmental conditions.

ACKNOWLEDGMENT

The authors extend their appreciation to U. Bachinski for technical assistance.

LITERATURE CITED

1. Baxter, F. P., and Hole, F. D. 1966. Ant (*Formica cinerea*) pedoturbation in a Prairie soil. Soil Sci. Soc. Am. Proc. 31:425–428.
2. Canada Soil Survey Committee. 1970. The system of soil classification for Canada. Can. Agric. Queen's Printer, Ottawa.
3. Czerwinski, Z., Jakubczyk, H., and Petal J. 1971. Influence of ant hills on the meadow soils. Pedobiologia VII:277–285.
4. Day, P. R. 1965. Particle fractionation and particle size analysis. *In* C. A. Black et al. (ed. in chief) Methods of soil analysis. Part 1. Agronomy 9:545–567. Am. Soc. of Agron; Madison, Wis.
5. Green, R. D., and Askew, G. P. 1965. Observations on the biological development of macropores in soils of Romney Marsh. J. Soil Sci. 16:342–349.
6. Heath, G. W. 1965. The part played by animals in soil formation. p. 236–243. *In* E. G. Hallsworth and D. V. Crawford (ed.). Experimental pedology. Butterworths, London.
7. Hesse, P. R. 1955. A chemical and physical study of the soils of termite mounds in East Africa. J. Ecol. 43:449–461.
8. Hole, F. D. 1961. A classif ation of pedoturbation and some other processes and factors of soil formation in relation to isotropism and anisotropism. Soil Sci. 91:375–377.
9. Lee, K. E., and Wood, T. G. 1971. Physical and chemical effects on soil of some Australian termites and their pedological significance. Pedobiologia VII:376–409.
10. Lee, K. E., and Wood, T. G. 1971. Termites and soils. Academic Press, London.
11. Leco. 1954. Instruction manual for operation of Leco induction furnace. Laboratory Equipment Corp., Saint Joseph, Mich.
12. MacFadyen, A. 1959. The systematic study of soil ecosystems. The Soil Ecosystem-A. Symposium. The Systematics Assoc. Publ. no. 3, London.
13. McLean, A., Lord., T. M., and Green, A. J. 1971. Utilization of the major plant communities in the Similkameen Valley, British Columbia. J. Range Manage. 24:346–351.
14. Ollier, C. D. 1959. The two cycle theory of tropical pedology. J. Soil Sci. 10:137–148.
15. Rode, A. A. 1947. The soil forming process and soil evolution. Gosudarstvennoe Izdatel'stvo Geograficheskoi Literatury, Moscow. Translated by Israel Program for Scientific Translations, Jerusalem, 1961.
16. Salem, M., and Hole, F. D., 1968. Ant (*Formica exsectoides*) pedoturbation in a forest soil. Soil Sci. Am. Proc. 32:563–567.
17. Schaller, F. 1968. Soil animals. Univ. of Michigan Press, Ann Arbor.
18. Stanton, R. E., and McDonald, A. J. 1966. The colorimetric determination of boron in soils, sediments and rocks with methylene blue. Analyst 91:775–778.
19. Thorp, J. 1949. Effects of certain animals that live in soils. Sci. Mon. 68:180–191.
20. Vilenski, D. G. 1957. The Russian school of soil cartography. Izdatel'stov Nauka, Moscow. Translated by Israel Program for Scientific Translations, Jerusalem, 1967.
21. Waloff, N., and Blackith, R. E. 1962. The growth and distribution of the mounds of *Lasius flavus* (Fabricius, HYM Formicidae) in Silwood Park, Berkshire. J. Anim. Ecol. 31:421–437.

DIVISION S-6—SOIL AND WATER MANAGEMENT AND CONSERVATION

Line Source Sprinkler for Continuous Variable Irrigation-crop Production Studies[1]

R. J. HANKS,[2] J. KELLER,[3] V. P. RASMUSSEN,[2] AND G. D. WILSON[2]

ABSTRACT

The design details and a sample set of field test results for a line source sprinkler plot irrigation system are presented. The system produces a water application pattern which is uniform along the length of the plot and continuously, but uniformly variable across the plot.

By applying a fertility variable along a plot (. right angles to the water variable) planted in some test crop, the system offers a convenient means for developing crop production function data. The system test area and water supply are both small. However, the application of the system may be limited by wind and all water application levels within a plot must be supplied at the same irrigation frequency.

Additional Index Words: water use studies, experimental plot irrigator, water-fertility interactions.

CROP PRODUCTION surfaces as influenced by water levels are needed for many analyses to relate economic returns to soil water management practices. Fox (1973) reported on a system for producing these surfaces using a large number of N fertility treatments which varied systematically from one end of a single plot to the other. Fox suggested that water could be varied at right angles to N fertility treatments. Bauder et al. (1975) reported on a study where N fertility levels were imposed at right angles to the water levels. This system has an advantage in that the crop pro-

[1]Contribution from Utah State Univ. in cooperation with the Utah Agric. Exp. Stn., Logan, UT 84322. Journal Paper no. 2049. Supported in part by Grant B121, Utah Center for Water Resources Research, Grant C5189, Consortium for International Develop., Office of Water Research and Technology, USDI and Contract AID-csd-2459 U.S. Agency for International Development. Received 11 Nov. 1975. Approved 24 Jan. 1976.

[2]Professor and Research Assistants, respectively, Dep. of Soil Science and Biometeorology.

[3]Professor, Dep. of Agric. and Irrig. Eng.

Encl. 14

·ction surface can be seen visually in the field. The need ›r a buffer area around each treatment was eliminated since e incremental change between adjacent treatments is ·all.

Accurate water control is necessary to produce the nu-·erous water levels required to generate the desired produc-·n surface. Bauder et al. (1975) used a trickle (drip) irriga-·n system to obtain the high degree of water control ·ded. The trickle system gave good control of the irriga-·n water added, but was quite expensive and required con-·derable manpower to operate effectively. The trickle sys-·m used for corn was 10 rows wide (row width 76 cm) and ·out 24 m (80 feet) long which had about 400 tricklers. ·is plot was replicated four times. Periodic and extensive ·tering and testing of emitters was necessary to determine ·e exact water application time for the small incremental ·ailability differences required. An additional problem ·s the need to filter the water very thoroughly. Because of ·se problems, alternate schemes of irrigating at varying, ·t consistent levels were tried in an effort to obtain a more ·icient system. A system developed in 1973 that works ·ll is a design which used a single line of sprinklers down center of the plot. The purpose of this paper is to ·cribe the design and layout of this line source sprinkler ·irrigation system and some of the results obtained with The design is currently being used in Arizona, Califor-·, Colorado, and Utah for an experiment involving irriga-·n, stage of plant growth, and salinity; all as related to ·n (*Zea mays* L.) production.

PROCEDURE

System Layout

The design criteria for the water application pattern from a line ·inkler plot irrigation system are: To obtain the desired "triangu-pattern line source" effect, sprinklers should be closely spaced ·ng the water supply line. Furthermore, the individual sprinklers ·uld be the same and each produce a triangular shaped profile ·en operated in low winds at the design pressure. The best or ·al spacing is a compromise between:

1) Uniformity along the plot which is optimum with sprinklers spaced at approximately 10% of the wetted diameter or closer and reasonable for spacings up to approximately 20–25% of the wetted diameter.
2) Application rate and system flow rate which vary inversely with the sprinkler spacing.
3) System cost which increases as the sprinkler spacing is decreased.
4) Compact to minimize the size of the required end buffer zones.

Because of application rate and costs, it is generally desirable to · the widest spacing which will give reasonable uniformity, i.e., ·ations along the line not exceeding approximately ± 10% of mean.

The maximum spacing limits for reasonable uniformity which above were arrived at by analyzing a number of sets of over-·ed "can catch data" which synthesized various sprinkler spac-· along the lateral from single sprinkler catch data. A computer ·ram was used to expedite the overlapping process and primary ·h data from several sprinkler body-nozzle-pressure combina-·s were analyzed. In general a "reasonable" uniformity along line was achieved under calm conditions by applying the · spacing criteria regardless of the sprinkler body-nozzle-· relationship. However, the sprinkler body-nozzle config-·ns described below which we chose for our field system ·duced the "best" triangular pattern.

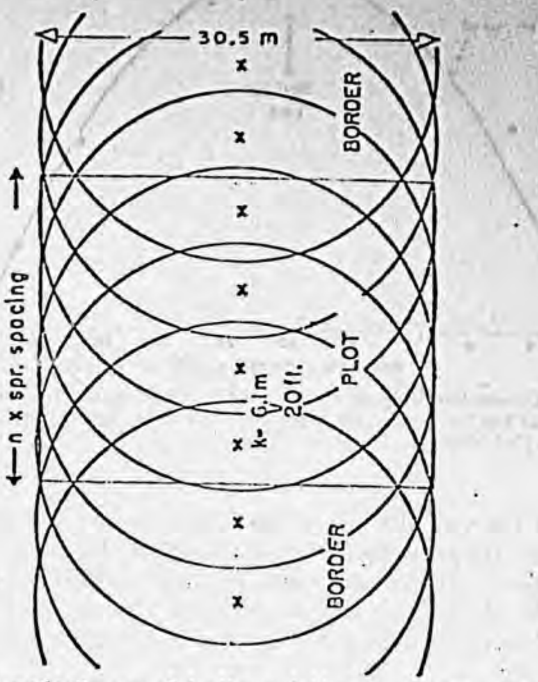


Fig. 1—Schematic diagram of the line sprinkler plot showing wetted perimeter of each sprinkler. A border area of about 1 m is needed on the sides of the plot.

Figure 1 shows a schematic layout of the line sprinkler plot design to meet these criteria. The line of sprinklers is through the center of the plot and parallel to the row direction. The length of the plot can be increased by adding more sprinklers. However, the width of the plot is governed by the wetted diameters of the sprinklers. There are two replications—one on each side of the sprinkler. A border of about 1 m, not shown in Fig. 1, is needed on the edges of the plot.

To obtain the "line source" effect, sprinklers should be spaced as closely as practical on the water supply line with spacing not exceeding 25% of the wetted diameter. Furthermore, the individual sprinklers should produce a triangular shaped profile when operated in low winds at the design pressure.

The test system (results shown in Fig. 2) had eight sprinklers spaced at 6.1 m (20 feet) which gave an overall usable plot of 24.4 by 30.5 m (80 × 100 ft). Model 30 TNT sprinklers with a 4.8-mm (3/16 inch) range by 2.4-mm (3/32 inch) spreader nozzles produced by Rain Bird Sprinkler Manufacturing Company of Glendora, Calif., USA, were selected for the layout. The sprinklers were operated at approximately 3 bars (45 psi) and produced a wetted radius of approximately 15 m (50 feet). Satisfactory results have been obtained with the same sprinklers operated at pressures up to 4 bars (60 psi).

The plot area was essentially level and the sprinklers were placed on 60 cm (2 feet) high by 2.5 cm diameter (1 inch) risers attached to a 7.5-cm diameter (3 inch) quick coupling portable aluminum supply line. The supply line had nondrain gaskets. The pressure head difference between the ends of the line was approximately 1% of the inlet pressure and each sprinkler discharged 0.54 liters/sec (8.5 gpm) giving a total system discharge of 4.32 liters/sec (68 gpm).

RESULTS

Table 1 shows the results of a test to determine the influence of distance from the sprinkler line and position along, but at right angles, to the sprinkler line on irrigation applied. Adjacent to the sprinklers the irrigation applied was greater than between sprinklers. At distances greater than about 1 m from the line, the differences at the sprinkler and

Model 30 T.
3/16 × 3/·
3" q·
alum
Non-drain
gaskets

21

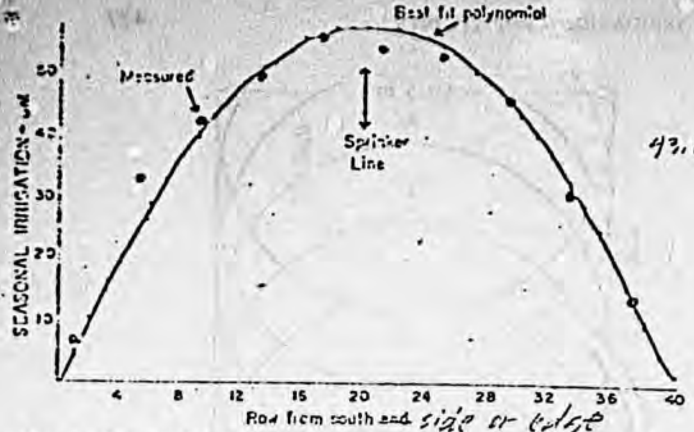


Fig. 2—Cumulative irrigation as related to the distance from the sprinkler line for corn trials at Logan, Utah 1974. Row width was 0.75 m (2.5 feet).

between the sprinklers were about the same as between replicates. The peak application rate was shifted to the north by a slight breeze from the south. The results of Table 1 indicate that the irrigation application rate falls off approximately linearly with distance from the line sprinkler source as desired.

Therefore, the line sprinkler source system was used in 1974 as a part of a larger experiment. Table 2 shows the irrigation application for different dates during the season. Practical use of the system during 1974 indicated that the principal disadvantage was wind drift. Efforts were taken to only sprinkle on days when wind was small, but this was not always possible. An extreme example was 9 July 1974. We waited several days for a calm period, but it did not occur so irrigation was done. The data show a shift of the peak at about 8 m. When the standard deviation was computed on relatively calm days, it was about 0.1 and was about the same at all distances from the line. Including the windy day data caused the standard deviation to increase to about 0.2 (or more on the south end).

When the data are summed up over a season, the normal wind variation tends to make the shape of the water distribution curve more curvilinear as shown in Fig. 2. To estimate the irrigation as a function of position, a second degree polynomial was fitted to the measured data as shown in Fig. 2.

The system was used in 1973 and 1974 to determine corn production as related to irrigation. To maintain a clearance of 30 cm above the crop, the sprinkler heads were raised periodically during the season. At the end of the season, the sprinkler heads were 3.05 m high (10 feet). Small rain gages set at right angles to the irrigation line in 3.05-m (10 feet) intervals measured the water applied. These were raised during the season to be just above the crop canopy.

Figure 3 shows the dry matter and corn yields as related to estimated evapotranspiration (sum of water applied plus rain and soil water depletion) resulting from system use in 1974. There were 40 rows in the plot with every other row harvested for dry matter yield and the adjacent rows harvested for grain yield. The outside rows had a large border effect (as evidenced by a larger yield) so the data are not used. The data from the two inside rows next to the

Table 1—Relative irrigation measured as a function of distance from the sprinkler line and position along sprinkler line

Distance from sprinkler line	At sprinklers Rep 1	At sprinklers Rep 2	At sprinklers Avg	Between sprinklers Rep 1	Between sprinklers Rep 2	Between sprinklers Avg	Difference
South 13.3 m	0.0	0.0	0.0	0.0	0.0	0.0	
11.8	0.03	0.03	0.03	0.01	0.01	0.01	−0.01
10.3	0.12	0.13	0.12	0.14	0.13	0.14	−0.02
8.7	0.30	0.24	0.27	0.27	0.29	0.28	−0.01
7.2	0.48	0.37	0.43	0.39	0.38	0.38	+0.05
5.7	0.50	0.47	0.48	0.47	0.45	0.46	+0.02
4.2	0.55	0.61	0.58	0.55	0.62	0.59	−0.01
2.7	0.64	0.70	0.67	0.70	0.77	0.74	−0.07
1.1	0.87	0.80	0.84	0.78	0.78	0.78	+0.06
North 0.4	1.00	0.91	0.94	0.80	0.79	0.80	+0.14
1.9	0.76	0.79	0.78	0.70	0.83	0.77	+0.01
3.4	0.60	0.70	0.65	0.65	0.59	0.62	−0.03
4.9	0.43	0.63	0.53	0.51	0.50	0.50	+0.03
6.5	0.43	0.52	0.48	0.42	0.47	0.44	+0.04
8.0	0.37	0.43	0.40	0.41	0.50	0.46	−0.06
9.5	0.35	0.37	0.35	0.34	0.35	0.34	−0.02
11.0	0.26	0.22	0.24	0.26	0.23	0.24	0.0
12.6	0.03	0.05	0.05	0.03	0.09	0.06	−0.02
14.2	0.0	0.0	0.0	0.01	0.0	0.0	

Table 2—Relative irrigation measured at different distances from the sprinkler line during the 1974 season at Logan, Utah. The average irrigation received at 1.9 m north and south assumed 1.0

Date	South 14.1 m	South 11.0 m	South 8.0 m	South 4.9 m	South 1.9 m	North 1.9 m	North 4.9 m	North 8.0 m	North 11.0 m	North 14.1 m
6-15	0.09	0.34	0.75	0.93	0.93	1.02	1.03	0.81	0.57	0.15
6-22	0.04	0.43	0.72	–	1.00	–	0.91	0.65	0.43	0.19
6-29	0.03	0.32	0.74	0.74	0.95	1.05	0.89	0.71	0.47	0.25
7-9	0.0	0.0	0.13	0.16	1.00	1.00	1.08	1.12	0.54	0.24
8-21	0.12	0.52	0.76	0.98	1.00	1.00	0.86	0.81	0.62	0.31
8-28	0.13	0.55	0.75	0.92	1.00	1.00	1.02	0.77	0.63	0.24
9-3	0.12	0.71	0.86	0.90	1.05	0.95	0.86	0.67	0.57	0.27
9-10	0.10	0.61	1.01	0.91	1.11	0.89	0.71	–	0.33	0.10
Avg.	0.08	0.44	0.72	0.79	1.01	0.99	0.93	0.80	0.53	[illegible]
Avg.†	0.09	0.50	0.80	0.90	1.01	0.99	0.90	0.94	0.52	[illegible]
S_x	0.03	0.22	0.26	0.29	0.05	0.05	0.13	0.15	0.09	[illegible]
S_x†	0.04	0.14	0.10	0.08	0.05	0.05	0.12	0.06	0.10	[illegible]

† Excluding the data on 7-9 which was windy.

sprinkler line are not used because of leakage from the pipe junction. Evapotranspiration was estimated assuming runoff and drainage or upward flow during the season was negligible. Soil water depletion was measured using a neutron probe to 2.7 m (9 feet) depth. Irrigation was applied in intervals to keep runoff zero. When runoff started irrigation was stopped. This problem was highly dependent on soil condition.

The data of Fig. 3 show a strong linear relation between dry matter yield and estimated evapotranspiration, as has been shown for many studies. For the same estimated evapotranspiration, the north side of the plot gave slightly higher yields. This variation may be due to unknown factors such as fertility differences or measurement errors. Figure 3 also shows a linear relationship between grain yield and estimated evapotranspiration, but there is more variation in the data than for dry matter yields. The increased variation is expected because grain yields are more sensitive to influence during the season than is dry matter production (Hanks, 1974).

These data are similar to those of Hillel and Guron (1973) who used the traditional plot technique with four irrigation

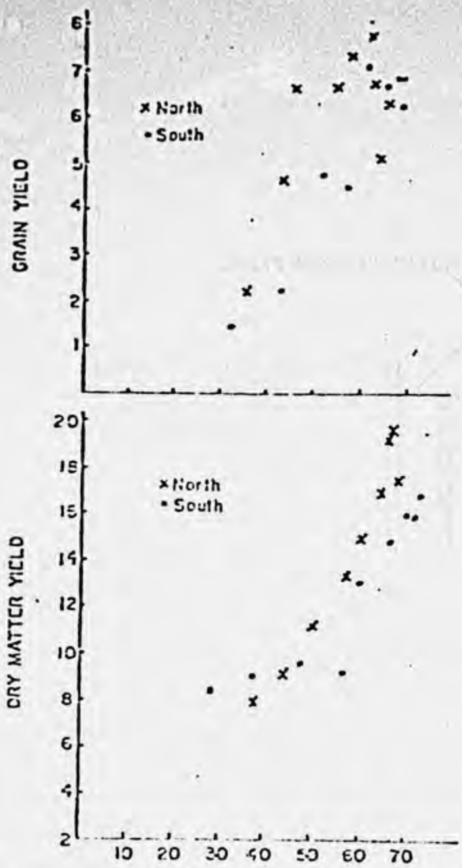


Fig. 3 --Dry matter and grain yield (metric tons/ha) for corn as related to evapotranspiration as produced by the line sprinkler system at Logan, Utah in 1974.

variables. The line sprinkler system described allows for more irrigation variables than the traditional system. With our system we had 18 irrigation variables which are repeated on each side of the sprinkler line.

We believe that the addition of more treatments covering the range of water variables is a distinct advantage for many purposes, especially those involving evaluation of optimum economic return, because the entire range of water application is covered.

LIMITATIONS

There are several limitations of the line source sprinkler plot irrigator which should be considered before laying out an experimental plot. These include the following:

1) Even low winds significantly alter the sprinkling patterns. The symmetry of the patterns can best be maintained by operating the system only during calm periods and laying the line of sprinklers parallel to the direction of the wind. Irrigation was generally applied only when the winds were < 3 km/hour (2.0 miles/hour) at right angles to the line and 8 km/hour (5.5 miles/hour) parallel to the row. However, even these light general winds caused an average variation of up to 2 m in the maximum irrigation rate.

2) All irrigation must be added at the same frequency on any given plot. This is an inherent feature of the line source concept. However, for some water use studies, it may be desirable to manipulate the water availability by utilizing different frequencies.

3) The maximum application rate along the line of sprinklers for the system design presented is approximately 20 m/hour (0.79 inch/hour). While a relatively high application rate provides flexibility for irrigating only during calm wind periods, ponding or runoff may be a problem. However, there are several solutions for these problems which include: operating the sprinklers intermittently, i.e., 15 min on, then 15 min off, etc.; operating every other sprinkler, apply half of total irrigation, then switch to the in-between sprinklers; automatically sequence the sprinklers one at a time; or provide small dams or pits at 1.0 m (3.3 feet) intervals along the length of the furrows to trap the ponded water and eliminate runoff.

4) Since wind distortion is a problem, it is advisable to monitor the water application by collecting water application data across the plot during each irrigation. For studies on tall crops such as corn, this can be a problem.

CONCLUSIONS

The use of the line source sprinkler plot irrigation system described herein appears to offer a reliable and convenient method for applying to a plot a two-dimensional, continuous-uniformly-varying level of water. By applying a fertility or other variable at right angles to the water variable, it appears that this method should be useful for developing crop production function data. The system is economical and simple to install and operate. Furthermore, both the test area and water supply can be relatively small.

LITERATURE CITED

1. Bauder, J. W., R. J. Hanks, and D. W. James. Crop production function determinations as influenced by irrigation and nitrogen fertilization using a continuous variable design. Soil Sci. Soc. Am. J. 39:1187–1192.
2. Fox, R. L. 1973. Agronomic investigations using continuous function experimental designs-nitrogen fertilization of sweet corn. Agron. J. 65:454–456.
3. Hanks, R. J. 1974. Model for predicting plant yield as influenced by water use. Agron. J. 65:660–665.
4. Hillel, D., and V. Guron. 1973. Relation between evapotranspiration rate and maize yield. Water Resour. Res. 9:743–749.

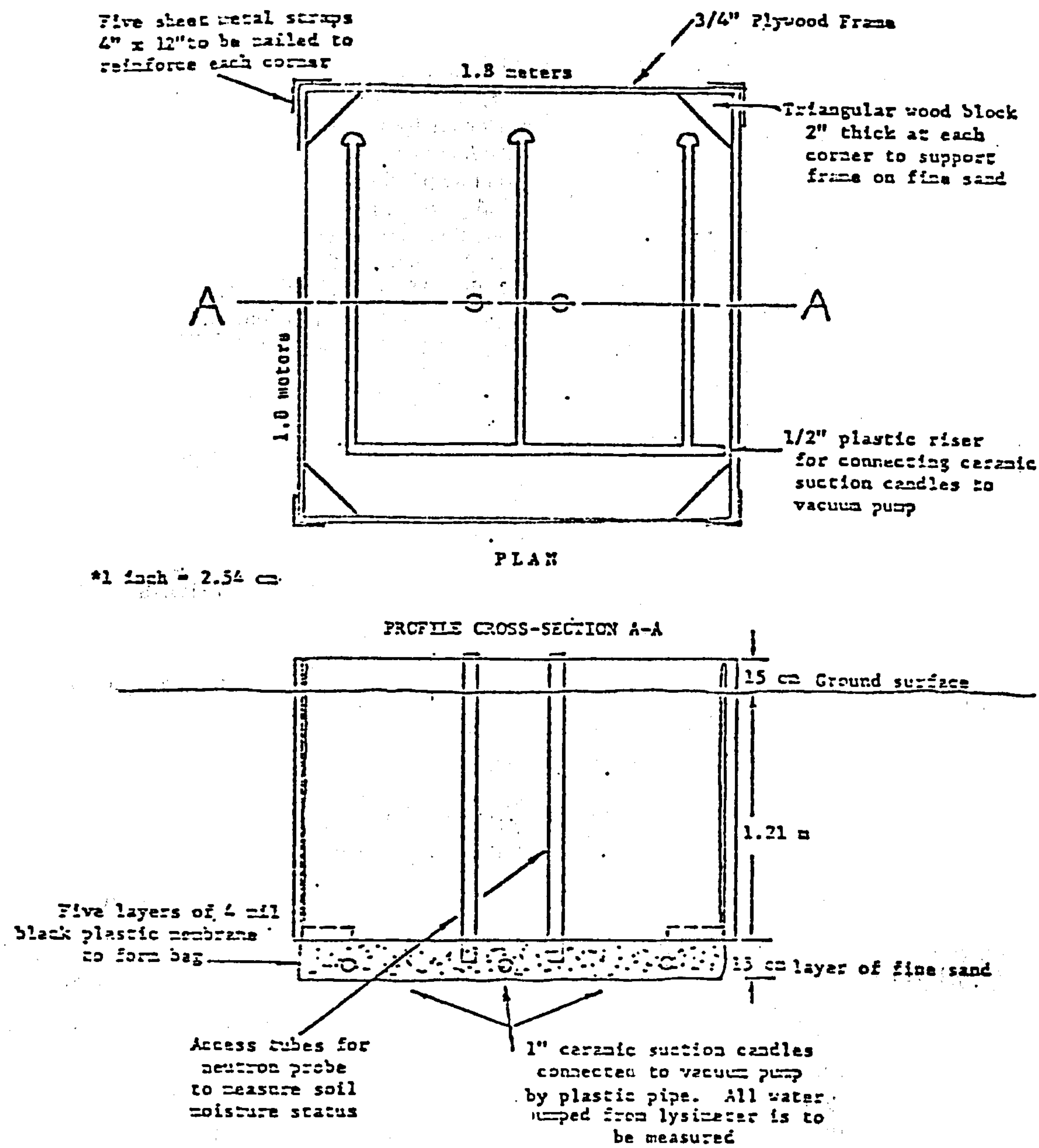


Figure 4. Plan and profile of drainage-type lysimeters.

See References Page 33

Encl. 15

Encl. 16

25

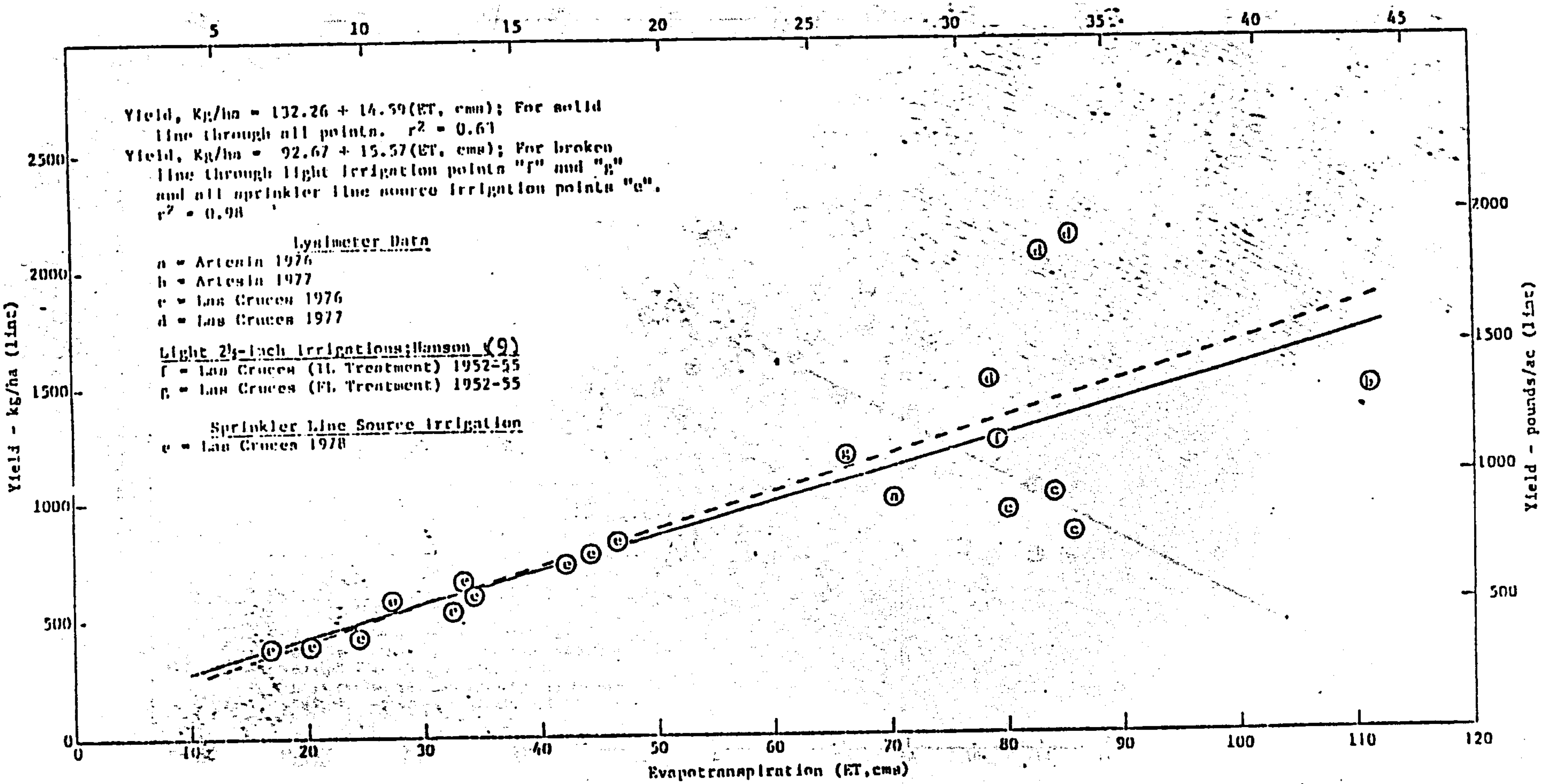


Figure 8. Crop-production function for cotton. See References Page 33

Encl. 17

26

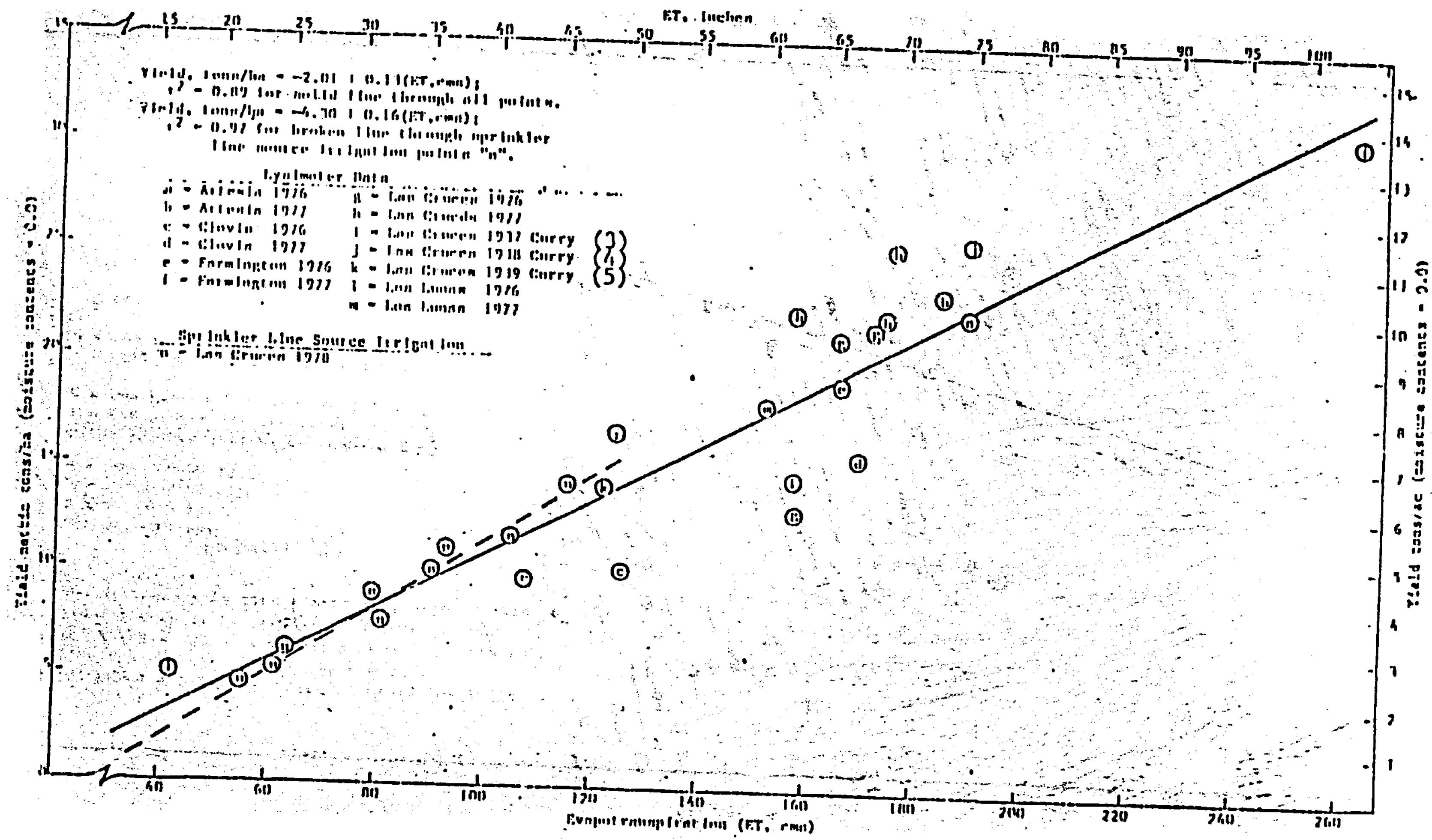


Figure 7. Crop-production function for alfalfa

see References Page 33

Encl. 18

27

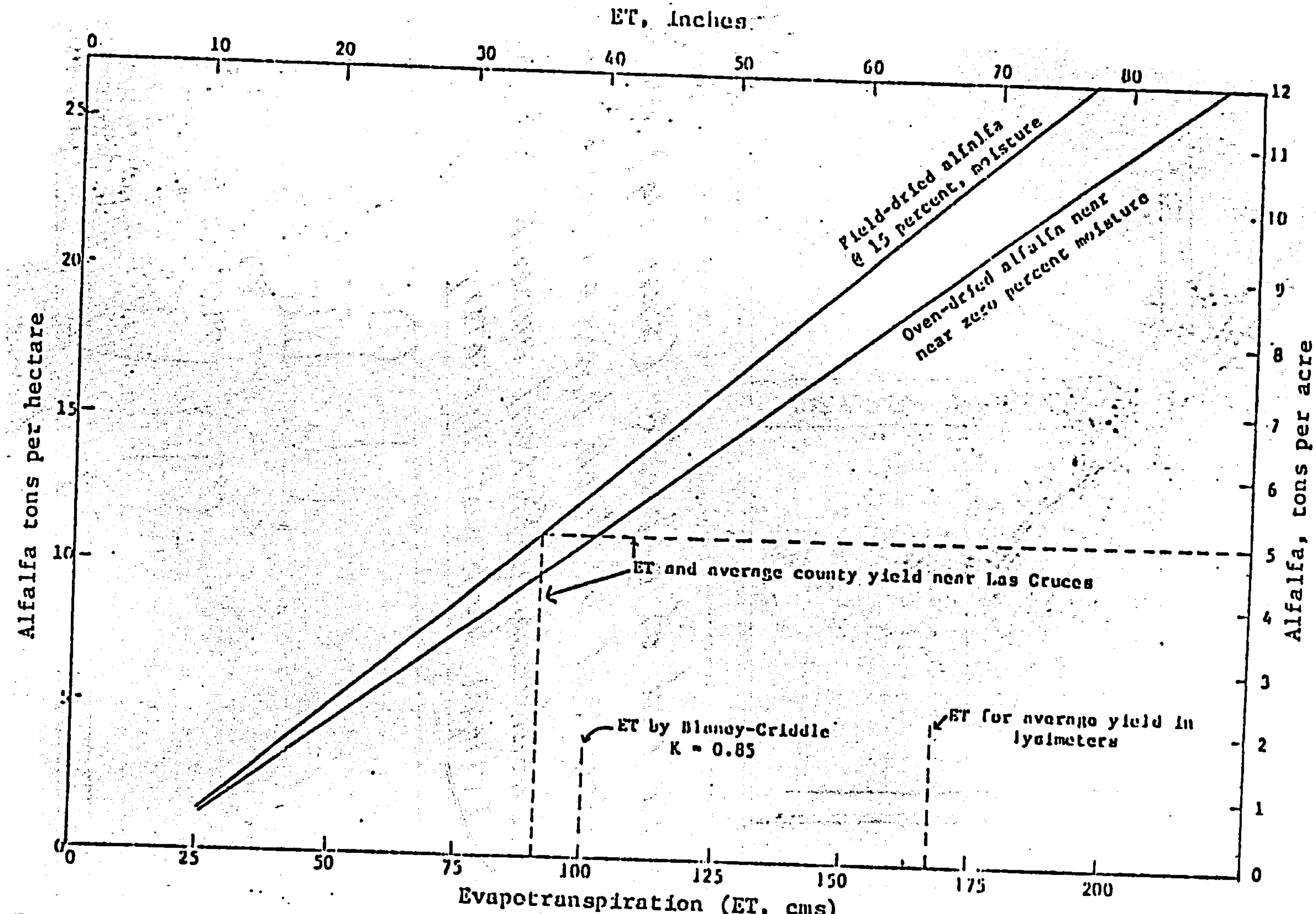
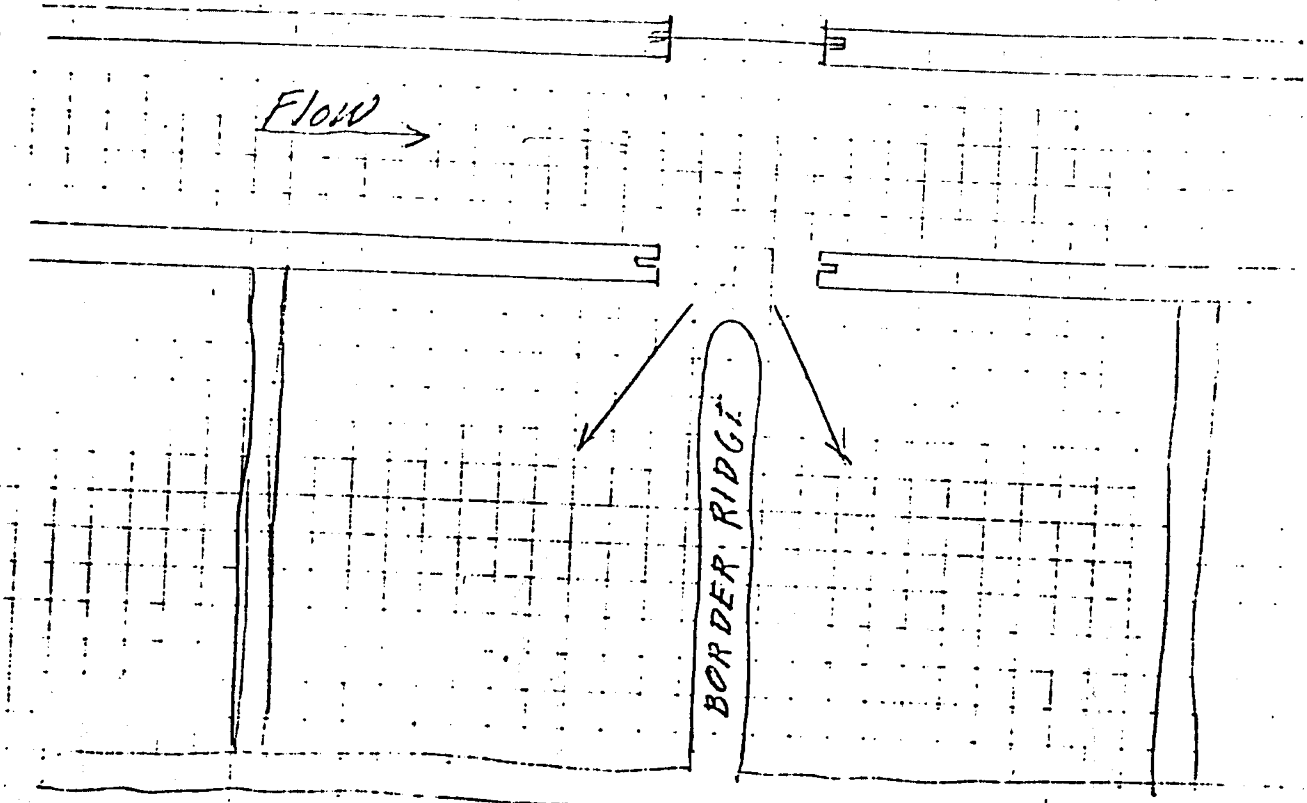
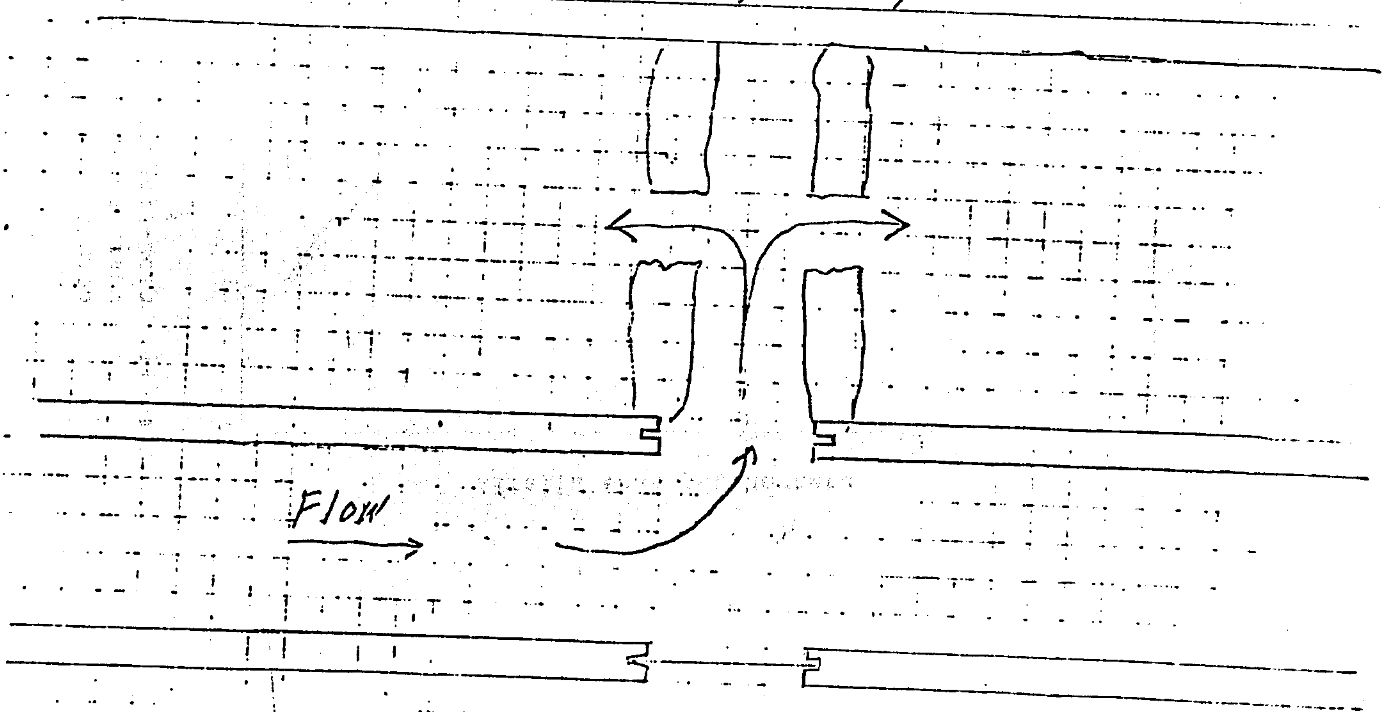


Figure 11. Crop-production function for alfalfa showing the average evapotranspiration measured in lysimeters at Las Cruces as compared to that of the average county yield and the Blaney-Criddle method.

See References, Page 33



Using the end of a border (above fig.) as a divide or holes cut in ditch banks (below) will probab give considerably different amounts on the two plots. Irrigate each plot separately.



Encl. 19.

5.2. Water Meters. Water meters are available for installation in pipe lines. Propeller-type meters (Fig. 5.3) are most common. A register on top of the meter indicates the total volume of water that has passed through the meter, or an indicator is supplied on some models to show instantaneous rates of flow. Care should be taken that no debris is deposited in the propeller.

5.3. Weirs. A weir is a notch of regular form through which water may flow. In its simplest form a weir consists of a weir wall or bulkhead of timber, metal or concrete with an opening of fixed

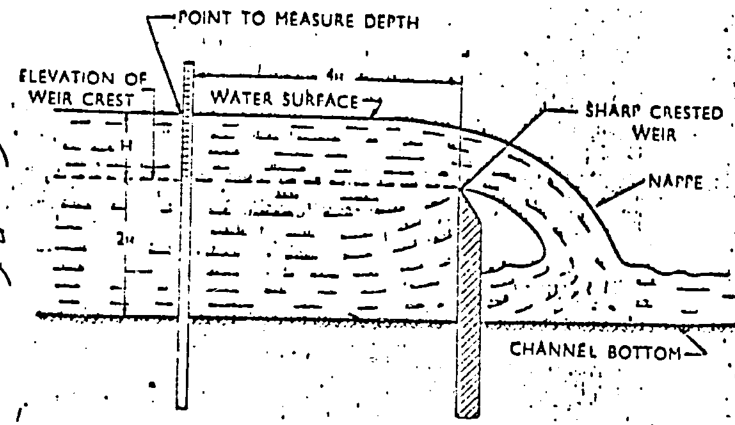


Fig. 5.4 Profile of a sharp-crested weir.

dimensions cut in its top edge. This opening is called the weir notch and may be either rectangular, trapezoidal or triangular in shape. Weirs may be either portable or permanent.

Weirs are simple, cheap and reliable. They require only one reading of the head to determine the discharge. They are not clogged easily by moss or floating trash. But they require a considerable fall of the water surface, which makes their use in areas having level land difficult. Periodical cleaning of weir pond may be required due to deposition of silt.

The bottom edge of the weir notch is the weir crest. The depth of flow over the crest (measured at a specific distance upstream from the bulkhead) is called the *head*. The sheet of water passing through the notch and falling over the weir crest is known as the *nappe*. The horizontal distances from the ends of the crest to the sides of the channel are called *end contractions*. When the water

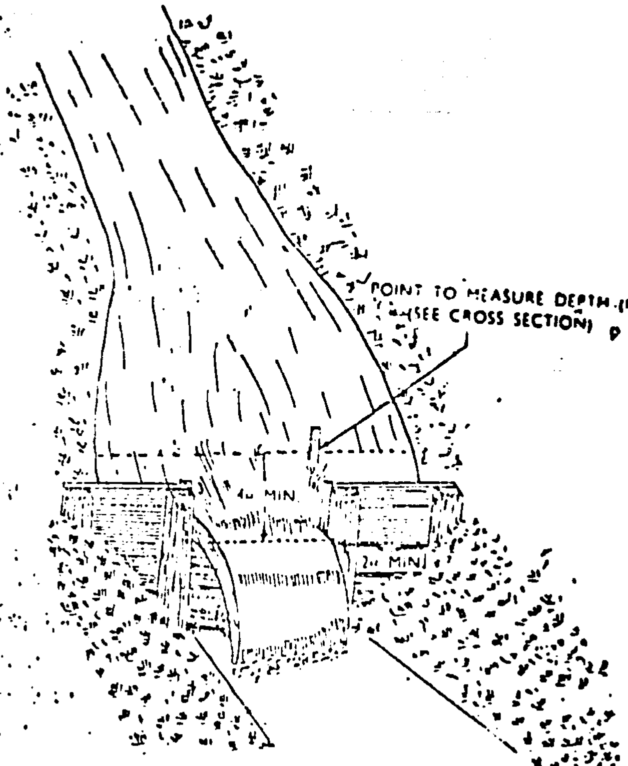


Fig. 5.6 Installation of a rectangular weir with end contractions in a small stream.

surface downstream from the bulkhead is far enough below the crest so that air has free access completely around the nappe, the flow is said to be free; otherwise it is submerged.

The basic formula for calculating discharge through weir is : $Q = CLH^m$

where, Q = discharge

C = a coefficient dependent on the nature of the crest and approach conditions.

L = length of crest

H = head on the crest (see Fig. 5.4)

m = exponent depending upon the weir opening.

Types of Standard Weirs: Weirs are classified according to the shape of the notch, the type of crest and whether they are contracted or suppressed. Examples of weirs classified according

Encl.: 21

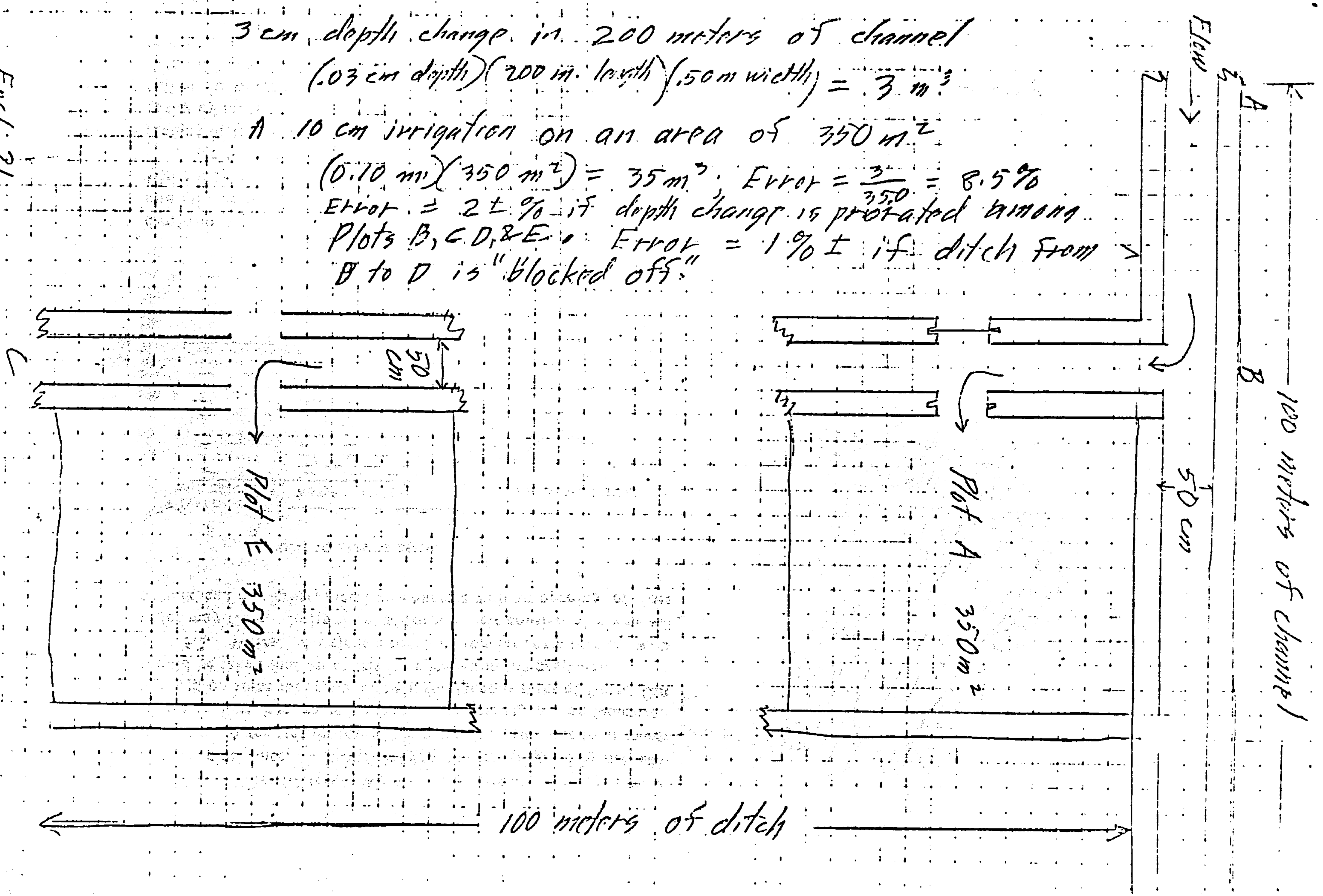
3 cm depth change in 200 meters of channel

(.03 cm depth)(200 m. length)(.50 m width) = 3 m³

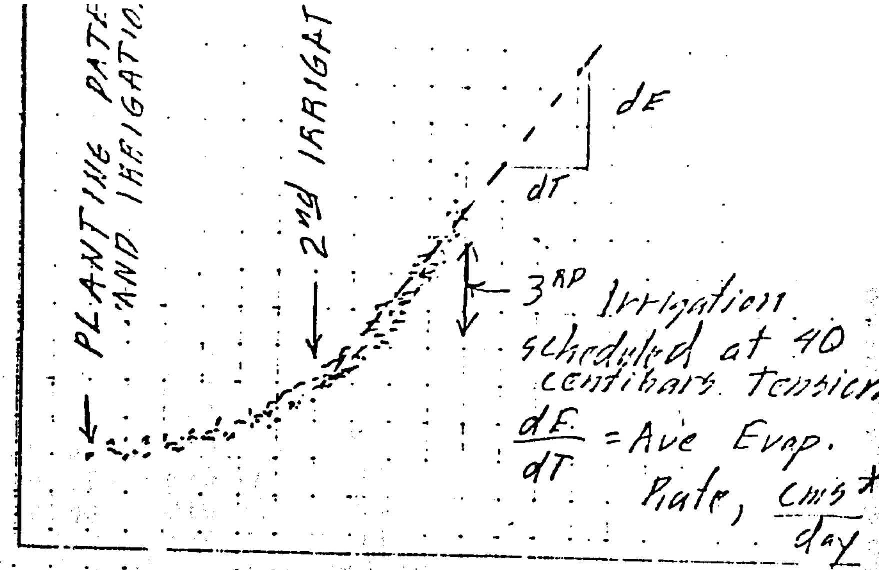
A 10 cm irrigation on an area of 350 m²

(0.10 m)(350 m²) = 35 m³. Error = 3/35 = 8.5%

Error = 2± % if depth change is prorated among Plots B, C, D, & E. Error = 1% ± if ditch from B to D is "blocked off."



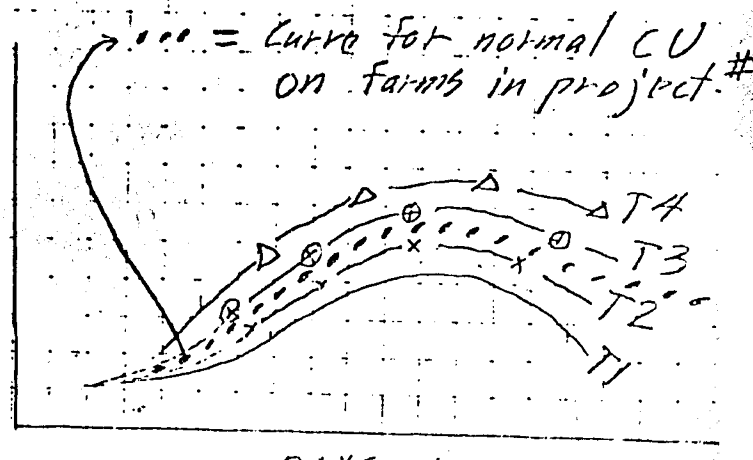
PAN EVAPORATION (ACCUMULATIVE) cms



* Average cms per day times days since last irrigation = Epan cms since last irrig. THIS MAY BE USED TO DETERMINE THE CMS OF WATER FOR IRRIGATING THE ASSUMED TREATMENTS SHOWN ON ENCL NO. 1:

LYSIMETER FOR	T1,	APPLY	0.4 Epan;	TENSION =	40 CEN
" "	T2,	"	0.8 Epan;	"	" "
" "	T3,	"	1.0 Epan;	"	" "
" "	T4,	"	1.2 Epan;	"	" "

Use the treatment data with yields to construct crop-production functions which may be used to estimate normal ET, seasonal and monthly etc.



Position of curve in the figure is determined by normal yields on farms and the crop production function

		CMS	Kg/Fed
T2	A 1	60.00	430.000
T1	A 2	50.00	400.000
T2	B 3	60.00	425.000
T4	B 4	80.00	380.000
T3	C 5	70.00	385.000
T2	C 6	60.00	380.000
T3	D 7	70.00	370.000
T4	D 8	80.00	355.000
T4	A 9	80.00	435.000
T3	A10	70.00	450.000
T1	B11	50.00	370.000
T3	B12	70.00	420.000
T4	C13	80.00	365.000
T1	C14	50.00	355.000
T2	D15	60.00	360.000
T1	D16	50.00	350.000

DESCRIPTION

T1, IRRIGATE AT 20 CENTIBARS Epan CMS (*)

T2, IRRIGATE AT 40 CENTIBARS Epan CMS

T3, IRRIGATE AT 60 CENTIBARS Epan CMS

T4, IRRIGATE AT 80 CENTIBARS Epan CMS

(*) Epan CMS = Total CMS of PAN EVAP. SINCE LAST IRRIG.

TREATMENT	PLOT No.	WATER APPLIED CMS	YIELD Kg/Fed
T1	2A	50.00	400.000
T1	11B	50.00	370.000
T1	14C	50.00	355.000
T1	16D	50.00	350.000
AVE.			368.750
T2	1A	60.00	430.000
T2	3B	60.00	425.000
T2	6C	60.00	380.000
T2	15D	60.00	360.000
AVE.			398.750
T3	5C	70.00	385.000
T3	7D	70.00	370.000
T3	10A	70.00	450.000
T3	12B	70.00	420.000
AVE.			406.250
T4	4B	80.00	380.000
T4	8D	80.00	355.000
T4	9A	80.00	435.000
T4	13C	80.00	365.000
AVE.			383.750

Encl. 23

Source of variance	(df)	(ss)	(ms)	F	5%	[illegible]
Total	15	16044				
Treatment	3	3318.75	1106.25	1.04	3.49	5.9
Error (R/T)	12	12725.00	1060.42			

REFERENCES

Enclosure	Page	Source of Information
5	9	Campus Team, Colorado State University: Problem Identification Training Manual for On-Farm Irrigation Systems. Egypt Water Use and Management Project Vol. II. Summer 1980, page 362.
6	10	Israelsen, O.W. Irrigation Principles and Practices 2nd Edition. John Wiley and Sons Inc. New York 1958, page 290.
7	11	do. Page 205
8	12	Doorenbos J., and W.O. Pruitt. Crop Water Requirements. FAO Irrigation and Drainage Paper 24. Food and Agriculture Organization of the United Nations. Rome. Revised 1977, page 76.
12	16	Shockley, Dell G. "Evapotranspiration and Farm Irrigation Planning and Management", in Conference Proceeding: Evapotranspiration and its Role in Water Resources Management. Am. Soc. of Agr. Eng'rs. St. Joseph Michigan. 1966. Pages 3 to 5.
13	19	Sammis, Thevdore W. and Eldon G. Hanson. Consumptive Use and Yields of Crops in New Mexico. WRRI Report No. 115. New Mexico Water Resouces Research Institute. Las Cruces N.M. 1979. Page 12.
15	24	do. Page 8.
16	25	do. Page 25
17	26	do. Page 24.
18	27	do. Page 41
20	29	Michael, A.M. and T.P. Ojha. Principles of Agricultural Engineering. Vol. II. Jain Brothers, Rateinda Road, Jodh pur. 1966. Pages 180, 181.

RECOMMENDATIONS

1. An annual conference should be held with at least all senior researchers of all projects being conducted at all experiment stations. All administrative people in the main office who are directly responsible for the research program at any or all experiment station should also attend all sessions of the conference. Each project should be discussed briefly relative to procedures, layout of treatments in plots, measurement procedures of determining crop yields, irrigation water, and soil moisture; and results, conclusions, and problems relative to needs of additional equipment and personnel. Time should also be allowed for the researchers to visit with each other in informal meetings during breaks between formal sessions. The exchange of ideas and experiences among researchers is vital to the success of research program. Occasional attendance of national meetings in other countries is of vital importance to the professional growth of the researcher.

2. An Advisory Project Review Committee, consisting of three or more members of the research staff, should be designated to review new project proposals. After reviewing a proposal and writing recommendations to improve the proposal, the committee should meet with the researcher for a discussion of the recommendations. It should not be mandatory that the researcher adopt the recommendations, except in the case where the administration is certain that specific recommendations of the committee will be vital to the success of the project.

3. Researchers should make full use of the computer that is available at the EWUP headquarters.

   When a project proposal is submitted for approval, the treatments, plot layout, etc., should be designed, wherever possible, to be compatible with statistical analysis which may be accomplished on the computer. This will result in a considerable saving of time for the researcher.

   Soon after the harvesting of crops and yields are tabulated by treatments, the research data should be submitted for computer analyses which will be completed in a form similar to the one presented in Enclosure B "analyses of crop yields by treatments".

   When the analyses are returned to the researcher, objectives, procedures, and results should be summarized and submitted to the headquarters where copies will be reproduced for Dr. Wahby, Dr. Brooks, Nadia Wahby and the researchers.

4. All projects in all of the experiment stations should be reviewed in the near future to determine if help is needed pertaining to randomization of treatments, measurement of soil moisture or irrigation water, measuring of plot yields excluding border effects, and other topics which were discussed in the workshop and which are included in Enclosure B.

5. Research should be initiated to determine crop-production functions which show the relationship of evapotranspiration to yield of crops. Initially, one experiment station should be designated for this work. The Saaka station appears to be the most centrally located station. With the water table at approximately 150 cms deep at Saaka, some type of lysimeter must be used due to the probable upward flow of capillary water to the root zone. Plans for a low cost drainage-type lysimeter which have been found to be suitable in New Mexico, U.S.A. are contained in Enclosure B.

6. All measuring devices (masonry critical depth flumes and weirs) which have been in use for a considerable number of years should be recalibrated to check the validity of the calibration table or chart and to make sure that the current researchers are using them correctly. Flow meters on pumps should be checked annually for accuracy.

7. The research results from the Water Requirements section should be of vital interest to EWUP and to the other three sections (Water Distribution, Irrigation Technology and Water Losses) of the Institute. Therefore the leader of the Water Requirements section should meet regularly to discuss research results with senior staff members of EWUP and the other sections of the Institute.

EH/ja

Encl.

On-Farm Water Management Short Course

Summer 1980

TRAINING PROGRAM SCHEDULE OUTLIME

WEEK	DATES	MAJOR EMPHASIS
	MAY 19-24	TRAINER ORIENTATION TO EGYPT AND THE KAFR EL SHEIK AREA FINAL SELECTION OF SAKIA STUDY AREAS SUBDIVISION OF TRAINEES INTO STUDY TEAMS
ONE	MAY 25-31	TRAINEES ARRIVE AT KAFR EL-SHEIK DIAGNOSTIC EXAMINATIONS FIELD STUDY SITES ASSIGNED TO EACH TEAM BASE SURVEY PREPARATIONS, COURSE INTRODUCTION. OVERALL INFORMATION AND ORGANIZATION
TWO	JUNE 1-7	BASE SURVEY ACTIVITIES BY EACH TEAM AT STUDY SITE SUPPORTIBG LECTURES, DEMONSTRATIONS AND FIELD SUPPORT
THREE	JUNE 8-14	COMPLETION OF BASE SURVEY CO ACTIVITIES. DATA BASE EXPANDED TO AGRICULTURAL INFRASTUCTURE IN AREA. DATA ANALYSIS AND SELECTION OF PRIMARY PROBLEMS FOR INTENSIVE STUDY. SUPPORTING LECTURES.
FOUR	JUNR 15-21	DETERMINATION OF SPECIFIC DATA NEEDED FOR PROBLEM DELINIATION ASSIGNEMENT OF TASKS FOR TEAM MEMBERS. COORDINTION OF ACTIVITIES. LECTURES AND FIELD SUPPORT ACTIVITIES.
FIVE	JUNE 22-26	COLLECTION OF SPECIFIC FIELD DATA BY TEAMS AND BY DISCIPLE GROUPS. COORDINATION AND EXCHANGE OF DATA. BEGIN ANALYSIS OF DATA AND
SIX	JUNE 29 JULY 3	PREPARATION OF FINAL REPORT AND DOCUMAENTATION OF MAJOR PROBLEMS. COLLECTION OF FINAL DATA. DIAGNOSTIC EXAMINATIONS. REPORTS BY EACH TEAM. GRADUATION.
	JULY 6-12	REVIEW DESIGN OF TRAINING PROGRAM AND MAKE NEEDED MODIFICATIONS REVIEW PERFORMANCE AND DIAGNOSTIC EXAMINATIONS OF TRAINEES PREPARE DATA FOR FINAL REPORT AND FOR ORAL REPORT TO EWUP STAFF. DEVELOP DETAILED SUGGESSTIONS FOR FUTURE TRAINING PROGRAMS AND FOR ADDITIONAL TRAINING ACTIVITIES

THE TRAINING STAFF MET WEEKLY DURING THE SPRING TO WORK TOGETHER IN PREPARING THE MANY DETAILS OF THE PROGRAM. THIS WAS A VERY VALUABLE EXERCISE IN THAT IT PROVEDED TIME FOR THE TRAINING STAFF TO BECOME A SMOOTH WORKING TEAM AND BY COVERING ALL OF THE DETAILS OF THE PROGRAM, THE STAFF WAS MADE FULLY AWARE OF THE PURPOSE OF THE TRAINING, THEIR INDIVIDUAL ROLES, AND THE ROLES OF ALL OB THE OTHER STAFF.

THE BASIC ELEEMENTS OF THE TRAINING WERE TO SUBDIVID THE TRAINEES INTO INTERDISCIPLINARY TEAMS AND GIVE EACH TEAM A SPECIFIC STUDY AREA. THESE STUDY ARESE WHERE INDIVIDUAL SAKIA SITRS AS THIS IS A BASIC IRRIGATED UNIT THAT STILL CONTAINS A VARIETY OF CROPS, A NUMBER OB DIFFERENT FIELDS, AND A NUMBER OF FARMERS. THIS STUDY AREA GAVE SUFFICIENT DIVERSITY TO THE AGRONOMISTS AND THE ENGINEERS, BUT FOR THE ECONOMISTS AND SOCIALOGISTS IT WAS NECESSARY TO EXPAND THE STUDY AREA TO INCLUDE THE AGRICULTURAL INFRASTRUCTURE ORGAINIZATIONS INTH THE AREA.

THE TRAINING PROGRAM EMPHASIZED THE FOLLOWING POINTS BY BOTH LECTURE AND FIELD OPERATIONS.

- INDIVIDUAL HANDS ON SKILLS FOR EACH DISCIPLINE
- KNOWLEDGE AND PRACTICE ABOUT THE APPLOCATION OF THESE SKILLS AND
  - HOW AN INDIVIDUAL DISCIPLINE MAKES A CONTRIBUTION T O THE PROJECT ACTIVITIES
  - AN APPRECIATION FOR AND KNOWLEGDE ABOUT THE AC TIVITIES OF THE OTHER DISCIPLINES
  - DETERMINTATION OF NEDED DATA BASED UPON THE OBJECTIVE OF THE ACTIVITY
  - INTERPRETATION AND USE OF DATA
  - WAYS IN WHICH DATA CAN BE EXCHANGED BETWEEN DISCIPLINES AND HOW THIS AT DATA CAN BE UTILIZED BY ORHERS

IN ADDITION TO THE ABOVE POINTS, BY NATURE OF THE TEAM OPERATIONS AND THE ACTIVITIES SELECTED, THE FOLLOWING POINTS WERE ALSO EMPHASIED.

- BASE SURVEY PLANNING AND OPERATION
- TEAM MANAGEMENT AND ORGANIZATION
- TASK ALLOCATION AND DATA CORRELATION
- INTERPRETATION OF DATA AND PREPARATION OF FUNCTIONAL REPORTS
- ORGANIZATION AND CONDUCT OF MEETINGS

DELINIATION OF GOALS AND DETERMINATION OF SCHEDULES AND ACTIVITIES

THE TRAINEES WORKED WELL TOGETHER AMD ALL MADE AN EFFORT TO BOTH LEARN ABOUT THEIR OWN DISCIPLINE AND OTHER DISCIPLINES. THEY COOPERATED WELL IN THE TEAM ACTIVITIES AND MADE GOOD PROGRESS IN LEARNING COOPERATIVE SKILLS AND ORGAINIZATIONAL ABILITIES.

A LATER REPORT WILL PROVIDE THE SPECIFICS ABOUT EACH TRAINEE AND THE PROGRESS THAT THEY MADE.

TRAINING STAFF

ADMINISTRATIVE	DR. MOHAMMED S. SALLAM	EWUP TRAINING OFFICER
	SALLAH EL-DIN	EWUP ASSISTANT TRAINING OFFICER
	DR. DAVID J. REDGRAVE	TRAINING PROGRAM COORDINATOR
DISCIPLINE TRAINERS	DR. YACK MOSELEY	ENGINNERING(IRRIGATION)
	DR. JIM LAYTON	SOCIOLOGY
	DR. LARRY NELSON	AGRONOMY
	DR. AL MADSEN	ECONOMICS (first part)
	MOHAMMED HAIDER	ECONOMICS (SECOND PART)
	ThoMAS EDGAR	*IRRIGAR ENGINBERING(DRAINAGE)
ASSISTANT TRAINIRS	NANCY ADAMS	ENGINEERING(IRRIGATION)
	JOYCE HAM	SOCIOLOGY
	GALE DUNN	AGRONOMY
	RAGI DARWEESH	ECONOMICS
	ROGER SLACK	INBINEERING(DRAINAGE)

TRAINEES

Azza Nasr	Engineering
Sabah Mahmoud El Sayed	Agronomy
Esmat Wafik Ahmed	Engineering
Ahmed A. Dardir	Engineering
Kamal Ez El Din Khalil	Engineering
~~Ibrahim Mohamed Metawie~~	~~Student~~
Mohamed Refat Farag	Engineering
Salah El Din Mahmoud	Engineering
Gamal Fawzi	Economics
Mohamed Gabaly	Economics
Farouk Ahmed Abdel Al	Sociology
Ahmed El Attar	Sociology
Abdel El Masry	Sociology
Abhallah Saber Aly	Sociology
Nehad Mohamed Ibrahim	Agronomy
Ahmed Tahoon	Agronomy
Mohamed Mahmoud Awad	Agronomy
Mohamed Melcha	Agronomy
Mahmoud Saied	Agronomy

Double space

FIELD STUDY TOUR

THE FIELD STUDY TOUR INCLUDES STUDY LOCATIONS IN COLORADO, ARIZONA, AND CALIFORNIA. THE MAJOR EMPHASIS IS UPON IRRIGATION ACTIVITIES IN THOSE STATES WITH SPECIFIC EMPHASIS UPON IRRIGATION PROJECTS, WATER STORAGE AND DISTRIBUTION FACILITIES, AGRICULTURAL RESEARCH ACTIVITIES , CREDIT OPERATIONS AGRICULTIRAL EXTENSION OPERATIONS, AND THE VARIOUS FORMAL AND INFORMAL FARMER ORGANIZATIONS THAT MAKE UP THE TOTAL PACKAGE OF A VIABLE IRRIGATION AREA.

COLORADO	BIG THOMPSON IRRIGATION PROJECT
	ACTIVITIEAS AT COLORADO STATE UNIVERSITY
	ACTIVITIES OF THE EXTENSUON SERVICE
	INDIVIDUAL IRRIGATED FARMS
	FARM CREDIT, MANAGEMENT, MARKETING ORGANIZATIONS
	IRRIGARTION R AND D AT GRAND JUNCTION
	SALT CONTROL ACTIVITIES AND RESEARCH AT GRAND JUNCTION
	DITCH/CANAL LINING FOR SALT CONTROL LEVEL BASIN RESEARCH
ARIZONA	GLEN CANYON DAM AND POWER PLANT
	SALT RIVER PROJECT
	USDA WATER L'B AND FIELD
	IRRIGATION FIELD RESAERCH
	IRRIGATED FARM OPERATIONS
	SALT MANAGEMENT AND DESALINATION ACTIVITIES
	WELTON-MoHAWK PROJECT
	UNIVERSITY OF ARIZONA ESPERIMANT STATION
	LEVEL BASIN IRRIGATION
CALIFORNIA	IMPERIAL VALLEY FARMING OPERATIONS
	IRRIGATION OOERATIONS AND DEVELPOMENT IN THE COACHELLA VALLEY
	USDA SALINITY LAB. AT RIVERSIDE
	IRRIGATION EXTENSION ACTIVITIES
	AUTOMANTED IRRIGATION SYSTEMS
	STEEP LAND IRRIGATION AND INTENSIVE VEG. IRRIGATION
	IRRIGATION ON SMALL FARMS WITH HIGH WATER COSTS

TOUR PARTICIPANTS

IN ADDITOON TO THE TRAINES, AN ADDITIONL NUMBER OF PEOPLE FROM VARIOUS ORGABISATIONS IN EGYPT ARE INVITED TO ATTEND THE STUDY TOUR TO OBSERVE THE IRRIGATION METHODS AND RESEARCH THAT ARE BEING CONDUCTED IN THE SOUTHWESTERN U.S.

Saad Hanafy	Vice Minister of Planning
Ismail Badawy	Vice Minister of Finance and Economy
Fawzy Farag Helwa	Under-Secretary for High Dam Authority
Wahid Moustafa Ismail	Director of the Gen. Irrig. Co.for Mech. Excava
Yehya Attia Abdel Khalek	Under-Sec. of St. for MOI, El Gharbia
Ezat Abdel Raouf Fayed	Under-Sec. of St. for MOI, Kaloubia & Ismalia
Saad Abdel Latif Al Samalify	Under-Sec. of St. for MOI, Sharkia
Mohamed Gamal El Din Ahmed Bahgat	Gen. Dir. of Tech. Off. for the Vice-MOI
Naguib Hamdy	Team Leader, Wheat & Barley Prog. Skaha Sta. MCP
Naibl Khamis	Team Leader, Maize & Sorgum Prog. El Guimeza St.M
Hamed Ghanem	Team Leader, Wheat & Barley Prog. Sids St. MCP
Ahmed Aly Hassan	Team Leader, Maize & Sorgum Prog. Shandawil St. M
Dr. Ali El Bassel	Dean, Cairo Un. at Fayoum

Dr. Mohamed Shafic Sallam, EWUP Training Officer

Dr. David Redgrave, EWUP Training Coordinator

~~Mike Phelan, Bus Driver~~

FINAL TDY REPORT

by
Robert P. King

Prior to my arrival in Cairo, the following six objectives for my TDY were identified through consultation with Drs. Mel Skold and Gene Quenemoen:

1. Present seminar on work in progress on Water Management Alternatives Study to acquaint EWUP personnel with the structure of the model being developed and to elicit their comments and suggestions. Expected output: initiate dialogue on the purpose and methods of the study.

2. Work with EWUP personnel to obtain data needed to estimate parameters of crop-irrigation response component of model. If possible, parameter estimation will be conducted in Egypt so that results can be examined and discussed by project participants there. Expected output: identification of adequate data sets for as many relevant crops as possible, initiation of further data collection efforts, and validation of model for at least one crop.

3. Work with economists and sociologists in Egypt to arrange for the administration of a questionnaire designed to elicit farmers' attitudes about on-farm water management activities and investments such as land leveling, mechanized water lifting equipment, field restructuring, etc. A preliminary version of the questionnaire is currently being prepared at CSU. Expected output: questionnaire revision in cooperation with local personnel and possible pretest.

4. Obtain information on current input costs, investment costs, and product prices needed to evaluate costs and benefits of alternative water management strategies. Related to this, it may be necessary to initiate new data collection efforts to obtain needed information. Expected output: cost and price data sets.

5. Work with project engineers and agronomists to specify a reasonable range of irrigation strategies and cultural practices for evaluation in the Water Management Alternatives Study. Expected output: identification of realistic water and crop management strategies for at least one study area.

6. Help to write reports for ongoing or recently completed projects as identified by Quenemoen and Ayad. Expected output: one or two project reports.

In this final report I will discuss my activities in Egypt as they relate to progress made on each of these objectives.

1. Seminars

With regard to the first objective, I presented a seminar on work in progress on the Water Management Alternatives Study on Thursday, June 25. In that seminar I discussed the objectives of the study and the overall structure of the models being developed. I then described in greater detail the components of the farm model, upon which most of my work has focused. Finally, I presented results of some preliminary tests of this model.

In addition to this initial seminar, I also presented a seminar to the project personnel at Kafr El-Sheikh on Wednesday, July 9, in which I discussed work in progress on the economic evaluation of wheat trials conducted at that site during the winter of 1979-1980. I also gave a general overview of the Water Management Alternatives Study.

Finally, with regard to this objective, I presented a seminar on Monday, July 21 to report on progress made in the farm level model during my TDY. A primary objective of this seminar was to acquaint project personnel in the main office with the computer programs developed for the Water Management Alternatives Study that are now available in the HP9825A.

2. Yield Response to Water and Farm Level Simulation Model

My work in Egypt focused primarily on the second of the objectives stated above. A considerable portion of my time was spent adapting FORTRAN programs written at Colorado State University for use in the HP9825A and gathering data required for the operation of these programs. The computer programs developed will be described and documented in a staff paper currently being prepared. They accomplish the following tasks:

1. Calculation of reference crop evapotranspiration using the evaporation method described in Crop Water Requirements by Doorenbos and Pruitt.

2. Calculation of potential evapotranspiration for specific crops using procedures described in this same publication.

3. Simulation of soil-plant-water relationships under typical Egyptian conditions including a high, fluctuating water table.

4. Simulation of water application to a level border field given user-specified field size, flow rate, soil characteristics, and depth of irrigation.

5. Simulation of water application, consumptive use, and yield reduction due to moisture stress over an entire growing season for a particular crop grown under level-border irrigation. This program determines net return, overall water application, irrigation labor usage, application efficiency, and water requirement efficiency under user-specified irrigation strategies and system design characteristics.

The first three of these programs, when used in conjunction with data from experiments designed to determine the effect of water stress in crop yield, provide the information needed to estimate the parameters of a yield response to water model of the general form suggested by Hanks:[1/]

$$y_r = r_1^{\lambda_1} r_2^{\lambda} \cdots r_n^{\lambda_n},$$

where y_r = relative yield (actual yield divided by potential yield)

r_i = relative evapotranspiration in the i^{th} physiological growth stage (actual evapotranspiration for the period divided by potential evapotranspiration)

λ_i = a parameter to be estimated for the i^{th} growth stage.

This model was selected for use instead of that described in an earlier progress report[2/] because it provides a reasonably good fit and because its

---

[1/] Hanks, R. J., "Model for Predicting Plant Growth is Influenced by Evapotranspiration and Soil Water," Agronomy Journal, 66 (5): 660-665.

[2/] King, R. P. and E. N. Biggs, "Progress Report on Water Management Alternatives Study," mimeo.

functional form allows the use of linear regression for parameter estimation.

Using data provided by Dr. F. N. Mahrous of the Sakha Agricultural Research Station, the parameters of this yield response model were estimated for wheat. The details of the estimation procedure will be given in the staff paper currently being prepared. Allowances are made for water table fluctuations and their effect in root development and evapotranspiration. This is of particular importance for this data set, since water table levels were not controlled in the experiment which was the source of the data.

A coefficient of multiple determination of .70 was obtained in this initial test of the estimation procedure. This is an encouraging result, since the reliability of the parameter estimation process will likely be improved as programs to estimate actual and potential evapotranspiration and the effect of high water table levels are refined. It should be noted, however, that a sensitivity analysis indicated that the parameter estimates for the model are strongly affected by the accuracy of water holding capacity measurements for specified soil levels, which serve as inputs to the program which simulates soil-plant-water relationships. Since there was some question concerning the accuracy of these measurements for the experimental site, the results obtained to date must still be considered to be preliminary. This problem can be easily corrected in the future, however.

A matter of concern in the use of yield response models based in experiment station results is that they may not be reliable tools for the prediction of yield response under actual farm conditions. One of the advantages of this model is that the effects of at least some of the factors that cause such discrepancies--fluctuating water table levels, for example--are endogenous to the model. Still another advantage is that the dependent variable is relative rather than absolute yield. The model can be adjusted for changes in agronomic practices, then, by simply specifying a higher or lower potential yield. In order to test the validity of the model for typical farm conditions, it will be used to predict the results of wheat field trials conducted in the Kafr El-Sheikh area during the winter of 1979 and 1980. The results of these validation tests will be reported in a staff paper to be prepared this fall.

Using weather and soil data for the Kafr El-Sheikh area and the wheat yield response model, the fifth program identified above, which can be considered to be a prototype version of the farm level model, was used to evaluate a range of irrigation strategies. Results to date indicate that the model performs well. This fall it will be used to evaluate the effects of alternative water delivery schedules in water use and economic returns. It will also be used to determine the degree of economic loss, if any, caused by the effects of fluctuating water table levels.

As I noted in my initial seminar in Egypt the questions posed during the development of a system model may be as valuable as the answers it ultimately provides. Of particular importance are the data requirements identified as part of the modeling effort, since they can help to direct and structure the data collection process. In Appendix I of this report, I specify the data needed for the validation and operation of the models developed to date.

3. Questionnaire in Farmer Attitudes Concerning Irrigation Improvements

Before arriving in Egypt, I worked with Ray Renfro, a Colorado State University economics graduate student, on the formulation of a questionnaire designed to elicit information in farmer attitudes toward a range of irrigation improvements. With the help of project economist Yosef, I pretested the questionnaire in the Kafr El-Sheikh area. After this experience I feel that substantial revisions are needed in the questionnaire. I have included a copy of it and a paper written by Mr. Renfro along with a list of recommended changes in Appendix II of this report. I suggest that project economists and sociologists review this so that they can determine whether or not further work with the questionnaire is warranted.

4. Collection of Price and Cost Data

The farm level model being developed for the Water Management Alternatives Study evaluates changes in irrigation practices according to technical criteria, such as crop yield and water application efficiency, and according to the economic criterion of net financial return. Information on product prices and input costs is needed to determine the net return associated with any given irrigation management and investment strategy. While here in Egypt I have received a copy of an up-to-date report on current price and cost data prepared by Pacific Consultants. I have also arranged for the receipt of updated enterprise budgets currently being prepared by EWUP project staff economists and will receive a copy of the forthcoming publication on water lifting costs by Drs. Wahby and Quenemoen and Engineer Helal. Finally, with regard to the objective, my work on the analysis of the wheat trial data for Kafr El-Sheikh has given me some insights into the cost of land leveling.

5. Identification of Irrigation Strategies and Cultural Practices for Evaluation

The directions taken in the future development of the farm level model of the Water Management Alternatives Study will depend, to a large extent, on the priorities set by the project staff in Egypt. The model can be extended to evaluate a wide range of changes in system design. From my observations at the three project sites and my discussions with project personnel, for example, it is clear that the capability to simulate level furrow irrigation and the basin irrigation commonly practiced on Egyptian farms is needed as soon as possible within the model. Similarly, wheat, cotton, and maize appear to be the three crops that should be given the highest priority in the estimation of parameters for yield response models. More explicit consideration of the effects of drainage improvements and the interactions between irrigation practices and water table levels is also needed.

Additional new directions will, no doubt, be identified as the mid-project report is prepared. As pilot projects are designed, components of the farm level model may be useful tools for evaluative purposes. Perhaps as valuable as the answers the model can provide, are the questions it can generate. As efforts are made to incorporate a particular system improvement into the model, data needs will be made explicit and relationships which require further study will be identified. If this is done while projects are still in the design phase, important data collection opportunities will not be missed.

6. Project Reports

During my stay in Egypt, I had the opportunity to assist project economists Ragy, Shenawi, and Yosef in the preparation of an economic evaluation of the wheat trials conducted in Kafr El-Sheikh during the winter of 1979-1980. This was beneficial to my work because it gave me first-hand knowledge of the way field trials are conducted in the project and insights into the types of economic questions that arise in the evaluation of them.

In addition to this effort, I also consulted with economists Lotfy and Shenawi at Mansouria concerning the format for the economic report to be presented at the mid-project review meeting later this month.

Appendix I

Data Requirements for the Water Management Alternatives Study

System modeling efforts can help to direct and structure data collection activities within a project such as the Egypt Water Use and Management Project, since they identify specific data requirements for the evaluation of alternative improvements being considered. In this appendix I will ennumerate the data needed for the validation and operation of the simulation models developed to date for the Water Management Alternatives Study. Much of this information is already being collected by the project. There is a need, however, to standardize data collection procedures and to make information easier to access. Whenever possible, then, I will suggest units of measurement and data recording procedures to be used in collecting and organizing this information.

<u>Soil Properties</u>

The following information on soil properties is needed for the soil-plant-water simulator, the irrigation application model, and the over-all model:

1. Measures of water holding capacity (percent) for the following soil layers: 0-30 cm, 30-60 cm, and 60-90 cm. Such measurements for soil layers 90-120 cm and 120-150 cm will also be needed for areas where water table levels do not preclude root development to these depths.

2. Infiltration constants as defined in the SCS handbook on border irrigation.

3. Values of the roughness coefficient for different cropping conditions. Suggested values are given in the SCS handbook. These should be made readily available.

This baseline information should be compiled for as many sites as are deemed necessary in each project area. It could be published in staff paper or project paper form.

Weather Data

Weather data are required for the calculation of reference crop ET and the crop coefficients used to calculate potential crop ET. The following data are needed on a daily basis:

1. Maximum and minimum temperature (degrees Celsius)
2. Pan evaporation (mm/day)
3. Wind velocity (km/day measured at 2m)
4. Maximum and minimum relative humidity (percent)
5. Precipitation (mm)

This information should be available for each study area for as long a time period as possible. Ideally it should be recorded on a disk file that is updated monthly and can easily be used to create a subfile of weather data for any twelve month period.

Crop Data

The following information is needed for the determination of crop coefficients, the simulation of soil-plant-water relationships, and the estimation of the yield response model:

1. Specifications of the length of each of the four developmental stages defined by Doorenbos and Pruitt in Crop Water Requirements for as many crops as possible. Doorenbos and Pruitt provide suggested values, but they may need to be adjusted for Egyptian conditions.

2. Specification of the number and length of physiological growth stages for as many crops as possible. These growth stages do not necessarily coincide with those defined by Doorenbos and Pruitt. They should reflect variation in the sensitivity of a particular crop to moisture stress.

3. Maximum rooting depths and the number of days required to reach that depth for as many crops as possible. These values should be for well-drained soils. Suggested values for maximum rooting depths are given in Doorenbos and Pruitt.

It is likely that this information could be compiled in a staff paper or project paper by an agronomist in the main office using available secondary data.

Soil-Plant-Water Relationships

The following information is needed for the validation of the soil-plant-water simulator. To a large extent, it is already being collected in connection with field trials conducted in each of the study areas.

1. For a given crop, measurements of soil moisture (mm) prior to each irrigation for each of the soil layers identified in the section on soil properties.
2. Daily water table levels (cm from surface).

Data on actual consumptive use from experiments conducted with lysimeters would also be of considerable value for the validating crop coefficient values. Also useful would be information in the degree to which a change in an individual farmer's irrigation practices will affect water table levels within his fields. The matter of concern here is the degree of collective action required to lower water table levels.

Yield Response to Water Data

In order to estimate the parameters of a yield response to water model such as that proposed in my report, data from carefully designed experiments are needed. In such experiments the crop should be systematically stressed at different stages of its growth cycle so that the effect of the timing as well as the degree of moisture stress can be evaluated. This could be achieved by skipping one or two irrigations on a particular treatment, by filling the soil to less than field capacity on specified irrigations on a particular treatment, or by varying the irrigation intervals for particular treatments. In my opinion the first two types of experimental design are preferable because, with fixed irrigation intervals, they are simpler to administer.

The following information should be collected during yield response experiments:

1. Planting date, harvest date, and dates of transition between physiological growth stages.
2. Dates and amounts of water applied for each irrigation on each treatment.
3. Crop yield. Ideally measures of dry matter yield and grain yield should be made.
4. Daily water table levels.
5. Weather data such as that specified above.
6. Soil property information such as that specified above.

The publication Optimizing Crop Production through Control of Water and Salinity Levels in the Soil is an excellent source of insights on the design of such experiments.

Water Application

More work needs to be done on the water application component of the farm level model. Application systems other than a level border need to be modeled and attention nees to be given to conveyance losses. Much of the needed information on water lifting is already available in the project paper being prepared on that subject. Required data includes:

1. Purchase costs for alternative lifting devices.
2. Variable lifting costs (per hour or per cubic meter) for alternative devices.
3. Typical height of lift at alternative sights and information on the variability of that height.
4. Flow rates (l/sec.) attainable with alternative lifting devices given the height of lift.
5. Flow rates attainable in the gravity systems in operation in the El Minya area.

With regard to conveyance losses, simple estimates of percentage losses for a range of field configurations and soil types would be of great value. This information could be presented in a staff or project paper.

Cost and Price Information

Cost and price data are currently made available in the form of enterprise budgets prepared for a variety of crops grown in each of the three project study areas. This information will be adequate for the needs of the study if the budgets are kept up-to-date and if refinements in the format of the budgets are made as deemed necessary.

Appendix II

Comments on Questionnaire to Identify Farmers' Attitudes Toward Irrigation Improvements

In this appendix a copy of a questionnaire designed to identify farmers' attitudes toward a range of irrigation improvements and a paper by Raymond Z. H. Renfro that explains the rationale for and the structure of the questionnaire are presented. A simple pretest of the questionnaire was made in the Kafr El-Sheikh area. From that experience, I have several comments and suggestions for future revisions.

First, the questionnaire is far too long. Particularly time-consuming are the first four pages. The questions in this section were designed for the elicitation of background information on family size, farm size, livestock production, farm equipment, and cropping patterns. Such information is collected so that correlations between farmer characteristics and attitudes can be identified. This information is important but it should be recorded in much less detail. It should be sufficient for most analyses to determine:

1. Name, age, family size
2. Area owned, area cultivated,
3. Primary method of lifting water
4. Source of water supply
5. Cropping pattern (without yield and income data)

A second major problem with the questionnaire is that the farmer interviewed had a difficult time answering the open-ended questions in section IV (pp. 5 - 17). He had trouble identifying the costs and benefits associated with alternative improvements. As a result, too much prompting was required to draw out responses. The purpose of this section of the questionnaire is to provide a structural setting within which the project personnel can "listen" to the farmer. Therefore, the questions must remain open-ended. They need to be reworked, though, so that they relate better to the farmers' own conceptual categories.

This leads me to my third and final recommendation. If this questionnaire is used in the future, it should be revised extensively and written in Arabic by project economists and sociologists so that it can serve as a valid tool for the elicitation of information. I think some of the most severe problems we encountered in the pretest stemmed from the fact that the interviewer was required to translate the questions.

In closing, I believe the information provided by a questionnaire of this sort can be of considerable value in the designing system improvements and in the formulation of strategies for their implementation. The objectives and concepts outlined in Mr. Renfro's paper are valid. There is a need, however, to further refine the survey instrument he and I developed.

SURVEY OF FARMERS' ATTITUDES TOWARD IMPROVED TECHNOLOGIES

by Raymond Z. H. Renfro

The purpose of this survey, to take place in Egypt over the summer of 1980, is to evaluate farmers' attitudes towards the improved technologies and farming practices proposed by the Egyptian Water Use Project; namely, precision land leveling (PLL), field restructuring or improved field layout, pumps (to lift canal water to the field), open wells, improved drainage, motorized tillage equipment, and watercourse improvement and canal lining. The enclosed questionnaire is designed to elicit farmer responses that will be useful in evaluating the degree of farmer acceptance to these technologies and improvements.

In numerous cases throughout the world, the general success or failure of farmer-oriented development projects hinges on the degree of farmer acceptance, or lack of it, to the changes introduced. It is highly relevant for the Egyptian Water Use Project to attempt to assess the attitudes of farmers on watercourses in the project areas before initiating any new technological project, and thereby avoid many of the pitfalls of other ill-fated projects. This survey will also aid in the future design and implementation of chosen projects in Egypt, and the need, if any, for farmer subsidy or cost-sharing programs.

For this purpose, the questionnaire is organized into four major sections--identification, personal data, farm data, and farmer attitudes and perceptions--with the fourth section being the central concern of the questionnaire and survey. The farm data section examines many characteristics which distinguish between different types of farms and farmers, including farm size, location on watercourse, tenure status, farm and off-farm income, livestock and machinery, sources of water supply, canal water availability, labor, land use, cropping pattern, yields, and quantities and prices sold. The farmer attitudes and perceptions section examines the nature and degree of impact of new improvements in the irrigation system--namely, diesel and electric pumps, open wells, traditional and precision land leveling, drainage systems, investments in or rental of modern tillage equipment, earthen or lining improvements of watercourses or canals, and cleaning and maintenance of the watercourse, and other types of irrigation system improvements (if any) not specified here. This section also examines farmer attitudes toward government projects and workers, in general, and concludes by asking how farmers find out about government programs and new improvements and innovations. With regard to the six specific improvements considered in the survey, farmers are asked to specify the major benefits and costs of each, with distinction made between whether or not farmers have actually invested in and experienced the improvements. Attempt is also made to quantify these perceived benefits and costs, based solely on farmer responses and estimates.

My experience in Pakistan in evaluating the On-Farm Water Management Pilot Project's (OFWM) program in precision land leveling (see my report: Constraints on Small Farmers in the Precision Land Leveling Program in Pakistani Punjab, Water Management Technical Report No. 54, Water Management Research Project, Colorado State University, Fort Collins, December, 1979), and subsequent work in the evaluation of the other OFWM project in watercourse improvement and partial canal lining, has convinced me of the need to pay particular attention to existing farming systems, farmers' perceptions of existing and new irrigation innovations, and farmers' constraints to active participation in governmental development schemes and projects. A survey of the type proposed here will help to measure many farmers' attitudes, constraints and needs, and will help in avoiding many of the pitfalls and gross wastes of money which often characterize developmental programs such as are being currently promoted in Egypt. It is also relevant to note that farmers' perceptions should be largely considered in designing the programs envisioned.

The questionnaire enclosed here is based very heavily on the study I did in Pakistan with incorporation of the situations and conditions peculiar to Egypt. Prior to eliciting farmer responses with respect to the irrigation system improvements being considered by EWUP personnel, it is very important to properly identify the interviewer, farmer being interviewed, and location/setting where the interview took place. For this reason, not only are the interviewer (IA) and farmer (IIA) identified, but also the respondent's father's name (IIB), governate (IB), district (IC), village (ID), canal name (IE), basin name (IF), and cooperative membership number (IG). This data will allow for easy identification of the farmer if there is a need to contact him again after the interview, and for putting the farmer interviewed in proper locational perspective in comparison with other farmers being interviewed and with all farmers in the project areas.

It is also very important to elicit data regarding both "farmer characteristics" and "farm characteristics." This data will be most relevant in identifying major constraints on participation in governmental or private development and improvmeent schemes. Characteristics which may prove relevant in identifying major categories of farms and farmers, and identifying major constraints on participation, include age, education level, farm size, location/position on the watercourse, tenure status, both farm and off-farm income, equipment ownership or rental, source of water supply, and availability of canal water. Attempts to identify progressive farmers, and to design some measure of a farmer's degree of progressiveness, are important since progressive farmers are usually the first in the village to adopt new technologies and improvements and the first to become actively involved in most government projects. A hypothesis which could be tested in Egypt is that the progressive farmers tend to be middle-aged (i.e., 30-50, see IIC of the questionnaire), better educated (IID), have larger farm holdings (IIIA-F),[1] be concentrated on the head and tail reaches of the watercourses (IIIG), be full- or part-time owner operators and not tenants (IIIH), earn most of their income from farming (IIII-K), be wealthier (IIII-K, IIIL, IIIM, IIIP, IIIR,),[2] own relatively more pumps, wells, sakias, and tambours (IIIM), rent more mechanized equipment (IIIM), depend relatively less on canal water alone (IIIN), and, finally, assure themselves of adequate water throughout the year (IIIO).

Success of the proposed irrigation system improvement programs may very well depend upon the degree that both the progressive and "other" farmers in the project areas are willing to adopt these improvements.

---

[1]As in Pakistan, Egyptian farmers may farm land not only along one watercourse or in one "basin," but in several basins in the same village, and even in other villages. Also, of the total land farmed, some may be owned in the farmer's name, some may be operated or farmed that are owned in the farmer's relatives' names, some may be rented from others, some may be sharecropped, and some may be rented out to other farmers.

[2]Total income can be estimated as the sum of net farm income, off-farm work, and income from other sources (i.e., from sons or daughters working in Cairo or in another country). Net farm income can be roughly estimated as the sum of livestock products sold (IIIL) and crops sold (IIIR), less equipment purchases, rental, depreciation and expenses, and less labor used and wages paid. The percentage of total family income that is attributable to net farm income is given in IIII, as are the percentages of off-farm income (III J-K). Consequently, the L.E. amount of off-farm income can be roughly estimated.

Asking farmers questions relating to farm and farmer characteristics is not only useful as a source of data, but also forces farmers being interviewed to think of their existing farming system in physical and monetary terms. This will allow for more precise and accurate answers to the questions on "farmer attitudes and perceptions." In this major section of the questionnaire, it is important to attempt to elicit farmers' perceptions of the top priority farm improvement with a bare minimal use of prompting--before proceeding with detailed questions on the six irrigation improvements proposed by EWUP. This will allow for a somewhat unbiased answer to the question of top priority improvements. It is likewise important to end the series of questions on the six proposed irrigation improvements with queries on whether there are other types of irrigation improvements besides these six. It is likely that there are certain indigenous types of improvements or technologies that are not captured in this questionnaire.

For each of the six major irrigation improvements, both benefits and costs (and/or difficulties) must be illicited, ranked in order of importance, and quantified. Attempt must be made to quantify benefits and costs not only in physical terms (i.e., yield, total production, etc.) but also monetarily. The benefits should be monetarily evaluated on the basis of the "with and without" principle. Quantifying the benefits has often proved to be the most difficult undertaking of benefit-cost analysis. This questionnaire only allows for farmers' perceptions of these benefits. The space below the questions on benefits and costs should be used for calculation.

The questionnaire allows for illicitation of perceived benefits and costs regardless of whether or not the farmer has actually invested in or experienced any of the irrigation improvements. It is to be expected that the data provided by farmers who have not actually invested in or experienced these improvements is considerably less reliable and accurate than that provided by farmers who have invested in and experienced the improvements.

The questions on land leveling (IVJ-S) are designed to elicit data on traditional leveling (which every Egyptian farmer engages in to some extent) and to elicit views of precision leveling. The methods of traditional leveling include use of the weeden implement zahāfa and oxen team, and basin flooding and the use of zahāfa prior to rice transplanting or forecasting--a practice called tālweet in Arabic. The questions on precision leveling (i.e., use of tractor scraper and land plane) are mainly aimed at the four farmers whose fields were precision leveled by R. Kern Stutter in the fall of 1979 with the help of Ahmed Bayonmi in the Mansouria site and Majdy Awad, Ahmed Ismail, and Nehad Ibrahim in the Kafr El Sheikh site. Three fields were leveled in Mansouria, two in the El Hammani Canal and one in the Beni Magdoul Canal, and one field was leveled in Kafr El Sheikh on the Hamad Canal. (See R. Kern Stutter's "Final TDY Report," dated November 10, 1979, from Cairo.)

The questions on drainage (IVT-Y) are designed to examine farmers' attitudes toward joint farmer drains, open field drains, and government tiling projects. It will probably prove beneficial to interview some farmers nearby some of these government tiling projects, who may be aware of the benefits and costs of these projects and may be able to express interest in these projects relative to other types of irrigation improvements.

Since most, if not all, farmers are members of their local village cooperative, most farmers should be able to give some response to the questions on modern tillage equipment (IVZ-CC), since modern equipment is frequently rented from the cooperatives.

The questions on watercourse/canal improvement and maintenance, and canal lining with bricks and cement (IVDD-II) are designed to elicit data on the degree of popularity of both earthen and lined watercourse improvments, and to examine the degree of farmer cooperation in the cleaning and maintenance of earthen watercourses and canals. It has been effectively shown by the Colorado State University team of water management specialists in Pakistan that the watercourse (being a "collective good") is a source of divisiveness in rural Pakistani society.[3] The ability of farmers to organize and act collectively is an effective measure of the success that watercourse improvements will have in aiding the overall irrigation system. In Pakistan, canal laning appears to be one way of resolving this divisiveness among farmers, and well worth its cost or outlay amount. In Egypt, where farmers appear to be considerably more cooperative than in Pakistan, and where access to more than one watercourse or canal for one particular field frequently exists, watercourse or canal lining may be impractical. There is one watercourse (in Mansouria, I believe) that has been completely lined with bricks and cement, and this survey would benefit by interviewing some farmers who have been affected by this particular watercourse.

The questionnaire concludes with questions relating to other, indigenous types of irrigation system improvements not anticipated by EWUP (IVJJ-MM) asks the farmer to rank in order of importance the types of irrigation improvements incorporated in the questionnaire (IVNN) and, finally, asks some questions on experiences with government programs, government workers in general, and ways of hearing about programs and new innovations and improvements (IVOO-QQ).

---

[3]See Lowdermilk, M., Freeman, D., and Early, A., Farm Irrigation Constraints and Farmers' Responses: Comprehensive Field Survey in Pakistan, Water Management Technical Reports 48A-F, Water Management Research Project, Colorado State University, 1978; Mirza, A. and Merrey, D., Organizational Problems and Their Consequences on Improved Watercourses in Punjab, Water Management Technical Report No. 55, Water Management Research Project, Colorado State University, 1979; Merrey, D., Irrigation and Honor: Cultural Impediments to the Improvement of Local Level Water Management in Punjab, Pakistan, Water Management Technical Report No. 53, Water Management Research Project, Colorado State University, 1979.

SURVEY OF FARMERS' ATTITUDES TOWARD IMPROVED TECHNOLOGIES

Farmer Questionnaire

NOTE: Please make notes in spaces provided below each question or in margins of special cases, problems, or interesting comments not covered by questionnaire.

CODE

Sample I.D. No. ____

I. A. Interviewer ______________ Date ________ IA ____

B. Governate ______________ B ____

C. District ______________ C ____

D. Village ______________ D ____

E. Canal Name ______________ E ____

F. Basin Name ______________ F ____

G. Cooperative Membership Number ______________ G ____

II. Personal Data

A. Farmer's Name ______________

B. Father's Name ______________

C. Age (years) ______________ IIC ____

Code: 1. Under 30; 2. 30-50; 3. Over 50.

D. Formal Education ______________ D ____

Code: 1. None; 2. Primary (1-6); 3. Preparatory (1-3);
4. Secondary (1-3); 5. Over secondary (specify);
6. Tafeez-el-Quran; 7. Mahu-el-Humeya;
8. Other (specify) ______________

III. Farm Data

A. Total area owned (feddans) IIIA ____

1. Total area owned (feddans) in this basin A1 ____
2. Total area owned (feddans) in this village A2 ____
3. Total area owned (feddans) elsewhere A3 ____

B. Total area operated, but not owned (feddans) B ____

1. Total area operated, but not owned in this basin B1 ____
2. Total area operated, but not owned in this village B2 ____
3. Total area operated, but not owned elsewhere B3 ____

C. Total area rented (feddans) C ____

1. Total area rented in this basin C1 ____
2. Total area rented in this village C2 ____
3. Total area rented elsewhere C3 ____

	CODE
D. Total area sharecropped (feddans)	IIID ____
1. Total area sharecropped this basin	D1____
2. Total area sharecropped this village	D2____
3. Total area sharecropped elsewhere	D3____
E. Total area rented out (feddans)	IIIE ____
1. Total area rented out this basin	E1____
2. Total area rented out this village	E2____
3. Total area rented out elsewhere	E3____
F. Total farm area (A+B+C+D-E)	IIIF ____

G. Farm Location

	(a) This Watercourse	(b) This Village	(c) Elsewhere	(d) Total
1. Owned	IIIG1a_____	G1b____	G1c______	G1d____
2. Operated but not Owned	G2a_____	G2b____	G2c______	G2d____
3. Rented In	G3a_____	G3b____	G3c______	G3d____
4. Sharecropped	G4a_____	G4b____	G4c______	G4d____
5. Rented Out	G5a_____	G5b____	G5c______	G5d____
6. Total	G6a_____	G6b____	G6c______	G6d____

Code: 0. Not applicable 1. Head 2. Middle 3. Tail

H. Tenure Status IIIH

Code:
1. Owner-operator full time
2. Owner-operator part time
3. Tenant full time
4. Tenant part time
5. Owner/tenant full time
6. Owner/tenant part time

I. Percentage of family income from farm IIII____

Code: 1. 100% 2. 50-99% 3. 25-49% 4. less than 25%

J. Percentage of family income from off-farm work IIIJ____

Source ____________________________

Code: 1. 100% 2. 50-99% 3. 25-49% 4. less than 25%

K. Percentage of family income from other sources IIIK____

Source(s)____________________________

Code: 1. 100% 2. 50-99% 3. 25-49% 4. less than 25%

L. Livestock Inventory

	(a) No.	(b) Age(s)	(c) Uses	Value of Product Sold 1979-80 (d) Amt. Sold	(e) Price/Unit
1. Buffalo	IIIL1a____	L1b____	L1c____	L1d______	L1e______
2. Cattle	IIIL2a____	L2b____	L2c____	L2d______	L2e______
3. Donkeys	IIIL3a____	L3b____	L3c____	L3d______	L3e______
4. Goats	IIIL4a____	L4b____	L4c____	L4d______	L4e______
5. Sheep	IIIL5a____	L5b____	L5c____	L5d______	L5e______
6. Chickens	IIIL6a____	L6b____	L6c____	L6d______	L6e______
7. Other Poultry	IIIL7a____	L7b____	L7c____	L7d______	L7e______
8. Other (Specify)	IIIL8a____	L8b____	L8c____	L8d______	L8e______

Code (uses): 1. milk 2. meat 3. eggs 4. milk and meat 5. meat and eggs 6. field work 7. transportation 8. milk and work 9. milk, meat, and work 10. meat and work 11. milk and transport 12. meat and transport 13. milk 14. work and transport 15. milk, meat, work, and transport 16. wool 17. wool and milk 18. wool and meat 19. wool, milk, and meat

M. Equipment Inventory

	(a) No.	(b) Size	(c) Source (Owned/Rented)	(d) Year Purchased	(e) Initial Cost	(f) Operating & Rental Cost/Year
1. Sakia	M1a____	M1b____	M1c__________	M1d______	M1e____	M1f__________
2. Tambour	M2a____	M2b____	M2c__________	M2d______	M2e____	M2f__________
3. Tractor	M3a____	M3b____	M3c__________	M3d______	M3e____	M3f__________
4. Traditional ~~Plant~~ Plow	M4a____	M4b____	M4c__________	M4d______	M4e____	M4f__________
5. Mechanized ~~Plant~~ Plow	M5a____	M5b____	M5c__________	M5d______	M5e____	M5f__________
6. Diesel Pump	M6a____	M6b____	M6c__________	M6d______	M6e____	M6f__________
7. Electric Pump	M7a____	M7b____	M7c__________	M7d______	M7e____	M7f__________
8. Open Well	M8a____	M8b____	M8c__________	M8d______	M8e____	M8f__________
9. Other (Specify)	M9a____	M9b____	M9c__________	M9d______	M9e____	M9f__________

N. Source of Water Supply

Code: 1. Canal only 2. Well only 3. Canal and well
4. Canal drain 5. Well and drain
6. Other (specify)______________________

O. Canal Water Availability - Do you get enough water for your crop each season?

1. Summer Season IIIO1___

2. Winter Season IIIO2___

Code: 1. 25% or less 2. 26-50% 3. 51-75% 4. 76-100%

P. Family and Hired Labor

1. Number of adult male family workers IIIP1____
2. Number of adult female family workers P2____
3. Number of minor family workers P3____
4. Number of hired casual (part-time) workers P4____
5. Duration of hire P5____
6. Wage paid (cash and payment in kind) P6____

Specify____

Q. Land Use

Cultivated

1. Summer cropped area IIIQ1____
2. Winter cropped area Q2____
3. Total (1+2) Q3____

R. Cropping Pattern

	(a) Feddans (1979-80)	(b) Total Production	(c) Quantity Sold	(d) Price Sold
1. Cotton	IIIR1a________	R1b________	R1c________	R1d_____
2. Rice	R2a________	R2b________	R2c________	R2d_____
3. Maize/Corn	R3a________	R3b________	R3c________	R3d_____
4. Maize forage	R4a________	R4b________	R4c________	R4d_____
5. Berseem	R5a________	R5b________	R5c________	R5d_____
6. Wheat	R6a________	R6b________	R6c________	R6d_____
7. Sugar Cane	R7a________	R7b________	R7c________	R7d_____
8. Flax & Oilseed	R8a________	R8b________	R8c________	R8d_____
9. Vegetables	R9a________	R9b________	R9c________	R9d_____
10. Fruits & Citrus	R10a________	R10b________	R10c________	R10d_____
11. Pulses & Beans	R11a________	R11b________	R11c________	R11d_____
12. All other	R12a________	R12b________	R12c________	R12d_____

Specify____

IV. Farmer Attitudes and Perceptions

A. What is your top priority improvement? (Ask this question with no or a bare minimum of, prompting.) IVA_____

Code:
0. no response 1. diesel pump 2. electric pump
3. open well 4. land leveling and field reconstruction
5. fertilization 6. high yielding seeds
7. insecticides 8. drainage 9. other (specify) ______

____

B. If pump is owned or rented, what are the perceived benefits?

1. Most important benefit IVB1_____
2. 2nd most important benefit B2_____
3. 3rd most important benefit B3_____

Code:
0. not applicable/no response
1. lower cost of pumping water from canal
2. can supply canal water on a more timely basis
3. overcomes labor shortage/supplements labor (replaces tambour)
4. overcomes animal power shortage/increases livestock production
5. other (specify)_______________________________

C. If pump is owned or rented, what are the perceived costs and/or difficulties encountered?

1. Most important cost/difficulty IVC1_____
2. 2nd most important cost/difficulty C2_____
3. 3rd most important cost/difficulty C3_____

Code:
0. not applicable/no response
1. ownership purchase cost (L.E.)____________________
2. pump fuel and family labor time (L.E./year)____________
3. pump electricity and family labor time (L.E./year)__________
4. pump rental (L.E./year)____________________
5. breakdown and repairs (L.E./year)____________________
6. hired labor (L.E./year)____________________
7. other (specify)____________________
8. Total cost (L.E./year + purchase cost)____________________ C4_____

D. If pump is neither owned nor rented, what are the perceived benefits?

1. Most important benefit IVD1_____
2. 2nd most important benefit D2_____
3. 3rd most important benefit D3_____

Code:
0. not applicable/no response
1. lower cost of pumping water from canal
2. can supply canal water on a more timely basis
3. overcomes labor shortage/supplements labor (replaces tambour)
4. overcomes animal power shortage/increases livestock production
5. other (specify)_____

E. If pump is neither owned nor rented, what are the perceived costs and/or difficulties anticipated?

1. Most important cost/difficulty IVE1_____
2. 2nd most important E2_____
3. 3rd most important E3_____

Code:
0. not applicable/no response
1. ownership purchase cost (L.E.)_____
2. pump fuel and family labor time (L.E./year)_____
3. pump electricity and family labor time (L.E./year)_____
4. pump rental (L.E./year)_____
5. breakdown and repairs (L.E./year)_____
6. hired labor (L.E./year)_____
7. other (specify)_____
8. Total cost (L.E./year + purchase cost)_____ E4_____

F. If well is owned, what are the perceived benefits?

1. Most important benefit IVF1_____
2. 2nd most important benefit F2_____
3. 3rd most important benefit F3_____

Code:
0. not applicable/no response
1. use more and more water on same crops
2. grow more water-using crops (i.e., rice, sugarcane, vegetables)
3. planted orchard
4. increase cropping intensity (grow more crops)
5. increase crop area (or previously unirrigated land--for "tail" farmers
6. other (specify)_____

G. If well is owned, what are the perceived cost and/or difficulties encountered?

1. Most important cost/difficulty IVG1_____
2. 2nd most important cost/difficulty G2_____
3. 3rd most important cost/difficulty G3_____

Code:
0. not applicable/no response
1. ownership purchase cost (L.E.)______________________________
2. family labor and livestock power (L.E./year)________________
3. family labor and pump fuel (L.E./year)______________________
4. repair and maintenance (added digging costs)________________
5. hired labor costs for repair and maintenance________________
6. other (specify)____
7. Total cost (L.E./year + purchase cost)______________________ G4_____

H. If well is not owned, what are the perceived benefits?

1. Most important benefit IVH1_____
2. 2nd most important benefit H2_____
3. 3rd most important benefit H3_____

Code:
0. not applicable/no response
1. use more and more water on same crops
2. grow more water-using crops (i.e., rice, sugarcane, vegetables)
3. planted orchard
4. increase cropping intensity (grow more crops)
5. increase crop area (or previously unirrigated land--for "tail" farmers
6. other (specify)____

I. If well is not owned, what are the perceived costs and/or difficulties anticipated?

1. Most important cost/difficulty IVI1_____
2. 2nd most important cost/difficulty I2_____
3. 3rd most important cost/difficulty I3_____

Code:
0. not applicable/no response
1. ownership purchase cost (L.E.)______________________________
2. family labor and livestock power (L.E./year)________________
3. family labor and pump fuel (L.E./year)______________________
4. repair and maintenance (added digging costs)________________
5. hired labor costs for repair and maintenance________________
6. other (specify)____
7. Total cost (L.E./year + purchase cost)______________________ I4_____

J. Do you regularly level your land (i.e., after each cropping season or once per year)? IVJ_____

Code: 1. yes 2. no

K. If answer to J is no, have you ever leveled your land? IVK_____

Code: 0. not applicable 1. yes 2. no

Details:

L. Source of land leveling. IVL_____

Code:
0. not applicable/none
1. traditional method (cows or buffaloes and Zahāfa) broad-
2. plot flooding (i.e., prior to rice transplanting or ~~fore~~-casting--buddling or talweet)
3. precision leveling
4. other (specify)____________________

Details:

M. Implements used for land leveling IVM1_____ M2_____ M3_____

Code:
0. not applicable/no response
1. cows or buffaloes and zahāfa
2. tractor and scraper
3. tractor and land plane
4. tractor and scaper and land plane
5. other (specify)____________________

N. What knowledge do you have of precision leveling? IVN_____

Code:
0. none/no response
1. seen an experimental field
2. seen a government extension field
3. other (specify)____________________

O. If leveling was done (traditional and/or precision), what benefits did you realize?

1. Most important benefit IVO1____

2. 2nd most important benefit 02____

3. 3rd most important benefit 03____

Code:
0. not applicable/no response
1. reduced time to irrigate (less water per feddan)
2. increased crop production (higher yields)
3. reduced dependence on canal water
4. reduced dependence on well water
5. reduced pumping requirements and costs
6. easier planting
7. increase in cropping intensity
8. reclaim waste or defective land
9. easier operation of tractor and equipment (increase in plot size)
10. easier operation of cows, buffaloes, and equipment (increase in plot size)
11. reduction in family labor time
12. reduction in hired labor costs
13. easier to make furrows
14. other (specify)________________________________
(specify quantity improvements)

P. If leveling was done, what costs and/or difficulties did you realize (during and after)?

1. Most important cost/difficulty IVP1____

2. 2nd most important cost/difficulty P2____

3. 3rd most important cost/difficulty P3____

Code:
0. not applicable/no response
1. own tractor fuel and labor time (L.E.)________________
2. tractor rental and labor time (L.E.)________________
3. equipment rental (L.E.)________________
4. hired labor (L.E.)________________
5. need to restructure fields (L.E.)________________
6. need to use different irrigation methods (L.E.)__________
7. other (specify)________________________________

Q. If traditional leveling was done, what added (reduced) benefits would you expect from precision leveling?

1. Most important added (reduced) benefit IVQ1_____
2. 2nd most important added (reduced) benefit Q2_____
3. 3rd most important added (reduced) benefit Q3_____

(+) = added benefit (-) = reduced benefit

Code:
0. not applicable/no response
1. reduced time to irrigate (less water per feddan)
2. increased crop production (higher yields)
3. reduced dependence on canal water
4. reduced dependence on well water
5. reduced pumping requirements and costs
6. easier planting
7. increase in cropping intensity
8. reclaim waste or defective land
9. easier operation of tractor and equipment (increase in plot size)
10. easier operation of cows, buffaloes, and equipment (increase in plot size)
11. reduction in family labor time
12. reduction in hired labor costs
13. easier to make furrows
14. other (specify)________________________________
(specify quantity improvements (disimprovements) over traditional leveling)

R. If traditional leveling was done, what reduced (added) costs would you expect from precision leveling?

1. Most important reduced (added) cost IVR1_____
2. 2nd most important reduced (added) cost R2_____
3. 3rd most important reduced (added) cost R3_____

(+) = reduced cost (-) = added cost

Code:
0. not applicable/no response
1. own tractor fuel and labor time (L.E.)____________________
2. tractor rental and labor time (L.E.)____________________
3. equipment rental (L.E.)____________________
4. hired labor (L.E.)____________________
5. need to restructure fields (L.E.)____________________
6. need to use different irrigation methods (L.E.)____________
7. other (specify)____________________________
(specify quantity improvements (disimprovements) over traditional leveling)

S. 1. If no leveling has been done, would you prefer traditional leveling or precision leveling? IVS1_____

Code: 0. no response 1. traditional 2. precision

2. Why? IVS2_____

T. Source of dı inage. IVT____

Code:
0. not applicable/none
1. joint farmer drains
2. open field drains
3. both 1 and 2
4. government tiling project
5. other (specify)________________

U. Degree of awareness of government tiling projects IVU____

Code:
0. not applicable/no awareness
1. aware somewhat, but never seen in operation
2. aware somewhat and have seen in operation
3. other (specify)________________

V. If investment in drainage (i.e., open field drains) has occurred or if access to drainage exists, what benefits to you realize?

1. Most important benefit IVV1____
2. 2nd most important benefit V2____
3. 3rd most important benefit V3____

Code:
0. not applicable/no response
1. no benefit
2. reduced salinity and waterlogging
3. lower water table
4. increased crop production (higher yields)
5. saves crop (basin) area (for tile projects)
6. other (specify)
   (specify quantity improvements)

W. If investment in drainage has occurred, what costs and/or difficulties did you realize?

1. Most important cost/difficulty IVW1____
2. 2nd most important cost/difficulty W2____
3. 3rd most important cost/difficulty W3____

Code:
0. not applicable/no response
1. cleaning and maintenance
2. own and family labor
3. hired labor costs
4. reduced crop (basin) area
5. other (specify)________________

X. If investment in drainage has not occurred, or if access to drainage does not exist, what benefits would you expect from drainage?

1. Most important benefit IVX1_____

2. 2nd most important benefit X2_____

3. 3rd most important benefit X3_____

Code:
0. not applicable/no response
1. no benefit
2. reduced salinity and waterlogging
3. lower water table
4. increased crop production (higher yields)
5. saves crop (basin) area (for tile projects)
6. other (specify)
(specify quantity improvements)

Y. If investment in drainage has not occurred, or if access to drainage does not exist, what costs and/or difficulties would you expect?

1. Most important cost/difficulty IVY1_____

2. 2nd most important cost/difficulty Y2_____

3. 3rd most important cost/difficulty Y3_____

Code:
0. not applicable/no response
1. cleaning and maintenance
2. own and family labor
3. hired labor costs
4. reduced crop (basin) area
5. other (specify)

Z. Types of modern tillage equipment available, degree of use, and sources of each.

	(a) Availability and Use	(b) Source
1. Tractor	IVZ1a_____	Z1b____
2. Spraying equipment	Z2a_____	Z2b____
3. Airplanes for spraying cotton	Z3a_____	Z3b____
4. Plows	Z4a_____	Z4b____
5. Disc harrows	Z5a_____	Z5b____
6. Thrashers	Z6a_____	Z6b____
7. Portable diesel pump	Z7a_____	Z7b____
8. Other (specify) ________	Z8a_____	Z8b____

AA. Of all the types of modern tillage equipment you are familiar with, or aware of, which are the three most important to you?

1. Most important type of equipment IVAA1_____
2. 2nd most important type of equipment AA2_____
3. 3rd most important type of equipment AA3_____

Code:
0. not applicable/no response
1. tractor
2. spraying equipment
3. airplanes for spraying cotton
4. plows
5. disc harrows
6. thrashers
7. portable diesel pumps
8. other (specify)__________________________

BB. What are the perceived benefits of these three major types of equipment?

1. Most important benefit of type #1 IVBB1_____
2. 2nd most important benefit of type #1 BB2_____
3. 3rd most important benefit of type #1 BB3_____
4. Most important benefit of type #2 BB4_____
5. 2nd most important benefit of type #2 BB5_____
6. 3rd most important benefit of type #2 BB6_____
7. Most important benefit of type #3 BB7_____
8. 2nd most important benefit of type #3 BB8_____
9. 3rd most important benefit of type #3 BB9_____

Code:
0. not applicable/no response
1. increased production/yield
2. reduction in family labor time
3. reduction in hired labor costs
4. other

CC. What are the perceived costs and/or difficulties anticipated of these three major types of equipment?

1. Most important cost of type #1 IVCC1_____
2. 2nd most important cost of type #1 CC2_____
3. 3rd most important cost of type #1 CC3_____
4. Most important cost of type #2 CC4_____
5. 2nd most important cost of type #2 CC5_____
6. 3rd most important cost of type #2 CC6_____

7. Most important cost of type #3 CC7____

8. 2nd most important cost of type #3 CC8____

9. 3rd most important cost of type #3 CC9____

Code:
0. not applicable/no response
1. lack of influence with coop
2. work by coop member not done correctly
3. rental rate is too high
4. equipment not available on time
5. other (specify)

DD. Have the farmers along your watercourse(s) ever considered imporving the watercourse--either by regularly cleaning, repairing, and maintaining the watercourse, or making earthen improvements, or investing in partial lining with bricks and cement? IVDD_____

Code:
0. no response
1. very seldom clean the watercourse and never make earthen improvements
2. occasionally clean the watercourse and never make earthen improvements
3. regularly clean the watercourse and never make earthen improvements
4. seldom make earthen improvements
5. occasionally make earthen improvements
6. regularly make earthen improvements
7. watercourse is completely lined
8. watercourse is partially lined
9. other (specify)____

EE. How many farms are there along your watercourse? (Information also available from coops.) IVEE_____

FF. Have the farmers along your watercourse or village ever effectively organized for group activities, such as watercourse maintenance? IVFF_____

Code: 1. yes 2. no

GG. If yes, in what form and for what duration?

HH. What are the perceived benefits of watercourse improvement and canal lining?

1. Most important benefit IVHH1_____

2. 2nd most important benefit HH2_____

3. 3rd most important benefit HH3_____

Code:
0. not applicable/no response/no improvement
1. increase in crop production (more water for same crops)
2. increase in crop intensity
3. increase in amount of cropped land under irrigation
4. increase in more profitable, water-using crops (i.e., rice sugarcane, vegetables)
5. decrease in family labor time
6. decrease in hired labor costs
7. fewer quarrels and/or thefts over water
8. increase in cooperative spirit along watercourse/village
9. other (specify)______________________________

II. What are the perceived costs and/or difficulties experienced or anticipated from watercourse improvement?

1. Most important cost/difficulty IVII1_____

2. 2nd most important cost/difficulty II2_____

3. 3rd most important cost/difficulty II3_____

Code:
0. not applicable/no response
1. investment in bricks and cement
2. own and family labor time
3. hired labor costs (including masons)
4. loss of trees removed from watercourse
5. loss of land due to straightening or changing route
6. time spent organizing others, waiting for others, dealing with government officials
7. cannot put in illegal outlets to the fields
8. other (specify)______________________________

JJ. Are you aware of other types of improvements to conserve water and increase crop productivity which you would like to see encouraged by the government? IVJJ_____

Code: 1. yes 2. no

KK. If yes, what types?

LL. If yes, what are the benefits (rank them)?

MM. If yes, what are the costs (rank them)?

NN. Of all the types of improvements we have talked about (i.e., pumps, wells, land leveling and field reconstruction, drainage, modern tillage equipment, watercourse improvements, and any other). which are the most important to you?

1. Most important improvement IVNN1_____
2. 2nd most important improvement NN2_____
3. 3rd most important improvement NN3_____

Code:
0. not applicable/no response
1. diesel pump
2. electric pump
3. open well
4. precision land leveling
5. traditional land leveling
6. government tilling drainage
7. open field drainage
8. modern tillage equipment (specify)________________________
9. earthen watercourse improvement
10. canal lining
11. other (specify)____

OO. Experience with government programs. IVOO1_____

Code: IVOO2_____
0. not applicable/no response/no experience
1. IVOO3_____
2.

PP. Experience with government workers and personnel. IVPP1_____

Code: PP2_____
0. not applicable/no response/no experience
1. PP3_____
2.

QQ. How do farmers in your area hear about government programs or new improvements and innovations? IVQQ1_____

Code: IVQQ2_____
0. not applicable/no response
1. from other farmers IVQQ3_____
2. from project personnel
3. T.V., radio, newspapers, other public media
4. other (specify)

Water Budget

The results from the water budget studies can be used to predict the effects that changes in water management will have on water losses, drainage problems and salinity buildup. Three areas having different soil and agronomic conditions were selected. Water budget results from these three areas will represent results anticipated from other irrigated areas throughout Egypt.

Mansouria

The Beni Magdoul study area is in the southern portion of the Mansouria Irrigation District and consists of approximately 750 feddans under irrigation. The study area is a well defined hydrologic unit. The entire area is bounded by drains and water is supplied by the Beni Magdoul Canal. The surface soils of this area consists primarily of sandy clay, sandy clay loam and sandy loam. The log of the well installed for the deep pumping test located at the intersection of the Beni Magdoul Canal and the branch canal SE quadrant indicates that a clay layer exists to a depth of seven meters below ground surface. This clay was apparently encountered in the drilling of the domestic water supply well for Beni Magdoul village and a preliminary exploration hole drilled approximately 300 meters north of the Beni Magdoul Canal along the Nahia Drain. This clay layer would effectively limit deep vertical seepage of irrigation water and is in effect an impermeable subsurface boundary for the area.

The general concept for water balance for an area during a selected period of time is, "Inflow less outflow equals change in storge for the area." The primary inflow to Beni-Magdoul site is controlled by a calibrated Nyrpic gate at the junction of Mansouria canal and the Beni Magdoul canal. Other sources of water due to precipitation, deep wells, and interflow between adjacent areas have been determined to be relatively small and account for about five percent of the total inflow to the study site.

Consumptive use has been determined to be the most significant outflow from the area. More effort needs to be concentrated in consumptive use determinations. For this area, subsurface outflow is very small but can be increased by installing drains if salinity becomes a more serious problem. Surface outflow was very small and was controlled

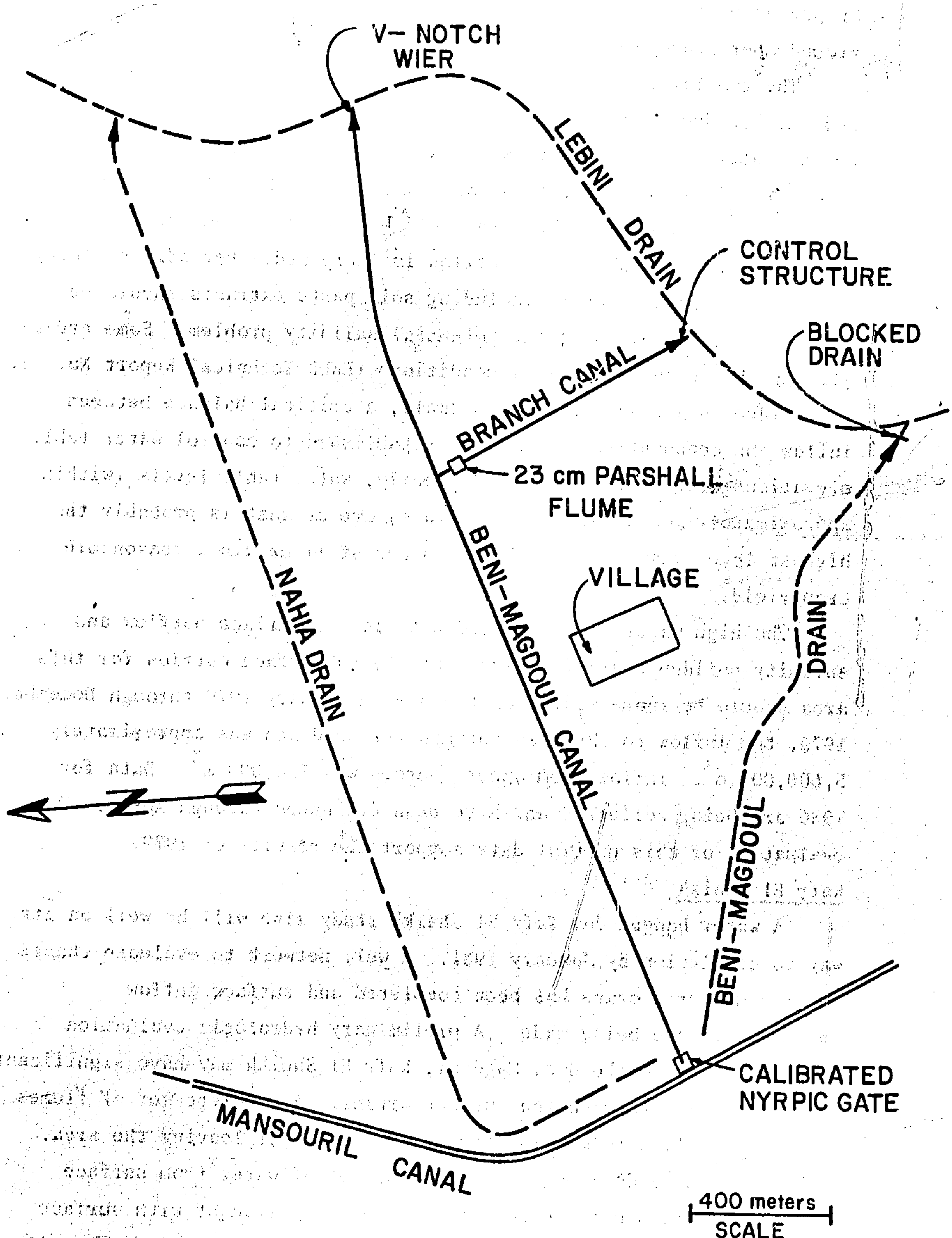


Figure III. Beni Magdoul Study Area

by proper management of surface inflows at the headgate. The change in groundwater storage was determined to be small over a one year period.

The two largest variables are inflow from the Beni Magdoul canal and outflow due to consumptive use. These two flows account for approximately 94 percent of the total volume balance.

There is very little subsurface outflow which would indicate that salinity buildup within the area could be a more serious problem in the future unless the subsurface outflow is increased. Periodic salinity measurements of all waters including soil paste extracts should be made in order to evaluate the potential salinity problem. Some areas already show high saline soil conditions (EWUP Technical Report No. 3).

Since subsurface outflow is small, a critical balance between inflow and consumptive use must be established to control water table elevations at desired levels. Presently, water table levels (within approximately 100 cm of ground surface) are at what is probably the highest level that can be maintained and still obtain a reasonable crop yield.

The high water table coupled with low subsurface outflow and salinity buildup would indicate that the subsurface outflow for this area should be increased. For the period January 1979 through December 1979, the inflow to the area through the headgate was approximately 5,600,000 m^3. Inflow from other sources was 330,000 m^3. Data for 1980 are being collected and have been evaluated through April. The evaluation of this partial data support the results of 1979.

Kafr El Sheikh

A water budget for Kafr El Sheikh study site will be well on its way to completion by January 1981. A well network to evaluate change in groundwater storage has been completed and surface inflow measurements are being made. A preliminary hydrologic evaluation indicates that unlike Beni Magdoul, Kafr El Sheikh may have significant surface outflow through the surface drains. A complete set of flumes will be installed to monitor the volumes of water leaving the area.

Preliminary data suggests that volumes of water from surface inflows and consumptive use will be highly significant with surface outflow being secondary and all other hydrologic factors being small. A complete water budget will provide an evaluation of each component of inflow and outflow for this site.

El Minya

A study area for water budget has been selected. Measuring structures such as flumes and observation wells are being installed on schedule. Measurements for water budget evaluations are being taken and will be evaluated by December 1981.